MAKING SENSE OF MITIGATION USED TO ADDRESS INDUSTRIAL EFFECTS ON WILDLIFE IN CANADIAN ENVIRONMENTAL ASSESSMENTS

SANDRA SARAH ELVIN

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Abstract

Within a given industrial project, adverse environmental effects are a likely occurrence. Current environmental sustainability doctrine in Canada suggests that adverse environmental effects need to be adequately addressed in order to be avoided or minimized. The Environmental Assessment (EA) process has been developed to provide a systematic means for effects analysis and to cultivate mitigation programs to offset adverse effects. However, the progress of EAs often leads to development of industry with inadequate regard for mitigation for wildlife and their habitats. To better understand the mechanisms of mitigation programs used to offset effects to wildlife in the Canadian EA process, I established three studies consisting of quantitative and qualitative methods of inquiry. In the first study, I interviewed mitigation experts on their use and perceptions of success of various mitigation programs. I found that programs used by experts in different occupation groups differ in terms of frequency of use. Further, the overall pattern for perception of success of mitigation programs remained consistent. Experts were hesitant to label any mitigation program as reliably successful in offsetting adverse environmental effects. Second, I examined the role of an informational tool in informing EAs and subsequent mitigation. Using a Strengths, Weaknesses, Opportunities, and Threats analysis, I evaluated the telemetry tool. I found that a specific set of support systems is needed to implement telemetry on a useful basis. Last, I used data from experts' knowledge interviews to unearth trends in mitigation practices. I used this information to develop policy and operational recommendations for improving the Canadian EA process. I conclude this dissertation with a synthesis chapter that demonstrates the contributions of these studies, and provides suggestions for future research.

Dedication

I dedicate this dissertation to all the wildlife (and plants) that have been disturbed, injured, and killed due to our incessant need for energy and dominance. I am sorry. I hope my work can be a positive force toward repairing the damage already done and preventing any more.

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Preface

This dissertation contains five chapters: an introduction (Chapter 1), three body chapters written as separate manuscripts (Chapters 2, 3, and 4), and a conclusion (Chapter 5). Chapters 2, 3, and 4 were composed as distinct chapters to be submitted for publication in peer-reviewed journals. For this reason, some repetitiveness exists amongst these chapters. Chapters 1 and 5 provide an overall introduction and conclusion to this dissertation, respectively.

Chapter 1.0: Introduction

1.1 Overview of research problem: the Environmental Assessment

Adverse environmental effects from industrial development projects are unavoidable and continually contribute to ecosystem degradation (Richter *et al.* 2003). For example, the longevity of hydropower dams is usually predicted over decades, sometimes centuries. The 14 GW hydropower project of Itaipu, Brazil, began in 1975 and is expected to provide continuous energy production over the next 200 years (Sternberg 2007). Yet the adverse effects of this hydropower facility are immediate following impoundment. In an attempt to encourage and oblige industries to follow ecologically sustainable pursuits, a methodical practice for evaluating environmental effects has been adopted by many nations over the last several decades (Glasson *et al*. 2005; Singleton *et al*. 1999). This practice is often referred to as the Environmental Assessment (EA); for example, it can be viewed in its legal form in Canada as the *Canadian Environmental Assessment Act* (see CEAA 2012). The purpose of EAs is to provide a process for evaluating and addressing interactions between the environment and industrial undertakings. Ultimately, EAs permit industrial development to occur as ecologically sustainable as possible (Glasson *et al*. 2005; Singleton *et al*. 1999). It is debatable whether the latter is achieved in Canada.

A major fallacy of the EA process is the assumption that degradation to ecosystem integrity can be adequately anticipated (and avoided or minimized) when all facts and baseline data are known and properly analyzed. Many researchers dispel the notion that EAs are fitted with the capacity to address environmental effects to the level that ensuring sustainability would require (e.g. Cashmore 2004; George 1999; Gontier *et al.* 2006; Harrop and Nixon 1998). Berkes (1988) described the ramifications of effects improperly predicted, overlooked, and missed altogether at La Grande hydroelectric complex of the James Bay hydroelectric project, Quebec, Canada. Berkes (1988) analyzed an improper diagnosis that resulted in the near losses of estuarine fish stocks. Only later revisions of the EA with appropriate mitigation options helped alleviate the decline. The author also described four cases of effects that were missed resulting in: 1) the drowning event of approximately 10,000 caribou (*Rangifer tarandus*), 2) the mercury buildup in downstream and reservoir sites, 3) the negative consequences of access roads to hunting territories of the Chisasibi Cree, and 4) the elimination of access to major water crossings on previously used land by the Aboriginal population. Berkes (1988) also pointed out an oversight that resulted in major alterations to wetland ecology. These missed and failed effect analyses may be attributed to the narrow perspective of the EA process. A larger ecosystem perspective for effects assessment is called upon by many authors to alleviate errors and omissions, and handle surprises in the EA process (e.g. Berkes 1988; Mandelk *et al.* 2005; Rapport *et al.* 1985).

Regardless of the intricacy involved in adequately addressing effects in the EA process, industrial projects are needed to meet the societal demands of population growth and/or economic development. Perseverance of industry projects through the EA process is manifested through the creation and implementation of mitigation approaches. Mitigation projects in general are sought after to lessen the load on ecosystem services burdened by industrial undertakings. A catalogue of initiatives to alleviate adverse effects are identified in various EAs, as directed by legislative documents (e.g. CEAA 2012), ranging from avoidance to enhancement (Treweek 1999; Trussart *et al*. 2002). For example, Trussart *et al.* (2002) provided a review of mitigation efforts for hydropower; however, the authors acknowledged the prevailing issue of the lack of scientific data on the effectiveness and efficiency of mitigation (see also Race and Fonseca 1996). Essentially, EA practitioners (or those ultimately responsible for designing adequate mitigation projects) are faced with potentially flawed EAs and yet must still decide on environmentally and socially acceptable schemes. These schemes must ensure that the overall purpose and longevity of the industrial project is not compromised while considering the needs of environmental values.

Addressing ecosystem services in a more directed, manageable, and concrete manner as Valued Ecosystem Components (VECs) has been a popular approach in Canada (see Beanlands and Duinker 1983). For example, the use of VECs enables wildlife to be considered on a speculative basis as specific adverse effects are anticipated. Analyzing VECs for changes due to industrial activities in this manner fits the overall global doctrine for conserving biodiversity (as noted in international agreements, see Mason 2001). Several steps are conducted in EAs to demonstrate the relationship to the effect (CEAA 2012). Breaking down components of VECs into indicators is one step that is required to understand how an industrial activity (e.g. construction and/or operation phase) might cause a change to the site and surrounding ecosystem (Barnes *et al.* 2000; Beanlands and Duinker 1983). Addressing the natural, temporal and spatial extent, period and frequency, reversibility, context, and quality of knowledge of each indicator is crucial to the effects analysis (Barnes *et al*. 2000; Beanlands and Duinker 1983). Environmental effects upon large-mammal indicators within a terrestrial VEC, for example, can be manifested as changes to habitat, habitat connectivity, mortality, and health of a species (e.g. Nalcor Energy 2009).

VECs and their indicators are site-specific and therefore range taxonomically. For example, the selection of black bears (e.g. *Ursus americanus*) as an indicator species within the Terrestrial Environment VEC stems from the recognition of the role of the large mammal in its biophysical and social environment. The black bear is an ecological generalist that uses a variety of habitats depending on life stage, location, and time of year (Chaulk *et al*. 2005; Donovan *et al.* 1987; Hellgren and Maehr 1992; Herrero 1972, 1978; Holcroft and Herrero 1991; Pelton 2003;

Veitch and Krizan 1996). As a species that occupies a wide niche, the black bear can be a vital link between project effects and other indicators of VECs (e.g. see Nalcor Energy 2009). Specifically, a measurable adverse change in black bear habitat, mortality, and health (Nalcor Energy 2009) is highly likely to infer a change in suitable forage upon which other VEC indicator species or human populations are dependent. The black bear is also subject to hunting pressures and a measurable change in population dynamics can translate to a decreased source of income and/or a decline in quality of life for those human populations dependent on the species for their livelihoods. Thus, it is foreseeable that a proposed large-scale industrial project, such as a hydroelectric development, would be predicted to have a range of effects on the black bear species with respect to both ecological and social realms.

Given that effects can be inherently uncertain due to the nature of 'predictions' (e.g. Berkes 1988; de Jongh 2001; Sarewitz and Pielke Jr.. 2000) and that industrial development projects are called upon to fulfill human consumption, the question is posed: how can sustainable development actually occur? The term 'sustainable development' is defined in the CEAA (2012, 2(1)) as "development that meets the needs of the present, without compromising the ability of future generations to meet their own needs", which is consistent with international dialogues (e.g. Brundtland Report UN 1987, see Halley and DesMarchais 2012 for a discussion on sustainable developing under the Canadian legal context). In the context of this dissertation, sustainable development refers to energy resource extraction in a manner that is as minimally harmful as possible to the natural environment. One way of addressing this complex question is to examine the mitigation component of EAs. Mitigation in its raw form is the alleviation of harmful effects. Thus, my research aims to evaluate the use of mitigation in EAs with the goal of developing practical improvements that enhance sustainability.

1.2 Relevance and novelty of this research: addressing the concept of mitigation in Environmental Assessments

In Canada, addressing the environmental damages of construction and operation activities of industrial projects is largely the responsibility of proponents (CEAA 2012; Singleton *et al*. 1999). As the rise of concern for healthy ecosystems leads to an increased public demand for environmental accountability (Mason 2001), developing projects in a more environmentally benevolent manner needs to be executed. The role of mitigation can be viewed as a tactical advantage for EA practitioners given the uncertain nature of EAs. For example, favoring ecosystem services over industrial desires during project design is one means of integrating sound mitigation (e.g. the provision of water and food, the regulation and feedback of climate, nutrient cycling, MEA 2005; SCEP 1970). In general, mitigation is viewed as the means to render a potentially degenerating situation favorable or at least neutral, and is portrayed in various industrial projects around the world most commonly: avoidance, reduction, enhancement and compensation (Ross 2001; Trussart *et al*. 2002). These approaches differ but share the same objective; to address the environmental problems associated with the transformation of natural hinterlands. They also form a hierarchy (see Figure 1.1) with effect avoidance as a preferred option and compensation as the last alternative (CEAA 2012; Demarchi 2001; Ross 2001; Singleton *et al*. 1999).

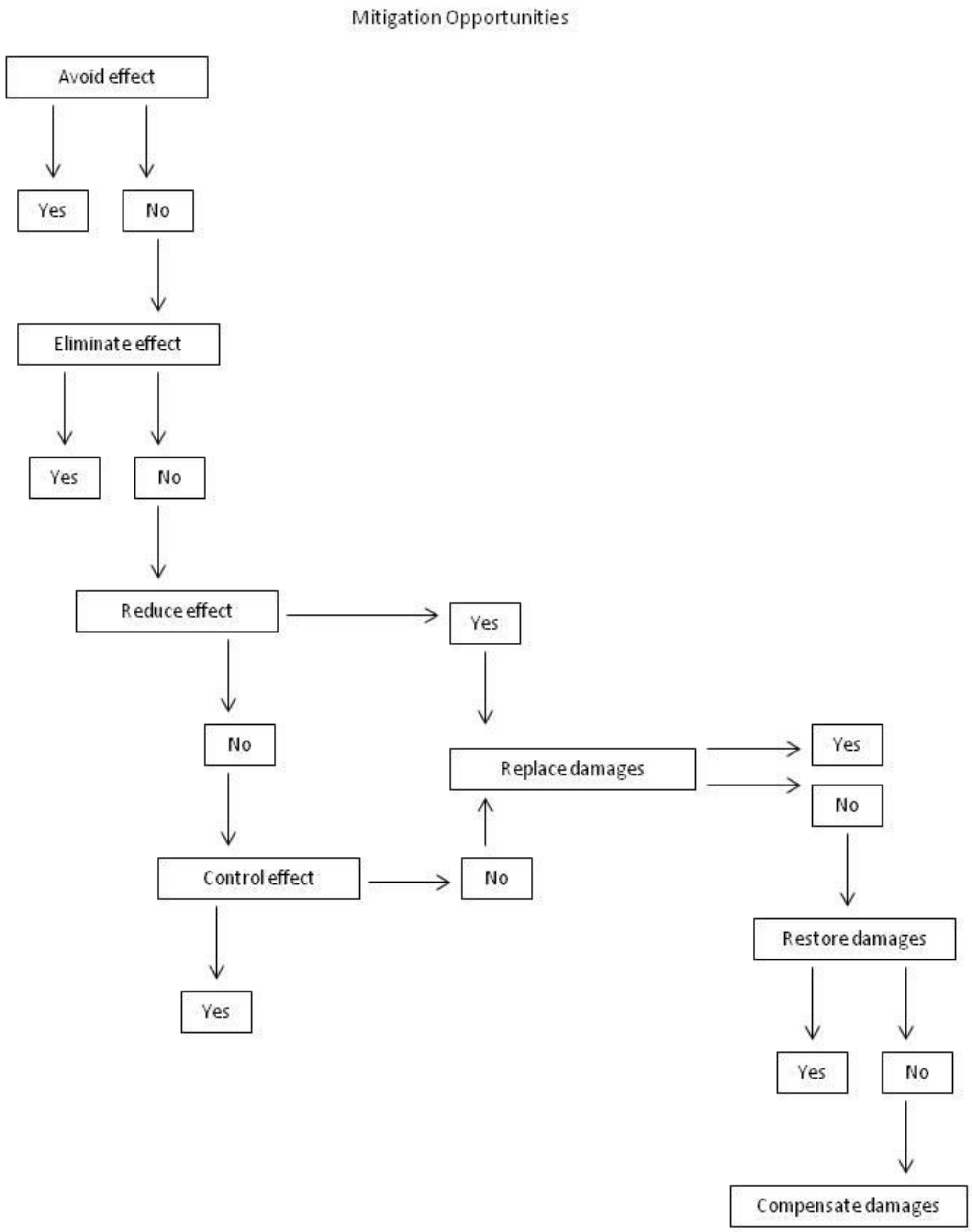

Figure 1.1: Hierarchy of mitigation opportunities. Designed and adapted based on CEAA (2012) text.

Avoidance refers to the intended actions that eliminate predicted adverse effects at the initial stages of project planning; reduction or control refers to those actions that address the origins of effects and seek to eliminate or minimize the magnitude of adversity. Restitution for damages is subsequently handled through various means: replace / restore refers to actions that reinstate or upgrade sites in an equal (or more) capacity prior to the disturbance of the original project. Compensation refers to those actions that counterweigh damages that cannot be avoided and/or are "residual environmental effects" after the project is operationalized (CEAA 2012; Ross 2001; Trussart *et al.* 2002). Mitigation herein is referred to undertakings that fall in any one of those categories.

Mitigation is used to protect components of the natural world yet the concept is not easily traced to any historical roots and likely only arose noticeably and formally during the latter half of the 20th century. The idea that ecosystem components have intrinsic values independent of human use and that they require unique and separate protection measures from industrial endeavours is apparent in documents from the 1950s (Bateman and Willis 2001). In subsequent decades, informal and premature EAs were created that attempted to address ecosystems in their entirety. Duinker and Greig (2005) argued that this informality resulted in a diluted understanding of adverse environmental effects from industrial activities. The popular VEC approach was borne in the early 1980s to allow mitigation practices to be more focused and effective. Nevertheless, the desired results of mitigation can still only be achieved as long as the whole environment is still addressed appropriately. The entire EA must include a comprehensive outlook that addresses the interrelationships among VECs (Beanlands and Duinker 1984; Szaro *et al.* 1998).

Using VECs to develop specific mitigation measures is a key practice in EA development (for example see recent Environmental Impact Statements online at CEAA 2012). However, the development of mitigation is often the result of brainstorming sessions where discussions are held behind closed doors, with or without the input of peer-reviewed and accepted evidence. Yet, mitigation offers a conceptual basis to offset foreseeable environmental effects and may save a proposed project. Since the first opportunity to mitigate effects is at the project planning stage; avoidance measures may not always be explicit as they can be embedded within the project design (see example Demarchi 2001). The remaining categories of mitigation are usually presented in relation to each VEC.

Mitigation of environmental effects affecting habitat, habitat connectivity, population mortality rates, and population health is assessed in terms of the criteria used for effects analysis, with the addition of level of significance (CEAA 2012; Benson 2003). Effects analysis is defined as "…a change that may be caused to the following components of the environment that are within the legislative authority of Parliament" (CEAA, 5. (1) (a) 2012). These components are further defined in the CEAA (2012) as fish and other aquatic species, migratory birds, and components listed in Schedule 2. Unfortunately, components in Schedule 2 remain incomplete at this time (June 2013). Previously, CEAA (1992) included change to wildlife and their habitat in the definition of effects analysis. Thus, defining "change" is a challenge currently addressed on an individual EA basis, perhaps due to limited guidance from the federal government. Moreover, no two projects are identical in space and time, which adds to the complexity of understanding "change". Noble (2006) outlined four possible spheres of change that a project can impose on the environment: biological, chemical, physical, and ecosystem. The definition of change within these four spheres in EAs is parallel to the discussion of significance and significance criteria since deviation from threshold values, qualitative or quantitative, is ultimately a change. CEAA's determination of significance reflects the systematic interface that is the result of the blend of scientific data, standards, ecological and social values, and expert opinion (CEAA 2012;

Lawrence 2003). According to CEAA (2012), the weight of significance is largely in favor of adverse change to ensure that the outcome of EAs demonstrates the range of cause and effect for any project.

The concept of significance and mitigation remains an ambiguous principle as it is based on designations that are subjectively established by EA practitioners (Benson 2003). These practitioners may have little to no background training in ecology or wildlife biology (see below for discussion of EA practitioners). For example, significance in an indicator species context can be defined as the level of change caused by an effect that alters a species' ability to maintain a viable population in a project's region (Hegmann *et al*. 1999). However, populations may be affected outside of a project's spatial extent due to the dynamics of animal dispersal and thus not considered appropriately in the original effects assessment. Other characterizations of significance include assessing the level of change in mortality, health, and habitat availability for a species - all of which can be contested in the EA process. In this dissertation, I will demonstrate that it is a lack of rigor that creates many challenges for EA practitioners to recommend appropriate mitigation approaches. I also uncover the trends of different mitigation uses in such flexible circumstances.

1.3 Central research questions

The following questions guided my overall research process. To what extent can mitigation through the Canadian EA process be strengthened to actively address wildlife in disturbed areas? Specifically, what do experts involved in the EA process think about the current status of mitigation development for wildlife? Based on this knowledge from experts, what improvements to mitigation practices in the EA process can be made to ensure Canada is on course for sustainable development?

1.4 Key terms

1.4.1 Wildlife mitigation

Mitigation used to offset effects from industrial development projects is hereafter and throughout this dissertation referred to as 'wildlife mitigation'. The shorthand version of 'wildlife mitigation' reflects the concept that programs are developed specifically to alleviate or offset effects from industrial development projects that affect wildlife species.

1.4.2 Decision-makers, EA practitioners, and mitigation experts

Crucial choices need to be made at every stage of the EA process, and it is important to identify the actors involved. In conventional terms, a "decision-maker" is an individual or group with the authority and/or responsibility to commit to action (Langley *et al*. 1995). As simple as this definition may be, a decision-maker is actually involved in a complex, multifaceted, and intricate process that is not always traceable. Numerous accounts of decision-making are described and analyzed in the literature (e.g. Keeney 1982; Langley *et al*. 1995; Silverman 1993). Most references indicate that each process is idiosyncratic based on context and perspective. Similarly, defining the decision-maker in the milieu of the EA process is a difficult task as it is based on an interpretation of the EA system. This interpretation can vary according to individual point of view, project need, responsible authority's objective, or even shifting economic, social, or biophysical priorities. Herein, I will present a characterization of the decision-maker based on experience, exposure, studying and analysis of the current EA system in Canada. Throughout my dissertation, however, I used the terms EA practitioner and wildlife mitigation expert as synonyms for decision-maker in their respective fields. Notably, an EA practitioner may be a wildlife mitigation expert and vice versa, but they are not mutually exclusive (see Figure 1.2).

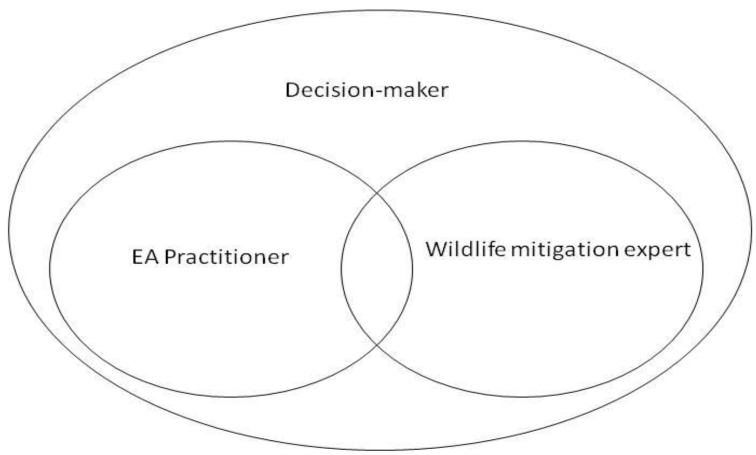

Figure 1.2: Relationship between titles of persons used throughout this dissertation. The Venn diagram shows synonymous and complimentary terms.

An accurate and diligent understanding of the requirements of the CEAA (2012) is necessary for a defensible execution of an EA. Usually it is the responsible authority that is commissioned to ensure all components of laws are adhered to in an EA, with the assistance of guiding principles derived from relevant governing policies. Specifically, a responsible authority is one or more representatives from government agencies with mandates specific to the nature of the project, who ensures the EA is executed, and who has the power to approve the project provided no significant adverse environmental effects will occur (CEAA 2012). For example, a waterways project might trigger delegates from Fisheries and Oceans Canada, Transport Canada, and Environment Canada depending on the nature and scope of the project. One of the tasks of the responsible authority in this waterways example is to ensure the project has justly calculated harmful, alteration, disruption, and destruction (HADD) losses to fish habitat according to the Policy for the Management of Fish Habitat (DFO 1986). It should be noted that responsible authorities are also referred to as ‘regulators’ by some EA practitioners.

Relating to the conventional definition of decision-maker, one might assume that the responsible authority is the ultimate decision-maker in the EA process since in essence the responsible authority can command a commitment to action. However, despite the directives of the responsible authorities, in Canada the execution of the EA still lies on the onus of the proponent (CEAA 2012). The proponent, defined in CEAA (2012), is the “person, body, federal authority or government that proposes the carrying out of a designated project”. The proponent is the entity with the vision and budget of carrying forth the project; the proponent will accomplish the project and in effect will commit and be held accountable for all related actions. In other words, the proponent is the decision-maker; however, only in a formal sense for the reasons outlined below.

Often, proponents do not have the in-house expertise to prepare an EA as per the specifications and demands of the CEAA (2012) and responsible authorities. Outsourcing has become a common practice where proponents will engage environmental consulting firms (e.g. Stantec Ltd, AMEC, Dillon Consulting Ltd.) with teams of specialists ranging from project managers, to environmental scientists, engineers, and Geographic Information System professionals. Often termed EA practitioners, the teams of specialists provide a range of services from project design, to biophysical analyses, and socioeconomic assessments to address the complex requirements of EAs. Although the EA details, data, and research remain the property of the proponent until publication on the public registry occurs, EA practitioners execute and prepare baseline information, produce draft and final versions of EAs and other related documents, and (when necessary) address public concerns. Thus, the success of EA practitioners in the execution of an EA to the final stage of completion relies largely on the communication between EA practitioners and the proponent (Federico 2005). For example, proposed projects through wetland habitats will likely necessitate a change in project design, if possible, to avoid excessive alterations of legally protected valuable wetland regions. In this example, the EA practitioners would inform the proponent of the legal constraints, identify the need for modification in the project design to develop appropriate solutions, and consider alternatives, in accordance with CEAA. However, a successful EA goes one step further: practitioners facilitate communication with the responsible authority to avoid unnecessary and unwelcome "surprises" (Federico 2005). Best EA practices include informing the responsible authorities ahead of time of the proposed project (also known as 'scoping') so that discussions and negotiations can begin with the intent of identifying alternatives and solutions to the original project design, particularly if adverse environmental effects are obvious (Alton and Underwood 2003; Federico 2005).

EA practitioners are tasked throughout the preparation of an EA with bridging the gap between established facts (presumed to be objective) and decisions that are largely subjective. The challenge for EA practitioners is not only to create a porthole into the process for the proponent, but also to acquire and present information in a comprehensible manner (Alton and Underwood 2003). EA practitioners must offer unbiased and accurate information to allow conclusions and resolutions that are timely, practical, legal, and scientifically reasonable (Alton and Underwood 2003). For example, Alton and Underwood (2003) discuss a common problem that can occur amongst EA negotiations that impede the timely completion of an EA: negotiations with regulators are halted due to debating scientific convictions in lieu of deliberating best criteria for decision-making. Thus, EA practitioners must prepare EAs in a manner that is not only inclusive of the best available data, but also in a manner that is comprehensible to an array of readers.

Over the years, the role of EA practitioners has strengthened due to the need for a multi-layered and profound understanding of the EA process. The role of EA practitioners has been crucial in a fundamental change in the EA process. The development of mitigation before a significance rating is assigned can be attributed to years of discussions amongst EA practitioners and responsible authorities (P. Trimper, pers. comm.). EA practitioners recognized that the reduction in the overall environmental footprint of a project is a key benefit of including mitigation as part of project design. When mitigation is included in the early stages of the EA process, protection and concern for the environment is an involuntary and permanent approach. Mitigation no longer appears as an afterthought, and instead emerges as an environmental image embedded in the blueprints of proposed projects. In an ideal EA world, the incorporation of mitigation at the design stage ultimately satisfies responsible authority requirements in a direct, candid, and immediate manner.

It is largely the engagement of decision-makers who are familiar with a broad range of successful and unsuccessful mitigation approaches (defined with respect to environmental sustainability) over the years that ultimately fuels the development of popular practices. Hence, I use the term wildlife mitigation expert in this dissertation, as someone who is not necessarily also an EA practitioner (Figure 1.1). The knowledge and experience of understanding how mitigation can work to alleviate environmental effects upon wildlife does not necessarily stem from working within the EA process. Mitigation knowledge and experience can be gained through years of scientific research and/or understanding anecdotal information from other fields (e.g. academic studies, government data, public accounts, Traditional Ecological Knowledge sources).

1.4.3 The Nalcor Energy Project

In Chapters 2 and 3, I used the Nalcor Energy project as a case study to apply the lessons learned from my research. Herein I provide the background information of the project. Nalcor Energy, a provincial corporation, is mandated to manage the energy resources for Newfoundland and Labrador on a long-term basis, with federal support from the Government of Canada (Nalcor Energy 2009). Nalcor Energy is developing the potential of several large-scale projects ranging from oil and gas to wind power including the generation and transmission of electrical power from the Lower Churchill Falls region of Labrador (see Figures 1.3 and 1.4).

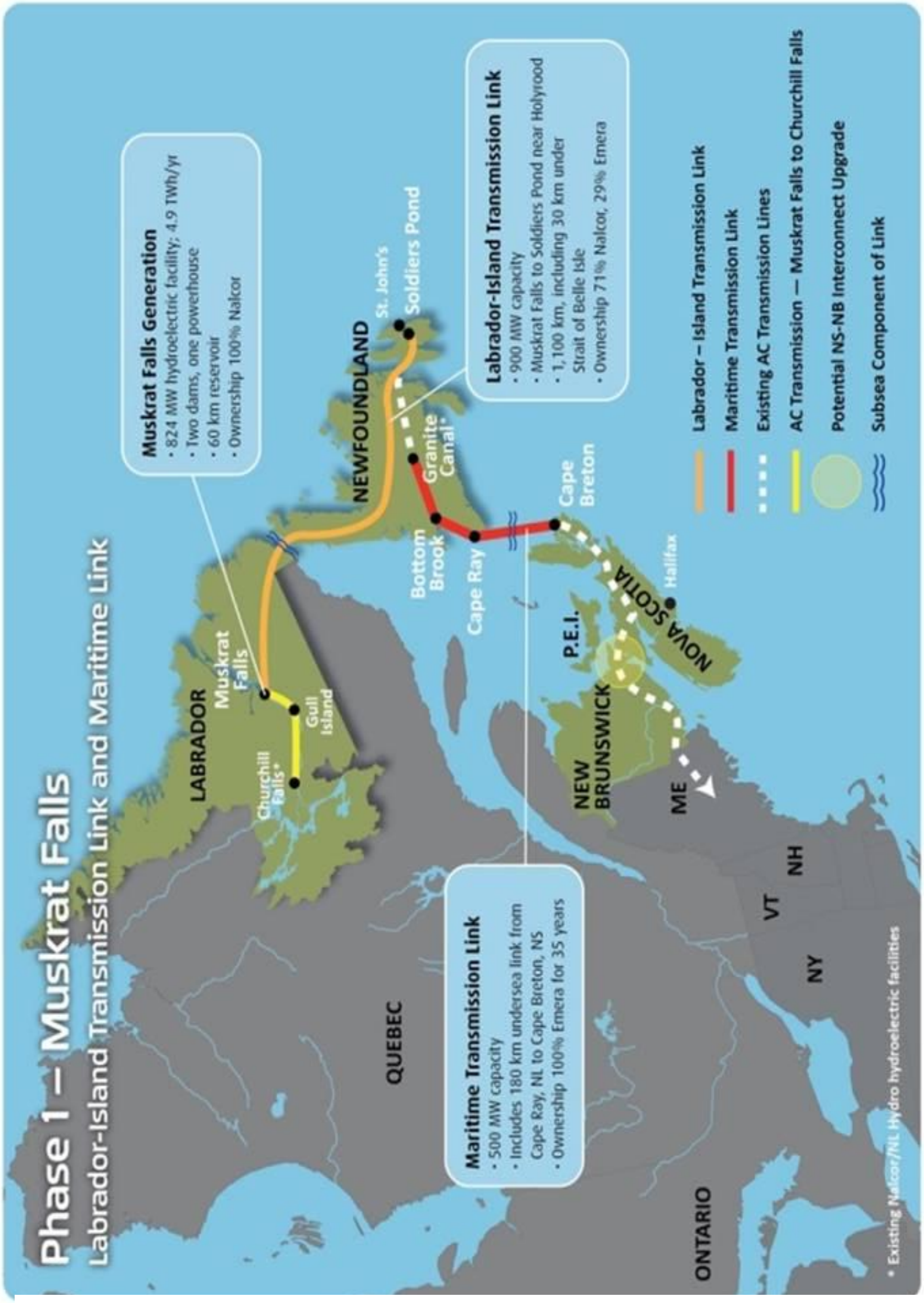

Figure 1.3: Phase 1 of the Lower Churchill Falls Hydroelectric Generation Project, Labrador. Reprinted with permission. Available at http://www.nalcorenergy.com/Lower-Churchill-Project.asp

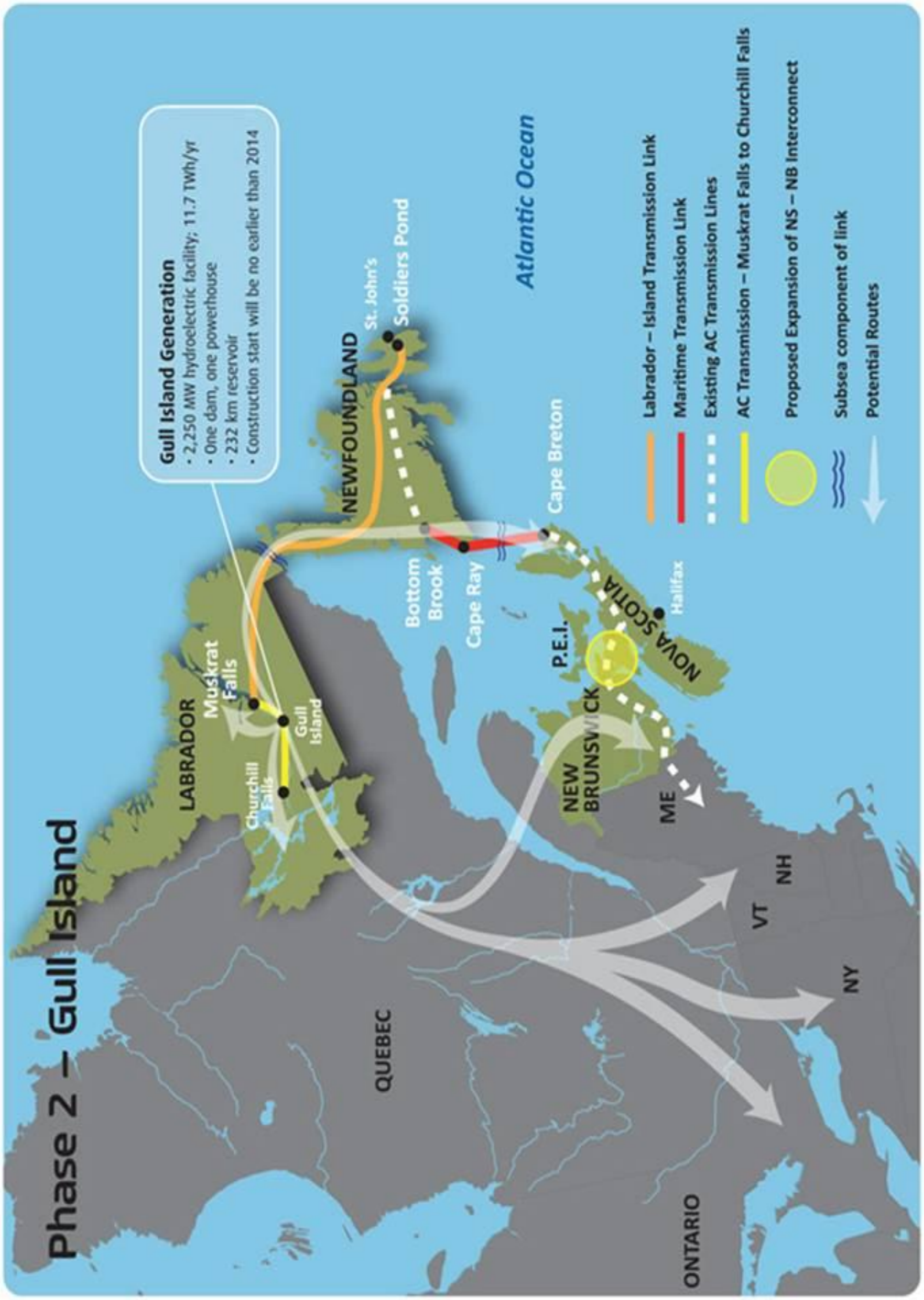

Figure 1.4: Phase 2 of the Lower Churchill Falls Hydroelectric Generation Project, Labrador. Reprinted with permission. Available at http://www.nalcorenergy.com/Lower-Churchill-Project.asp.

The existing Churchill Falls hydropower project is one of the world's largest powerhouses, yet the site is only generating 65% of its potential (Nalcor Energy 2009). The remaining 35% is expected to be developed through the operation of hydropower dams at Gull Island and Muskrat Falls and transmitted to Churchill Falls. The future development of Gull Island, Muskrat Falls, and the transmission corridor to Churchill Falls is known as the Lower Churchill Falls Hydroelectric Generation Project (referred to as Lower Churchill or the Project). The Environmental Impact Statement (EIS) for Lower Churchill was released as an Environmental Assessment by Nalcor Energy, February 2009. The EIS was created by Nalcor Energy's extensive team of specialists ranging from environmental consultants (e.g. Stantec Ltd, AMEC), engineers, socio-economic advisors, to scientists (including myself as team member on the project's black-bear study).

In Nalcor's EIS documents, key decision-makers (i.e., actual individual names) are not identified. Nalcor Energy's self-identification as one corporate proponent instead of one or more individuals complicates the task of accountability. The definition of 'corporation' allows Nalcor Energy to be portrayed on similar grounds as a named individual (Blumberg 1993). This premise of recognizing a corporation as one independent party creates difficulties for transparency and accountability since a corporation can undertake actions separate from the collective of executive officers, shareholders, and/or employees (Blumberg 1993). It remains almost impossible to pose a query to a corporate entity regarding a particular decision in the same manner as asking for clarification from a particular individual.

Nalcor Energy's EIS identified black bears as one of the Key Indicators (KI) for the Terrestrial Environment VEC. KIs and VECs were selected through a scoping process (see Kennedy and Ross [1992] for discussion on scoping) involving the Project's team members (Nalcor Energy 2009). Unfortunately, the black bear population in the region of the Lower

Churchill project is not well known and a high degree of uncertainty prevails surrounding the regional bear demographics. Despite the lack of information, there are no grounds for assuming an unhealthy (i.e., unstable and/or declining) black bear population is present in the region of the Lower Churchill Project.

Although four EAs exist for the Lower Churchill region, all with similar goals to the Project (Nalcor Energy 2009), there is a deficiency of local black bear population information to allow for a high level of confidence in effects analyses. In response, Nalcor Energy initiated an ecological study of black bears in the area involving a variety of sources of methodologies. A telemetry study on black bears was deployed as part of the environmental baseline characterization program (see section 2.4.6, Nalcor Energy 2009).

The technical report related to the baseline program, in concert with limited scientific sources specific to the region, provided the existing local biophysical and ecological information on black bears. Specifically, information related to: 1) habitat use, home range, translocated bears and homing, and denning were useful for input into habitat-based effect analyses; 2) population density, demographics and morphology, were useful for species assessment effect analyses; 3) food preferences were useful for diversity indices and biological assessments; and 4) mating and reproduction were useful for biological assessments. An additional reference included the publicly available research and supporting documents for the *Voisey's Bay Mine/Mill Environmental Impact Statement*, Labrador, located approximately 400 km northeast from the Project (JWEL 1997; VBNC 1997). The Voisey's Bay documents (JWEL 1997; VBNC 1997) supplemented the limited peer-reviewed published scientific sources (e.g. Chaulk *et al.* 2005; Veitch and Krizan 1996).

Using the biophysical information available, the black bear environmental effects assessment synthesis for the Lower Churchill EIS included a detailed description of project phase and activity. Phases and activities were separated in terms of construction activities, and operation maintenance activities (Nalcor Energy 2009). Pre- and post-impoundment were not described explicitly, but consideration of impacts before and after flooding were embedded in the environmental effects analysis. Each phase and activity was correlated with environmental effects criteria involving both temporal and spatial considerations: “nature, magnitude, geographic extent, duration/frequency, reversibility, ecological context, level and degree of certainty of knowledge, and likelihood” (Nalcor Energy 2009). Potential environmental effects of the Project upon the black bear population included: change in habitat, change in health, and mortality. Standard mitigation designs for the Terrestrial Environment Key Indicator included practices related to: site personnel and environmental awareness, surface disturbance, access roads, noise, rehabilitation following construction, blasting, construction camps – waste management, hazardous materials, quarries and borrow pits, and transmission line vegetation management. Additional mitigation designs specific to black bears included: food storage and waste management, personnel awareness and training, electric fencing, and other deterrent equipment implementation, black bear management decision process, and black bear surveillance prior to blasting events.

The adoption of mitigation measures allowed an evaluation of the residual environmental effects to proceed as not significant in the Nalcor Energy EIS (2009). However, exclusive methods for decision-making and criteria for success and failure of black bear mitigation options were not outlined in the EIS, even though specific Environmental Effects Management Measures were outlined for VECs (Nalcor Energy 2009). For example, in the areas associated with construction camp installation and operation, human-bear conflict reduction plans will be established. These conflict reduction plans will include education (e.g., bear awareness) and bear proofing (e.g., electric fences, warning devices, appropriate storage facilities and practices) to minimize the attractiveness of the site to black bears (Nalcor Energy 2009). Thresholds for success or failure of bear awareness programs were not listed as part of the mitigation program. Information needed to update and report on mitigation results was also not a requisite and was not listed in the EIS. Thus, it remains difficult to stipulate the successful use of mitigation options based on missing qualitative and quantitative characteristics of the measures of change for the Lower Churchill Project.

Decision-making, information requirement and data management of mitigation development under a high amount of uncertainty, as exemplified above for the Project, was explored in this dissertation. It is precisely the internal questions I had when working in the consulting industry that fueled my desire to examine the EA process in this dissertation. I considered the gaps in the knowledge base, the uncertainty behind assumptions of effects analyses, and the reliance on mitigation projects to be of upmost importance in suggesting minimum improvements to the EA process.

1.5 Research design

1.5.1 Methodology

My main goal in this research was to contribute to the discourse of improving mitigation in the Canadian EA process. My efforts to tackle this complex topic may be considered to be a mixed methods / applied research (Amaratunga *et al.* 2001) type methodology also found in other studies (e.g. Jones 1997). I used a positivist approach with quantitative methods to test several hypotheses regarding the use of mitigation (e.g. see Chapter 2) (Horna 1994), and I used a phenomenological approach with qualitative methods to understand trends in mitigation (e.g. Chapters 3 and 4) (Miles and Huberman 1994). Though some authors promoted the use of a single methodology (Miles and Huberman 1994; Yin 1994), others recognized the gains from using a combination of research methods (Das 1983; Fellows and Liu 1997; Rossman and Wilson 1991). Quantitative methods are useful in qualitative research since they can find patterns and address sample issues (e.g. outliers in data) (Amaratunga *et al.* 2001; Jayaratne 1993). Similarly, qualitative methods can help quantitative research by facilitating theoretical development (Amaratunga *et al.* 2001; Nau 1995).

In my research, I used quantitative methods in a descriptive analysis scheme to assess patterns of use of mitigation programs by experts. I used the results to characterize the groups of mitigation experts by occupation, and I applied statistical testing to validate the significance of patterns. These groups are then considered representative of the overall faction of individuals capable of exposing the reality behind mitigation practices. Subsequently, I applied qualitative methods to grasp the underlying themes, and I investigated points of view that are relevant to improving the status of mitigation in the Canadian EA process.

My research is also interdisciplinary as I integrated various bodies of knowledge such as natural sciences (e.g., ecology), environmental sciences (e.g., natural resource management), and applied environmental sciences (e.g., environmental assessment), with methods from business applications (e.g., SWOT analysis), social sciences (e.g., qualitative methods), and natural sciences (e.g., quantitative methods). Yet, Metzger and Zare (1999) offered a historical summary of the trend to favor distinct disciplinary research, which is evaluated by peer-reviewed publications. The peer-review process necessitated single-discipline departments to allow for specializations and expertise to develop among researchers (Metzger and Zare 1999; Rhoten and Parker 2004). Metzger and Zare (1999) described some emerging problems that may be alleviated with interdisciplinary research: narrow perspectives can result in impractical solutions, and separated fields can result in failed projects. Thus, interdisciplinary research can offer an integration of perspectives that allows for the creation of innovative, practical, and pragmatic solutions.

The problems I addressed in this research are by nature interdisciplinary as they involve perspectives from environmental sustainability in contrast with industrial energy development. Environmental sustainability derives from fields of biology, ecology, conservation and protection; whereas, industrial energy development derives from fields of economics, socio-economics, and commercial trade. The EA process is a supposed bridge between these major disciplines. Thus, my research focused on mitigation approaches for wildlife, which necessitates drawing from multiple perspectives. For example, I relied on expert interviews from different occupation groups: environmental consultants, government departments, and academic researchers.

1.5.2 Methods and analyses

Though other work exists on the concepts and inner workings of wildlife mitigation (e.g. Clevenger *et al.* 2001; Clevenger and Wierzchowski 2001; Foster and Humphrey 1995), to date there have been no empirical studies that address the "*hows"* of developing good decision-making specific to wildlife mitigation in relation to industrial projects. Limited explicit development of wildlife mitigation exists in the peer-reviewed and gray literature, yet this practice is performed given that mitigation programs are supposedly operational in projects approved by the EA process. Through the use of a mixed-methods research approach, including qualitative and exploratory techniques (see Cresswell 2009); I aimed to fill the gap of empirical studies relating mitigation and decision-making, to direct my central research question. Though my research looked to uncover expert opinion on wildlife mitigation, I also looked to inform the overarching policy directive in this area for EAs in Canada. The exploratory nature of the research was to identify variables used in applying mitigation and to isolate key relationships among the variables. Through this exploration, my goal was to ultimately develop stratagem for informing and improving Canadian EA practices.

The quantitative component of my research identified significant relationships between use of mitigation by experts in their respective occupation groups. Table 1.1 provides a list of mitigation programs referred to throughout this dissertation. I also examined experts' perceptions on the success of these different mitigation programs in Table 1.1. To achieve this, I organized my data from the experts' interviews for statistical analysis and processed the data in search for patterns.

Table 1.1: Definition of mitigation programs.

Mitigation Program	Definition	Example
Education and outreach	Programs created to raise awareness, inform, and teach proper human behaviour for the sake of safety and animal welfare, including removal of attractants.	Bear Wise program in Ontario, Bear Smart program in British Columbia. Specific animal safety training for employees.
Wildlife habitat enhancement	Specific designs to provide wildlife with quality habitat for any of the stages of their life cycle including foraging opportunities.	Creation of native plant communities to establish corridors to encourage animal movement.
Wildlife habitat replacement	Specific designs to create similar habitat for wildlife in another area from the original site affected by a project.	Decommission of an old industrial site and replacement with native plant communities.
Translocation	Capture and transport of an individual animal from the original site to an area not known to be part of his/her home range. Translocation (versus relocation) considers the animal's movement to be a permanent solution. Relocation is considered temporary as the new site is within the home range.	Capture of a bear and release outside of its home range.
Aversive conditioning	Continuous and consistent application of hazing agents used to teach an animal to avoid areas or cease an action.	Use of rubber bullets to chase bears from an area such as a garbage dump, or as it exits a trap.
Deterrents	Agents of aversive conditioning used to cause pain or irritation to an animal.	Rubber bullets, batons, bean bags, dogs, electric fencing.
Zoning/mapping for human associated structures	Charting specific areas for human-use.	Camp site selection and establishment as bear safe zone.
Zoning/mapping for wildlife	Charting specific areas for wildlife-use.	Denning site mapping, roadways.
Temporal plans and modifications	Managing human-use levels around important areas for wildlife. Closures of areas where wildlife-human conflict may arise.	Flooding/impoundment times to protect specific species. Road closed due to bear guarding carcass.
Conservation and protection	Establishing areas as preserves for wildlife. Establishing policies, or guidelines for the benefit of wildlife.	Protected areas, buffer zones, no hunting activities.
Fiscal compensation	The compensation principle follows that no net loss of habitat, natural processes, or biodiversity occurs.	Funds granted to conservation organizations for the benefit of wildlife, e.g. *DFO HADD policy.

* Department of Fisheries and Oceans (DFO). 1998. Decision Framework for the Determination of Harmful Alteration, Disruption or Destruction of Fish Habitat. 22pp.

I used two different qualitative methods and analyses in my research. The first method involves a Strengths, Weakness, Opportunities, and Threats (SWOT) analysis, which is a useful systematic tool for assessing weighted strategies (Pickton and Wright 1998). Rare in a natural resource management context, yet popular in business applications (e.g. Dyson 2004; Jackson *et al.* 2003), the SWOT analysis provides a framework through which risks and opportunities can be identified. Granted that many SWOT analyses can be subjective, adding justification for components used in resulting matrices helps increase the overall validity and reliability of the analysis. I provided these justifications, and I used the matrices to select the best strategies in a methodical manner.

The second qualitative component of my research reduces the data from wildlife mitigation experts' knowledge into a conceptual framework. To achieve data reduction (Miles and Huberman 1994), I followed the process of narrowing, selecting, focusing, and condensing the digital transcripts of interviews with experts into summaries, memos, codes, and themes. I reduced the data on a continuing basis as I completed transcripts. I followed an inductive and iterative process to allow me to identify appropriate themes, as suggested by many qualitative method authors (e.g. Patton 2002; Strass and Corbin 1998; Thomas 2006). I interpreted the data by looking for common patterns of agreement as well as patterns of contradictions, and I reformulated the themes as needed. This cyclical process formed the overall qualitative method of analysis activity that I followed (Miles and Huberman 1994).

1.6 Structure of the dissertation

The next chapters of this dissertation are independent from one another in the sense that they were written for the purposes of publication as journal articles, with the exception of the final chapter. Chapter 2 is a quantitative analysis of wildlife mitigation experts' knowledge. Chapter 3 is a breakdown of a spatial tool commonly used in ecology, which may be useful in mitigation applications. Chapter 4 is a policy guideline based on qualitative data from wildlife mitigation experts. And chapter 5 is a final chapter that provides concluding remarks to the dissertation. Below, I give a brief explanation of each chapter.

1.6.1 Chapter 2: Expert opinion on the use and success of wildlife mitigation in the Canadian Environmental Assessment process.

In this chapter, I presented a qualitative method of inquiry; an expert-based opinion study adopted to understand the use of different mitigation programs in relation to their perceived success (see Appendix A for the survey and interview questions). An expert-based study is useful for unearthing "hows" and "whys". For example, Eisenhardt (1989) and Yin (1994) applied it widely to gather information in research settings where the investigator has little to no control over settings and outcomes. The expert-based opinion analysis in this chapter detects patterns of mitigation program use, and I separated them according to the occupation group of each expert. This method allowed me to formulate propositions regarding the overall findings and their relationships to one another (Yin 1994).

Three main research objectives directed this chapter: 1) to unearth which mitigation program is relied upon given a specific context; 2) to develop an overall image of the success of different mitigation programs; and 3) to unearth the patterns of utility of mitigation. Subsequently, I used the results of my analysis to tabulate a basic design of patterns in the format of a matrix. I then applied this matrix in an academic exercise to the Lower Churchill Project.

1.6.2 Chapter 3: An exploration of the relationship between telemetry and wildlife mitigation in the context of Environmental Assessments.

The flexibility in the use of tools for biophysical assessments is relatively high; yet there are no guidelines or recommendations from regulatory bodies as to which ones to employ to acquire information relating to effects and subsequent mitigation. The telemetry analysis literature is an extensive collection of studies demonstrating various and often complex methods and programs (e.g. Gautestad *et al.* 1998; Horne *et al*. 2007; Hurlbert and French 2001; Moser and Garton 2007) and it is easy to have more questions than answers after reviewing the multitude of papers. For example, home range estimate sources (e.g. Girard *et al*. 2002; Manly *et al*. 1993; Smith and Schaefer 2002) can be quite mathematical and demonstrate a wide range of variables, which makes it relatively difficult to decide on the most appropriate method that is ecologically, academically, professionally, and editorially acceptable. In this chapter, I inquire about the dimensions of mitigation that can be achieved with telemetry. Specifically, the dimensions that I investigate are magnitude, reliability, and adaptability as an academic exercise to evaluate the utility of telemetry under the EA context.

Nalcor Energy (2009) had deployed eight telemetry collars on black bears of the Lower Churchill region. Considering the Lower Churchill Project, this chapter investigates how habitat models supported by the use of limited telemetry (i.e., small sample size) inform mitigation for large-scale projects. Through the use of a Strengths, Weaknesses, Opportunities, and Threats (SWOT) matrix (following Pickton and Wright (1998), and Weihrich (1982)), I evaluate the overall use of telemetry as a tool for mitigation development in the EA process and specific to the Lower Churchill Project.

1.6.3 Chapter 4: Using qualitative interview data to improve wildlife mitigation policy in Canada.

Currently, species-specific wildlife mitigation policy is incomplete at the federal level in Canada. The need for a strategic approach is demonstrable in the sense that EA practitioners must single-handedly interpret the CEAA for proponents without reference to a set of standards. Similar to the intentions of the Habitat Policy under Fisheries and Oceans Canada (DFO 1986) that alleviates pressure surrounding the mysteries of mitigating damage to fish habitat, a prevailing document or set of guidelines can work to stimulate immediate attention to the disturbance of wildlife habitat due to development projects. In this chapter, I used qualitative data from interviews to demonstrate the current challenges that wildlife mitigation experts face in the realm of mitigation development (see Appendix A for the survey and interview questions). I demonstrated common frustrations, gaps, and criticisms from experts, and I suggested options for implementation to overcome obstacles. Thus, this chapter serves as a guiding policy paper for improving the status of mitigation in the Canadian EA process.

1.6.4 Chapter 5: Conclusion.

I concluded my dissertation with this chapter. I provided a synthesis of my findings, and I discussed the overall contributions that my dissertation makes. Finally, I presented thoughts for direction for future research. In summary, my dissertation seeks to understand current mitigation practices under the Canadian EA process. Despite the inherent complexity involved in studying such an ambiguous topic, the mixed methods approach allowed me to dissect important aspects for analysis, which has proven quite fruitful in challenging the current and relatively inadequate EA system.

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Chapter 1 Appendix A: Survey and interview questions

Wildlife Mitigation Study – Questionnaire

Expert Profiling

Please note all names, position, and professional affiliations will be kept confidential.

Informed Consent:

Hello, my name is Sandra Elvin. I am a graduate student in the Faculty of Environmental Studies at York University, Toronto. I am conducting a study that will look at environmental mitigation for wildlife in industrial projects.

I am doing this research as part of my doctorate graduate studies and I will be conducting interviews as part of my data collection as the basis for my thesis. I may also use this information in articles that might be published, as well as in academic presentations.

Participation should take about 20 minutes of your time and participation is on a purely voluntary basis. You will be asked to answer a series of questions in relation to wildlife mitigation. There are no foreseeable risks to participation as I will keep all the data in aggregate form and individuals will not be identifiable. I will not use your name in my writing, and I will only write about groups of people based on their field.

If at any time and for any reason, you would prefer not to answer any questions, please feel free not to. If at any time you would like to stop participating, please tell me. We can take a break, stop and continue at a later date, or stop altogether. If you choose to stop halfway, I will destroy all previous answers and records.

I would like to record this interview so as to make sure that I remember accurately all the information you provide. I will keep these files in their original format and they will be stored only for the duration of my dissertation research. They will only be used by myself for coding purposes. I will permanently delete all media files from this research upon graduation. Please let me know if you prefer to participate without being recorded. I would also like to let you know that this research has been reviewed and approved by the research ethics protocols by the Human Participants Review Subcommittee of York University. For more information, the Faculty of Environmental Studies can be reached at (416) 736 2100 or the Office of Research Ethics can be reached at (416) 736 5914.

Do you have any questions or concerns you would like to discuss now? If you have questions later, you may contact me directly at 647 261 0430 or selvin@yorku.ca.

1) Do you agree to participate in the survey? It should only take approximately 20-30 minutes.

Yes or No

2) Would you be able to recommend anyone that might be a good person to include in this survey?

3) Which of the following most closely matches your occupation?
Government employee
Academic
Environmental consultant
Industry employee
Other (please indicate):

4) Do you have experience with black bears? Yes or No

5) Do you have experience with large-scale industrial projects? Yes or No

6) Do you experience with hydroelectric projects? Yes or No

7) Do you have experience with the EA process? Yes or No

8) Do you have experience with the Canadian EA process? Yes or No

9) Are you a decision-maker for mitigation? Yes or No

Part I – Open ended questions

1. How would you define mitigation?

2. How do you decide to use different mitigation programs (e.g. any specific processes you use to select appropriate mitigation programs? Any needs you are hoping to fill?)

3. How is the implemented mitigation program kept up to date?

4. Would you agree that current mitigation programs are beneficial to the overall EA process? In other words, would you agree that the use of mitigation furthers the goals of the EA process? How so?

5. For projects specifically involving [black] bears, what mechanisms are in place to determine if bears are benefitting from the mitigation programs?

Part II – Structured responses

Please indicate the extent to which the following statements are applicable. *Frequently* refers to almost 100% of the time, *sometimes* refers to approximately 50% of the time, and *never* refers to 0% of the time.

1) I choose this mitigation program when I am **uncertain of the status of the wildlife population** (please answer for each).

Mitigation program	***Frequently***	***Sometimes***	***Never***
Education and outreach			
Wildlife habitat enhancement			
Wildlife habitat replacement			
Translocation			
Aversive conditioning			
Deterrents			
Zoning/ mapping for human associated structures			
Zoning/mapping for wildlife			
Temporal plans and modifications			
Conservation and protection			
Fiscal compensation			
Other (please indicate) (1):			
Other (please indicate) (2):			

2) I choose this mitigation program when I am **uncertain with respect to project impacts** (please answer for each).

Mitigation program	***Frequently***	***Sometimes***	***Never***
Education and outreach			
Wildlife habitat enhancement			
Wildlife habitat replacement			
Translocation			
Aversive conditioning			
Deterrents			
Zoning/ mapping for human associated structures			
Zoning/mapping for wildlife			
Temporal plans and modifications			
Conservation and protection			
Fiscal compensation			
Other (please indicate) (1):			
Other (please indicate) (2):			

3) I choose this mitigation program **due to my familiarity with its implementation**.

Mitigation program	***Frequently***	***Sometimes***	***Never***
Education and outreach			
Wildlife habitat enhancement			
Wildlife habitat replacement			
Translocation			
Aversive conditioning			
Deterrents			
Zoning/ mapping for human associated structures			
Zoning/mapping for wildlife			
Temporal plans and modifications			
Conservation and protection			
Fiscal compensation			
Other (please indicate) (1):			
Other (please indicate) (2):			

4) I choose this mitigation program when **faced with budget limitations**.

Mitigation program	***Frequently***	***Sometimes***	***Never***
Education and outreach			
Wildlife habitat enhancement			
Wildlife habitat replacement			
Translocation			
Aversive conditioning			
Deterrents			
Zoning/ mapping for human associated structures			
Zoning/mapping for wildlife			
Temporal plans and modifications			
Conservation and protection			
Fiscal compensation			
Other (please indicate) (1):			
Other (please indicate) (2):			

Please indicate the extent to which you agree with the following statement.

5) How successful do you consider each wildlife mitigation program to be in relation to reducing or offsetting project impacts?

Mitigation program	***Definitely successful***	***Successful***	***Partly successful***	***Unsuccessful***	***Definitely unsuccessful***	***Don't know***
Education and outreach						
Wildlife habitat enhancement						
Wildlife habitat replacement						
Translocation						
Aversive conditioning						
Deterrents						
Zoning/ mapping for human associated structures						
Zoning/mapping for wildlife						
Temporal plans and modifications						
Conservation and protection						
Fiscal compensation						
Other (please indicate) (1):						
Other (please indicate) (2):						

Closing:
I thank you for your time and your valuable input. Your name and project affiliations will be kept confidential.

1) If I need to follow up on any of the above information, may I call you again? Yes or No

2) Do you have any additional comments or information you would like to provide before we sign off?

Chapter 2.0: Expert opinion on the use and success of wildlife mitigation programs in the Canadian Environmental Assessment process.

2.1 Introduction

The link between proactive implementation of environmental sustainability practices and industrial development is difficult one. Experts in several professions may find themselves isolated as they attempt to balance environmental and industrial needs through Environmental Assessments (EAs). Generally, an EA is a planning and decision-making tool through which environmental (ecological and socio-economic) sustainability is encouraged as economic and industrial gains are proposed and promoted (Glasson *et al.* 1999; Mandelik *et al* 2005). Although the EA process is designed to avoid adverse effects of projects, in reality EAs are used to mitigate and sometimes just to compensate for adverse effects (Galbraith *et al.* 2007). Mitigation programs have thus become major and essential components of EAs as they are implemented to avoid, reduce, or remedy specific effects identified in projects. Rundcrantz and Skärbäck (2003, p.206) defined mitigation in terms of a limitation or reduction of "the degree, extent, magnitude or duration of adverse impacts", whereas Treweek (1999) suggested mitigation can be measures that influence the cause of impacts or reduce the extent of exposure from them.

The main challenge for experts (see Krueger *et al.* 2012 for 'expert' discussion) is the selection of mitigation programs to offset adverse environmental effects from industrial projects. Mitigation program development usually elicits creativity and resourcefulness as EA practitioners seek to steer the overall industrial development process in a way that promotes ecosystem services and socio-economic conditions, while extracting natural resources in the least harmful yet economically feasible manner (McDonald and Brown 1995). Though several reviews of wildlife mitigation philosophy, hierarchy, and guidance exist (e.g. BC 2010; Bradshaw *et al.* 1997; Clevenger and Waltho 2000, 2005; Fisheries and Oceans Canada 2001, 2010; Glista *et al.* 2009), these studies do not discuss the contexts of decision-making when choosing mitigation programs. It is important to understand the success or perceived success of mitigation programs that experts rely upon in their decision-making so that future decisions can be guided towards sustainability.

Selecting mitigation programs to offset adverse environmental impacts of large-scale industrial projects is a delicate procedure simply because of the potential for error (e.g. Bailey *et al.* 2000; Forman *et al.* 2003; Glista *et al.* 2009; Northrup and Wittemyer 2013; Mills and Clark 2001). Though many EA practitioners are faced with this task at various stages throughout the EA process, two main stages are recognized (Greer and Som 2010; Kiesecker *et al.* 2010). The first stage is pre-EA write-up and this type of mitigation is directly embedded in project design. The second stage is the EA write-up. This type of mitigation is laid out in a systematic format with significance levels and residual effects noted (e.g. Nalcor 2009). Though it is difficult to bring to the surface the mitigation programs that have been integrated in project plans (Slotterback 2008), here I do not differentiate between the selections of mitigation at both crucial stages. Selection of mitigation occurs by those able to influence the choice of which mitigation program is considered appropriate to alleviate adverse effects. These influential individuals are usually within one of three occupation groups involved in the EA process: environmental consultants, government personnel, or academic or environmental non-government personnel (ENGO). Environmental consultants are often hired by project proponents to conduct the EA. Government personnel can be either the regulators responsible for approving proposed EAs, or often times, government projects trigger the EA process. In these latter situations, government personnel are essentially the proponent and can be directly involved in drafting EAs. Academics or ENGO personnel often have an alternative agenda from large-scale project proponents that may lean towards advocacy for change and sustainable development. Experts from all three occupation groups can be formally or informally involved in mitigation selection at any point throughout the EA process.

In this paper, I investigated the selection of mitigation programs by EA experts in all three occupation groups. My objective was to assess the frequency of use of 11 different mitigation programs related to wildlife: education and outreach, wildlife habitat enhancement, wildlife habitat replacement, translocation, aversive conditioning, deterrents, zoning and mapping for human-associated structures, zoning and mapping for wildlife, temporal plans and modifications, conservation and protection, and fiscal compensation. These 11 programs were chosen based on published literature (e.g. Arnett *et al*. 2010; Corlatti *et al*. 2009; Fisher and Lindenmayer 2000; Glista *et al*. 2009; Jarnevich and Laubhan 2011; Weber and Allen 2010), published EAs, personal experience and discussions with EA experts. I investigated the use of these mitigation programs under four contexts often encountered by EA practitioners: 1) uncertainty with respect to the status of the wildlife population, 2) uncertainty with respect to project effects, 3) familiarity with each program, and 4) budget limitations. Finally, I assessed the success of the 11 mitigation programs as perceived by each individual within their occupation group.

I hypothesized that differences exist among occupational groups (i.e., environmental consultants, government personnel, or academics or ENGOs) in their reliance on mitigation programs for bears due to the specific pressures and goals associated with each role that may influence their selection. I also hypothesized a positive relationship between frequencies of use of each mitigation program and their respective success scores (obtained in interviews). In other words, I expected that mitigation programs deemed successful would be used more often. Finally, I used information gathered from interviews to develop a strategic matrix that provides easy access to recommendations for future mitigation. I demonstrated how the strategic matrix might be applied to a real-world example, the Lower Churchill Falls Hydroelectric Project Environmental Impact Statement submitted by Nalcor Energy (2009) (herein referred to as the Nalcor Project).

2.1.1Background on the Nalcor Project

Proposed and established hydroelectric development projects have a complex environmental management history in Canada, and many of which are still pending controversial issues (e.g. proposed Rupert River project, Quebec; proposed Saskatchewan River project, Saskatchewan; established James Bay hydroelectric projects, Quebec; established Nelson River hydroelectric projects, Manitoba). Baseline ecological studies conducted by proponents or consultants to proponents have steered the environmental management programs for the energy development projects. Many of these studies are not published in the peer-reviewed literature, and may contain a large amount of uncertainty. Correspondingly, the Nalcor Project, Labrador, is facing a similar set of circumstances. The Government of Newfoundland and Labrador together with Newfoundland and Labrador Hydro (NLH) is seeking to develop large-scale hydroelectric resources in the Lower Churchill Falls area (NLH 2006b, Nalcor 2009). The Project is currently seeking approval in the EA process, and many ecological studies were conducted under the Nalcor name (NLH 2006; Nalcor Energy 2009).

As per EA legislation, all ecological and socio-economic potential impacts are considered including the potential environmental effects on the resident black bear (*Ursus americanus*). A less than complete understanding is prevalent surrounding the existing demographics of the local black bear population. There exists a gap in the knowledge regarding the ecological relationships linking local biological processes and black bear population trends for the Labrador region.

Garshelis (2002) provides a valuable summary of misunderstandings and fallacies concerning bear populations. These large pockets of uncertainty extend to the overall information gap of the sustainability of the black bear population in relation to the Nalcor Project. The current status of the black bear population and associated habitats fluctuates from one region to another throughout North America; some black bear populations are considered to be at healthy limits of abundance (e.g. Williamson 2002), while others have experienced sizeable declines through loss of habitat and/or over-harvesting (Servheen *et al* 1999). The demand for a high level of understanding of the black bear demographics in the Lower Churchill region is necessary since inevitable negative influences leading to population declines may occur as a result of the Project. These adverse effects may be due to habitat loss, irreversible habitat change, direct mortality events, or change in health, which all need appropriate approaches to natural resource management. Thus, as an academic experiment, I applied the strategic matrix results from expert interviews on wildlife mitigation to the Nalcor Project in an effort to suggest appropriate mitigation options.

2.2 Methods

2.2.1 Sampling and data collection

I solicited experts on the basis of specialized backgrounds in wildlife mitigation and more specifically American black bear (*Ursus americanus*) ecology. I found pools of experts within federal and provincial government databases, environmental consulting firms, and professional organizations (e.g., International Association for Bear Research and Management). I sent 222 emails to prospective experts, and I conducted 49 interviews by telephone over the period of August 2011 to August 2012. The individuals who responded were assumed to be representative of the total group of potential experts. I held the sole digital copies of the interviews, and I maintained confidentiality of the identities of interviewers.

I collected demographics for each expert, which consisted of seven questions. The first question required experts to identify their occupation, which was scored as follows: environmental consultant = C, government employee = G, or other = O (academic or environmental non-government organization). If an expert identified two occupations, I held further discussions to identify the expert's primary occupation. The following scores applied to questions 2 through 6: (1) experience with black bears: yes = 1, no = 0, (2) experience with large-scale industrial projects: yes = 1, no = 0; (3) experience with hydroelectric projects, yes = 1, no = 0; (4) experience with the Canadian EA process, yes = 1, no = 0; (5) decision-maker for mitigation, yes = 1, no = 0. The sums of scores were calculated. A high score thus indicated a wider range of experience to a maximum of five.

The survey involved five questions relating the use of different mitigation programs under different contexts. Questions 1 through 4 were context based and required experts to select which mitigation program they were likely to apply given: 1) uncertainty with respect to wildlife population status; 2) uncertainty with respect to project effects; 3) relative familiarity with mitigation programs; and/or 4) budget limitations. Possible answers to questions 1 through 4 were "frequently", "sometimes", and "never". Frequency of choice was scored as follows: "frequently" = 75.5% of time, "sometimes" = 25.5% of time, and "never" = 0.5% of time. A higher score thus indicated a higher rate of use of that particular mitigation program under the specific context. Question 5 involved the relative success of each proposed mitigation program; possible answers ranged from "definitely successful" to "definitely unsuccessful", with a "don't know" option. Success was scored on a 5-point scale, with "definitely successful" = 4, "successful" = 3, "partly successful" = 2, "unsuccessful" = 1, "definitely unsuccessful" = 0. A high score thus indicated a positive viewpoint about the success of the mitigation program in offsetting environmental effects of industrial projects. For all questions, a lack of response was classified as No Reply (N).

2.2.2 Analyses

I conducted analyses using SigmaPlot (version 11.0, Systat Software, Inc., San Jose, CA) and SPSS (version 20.0, IBM Corp Armonk, NY.). I calculated mean values for the frequency of use of each mitigation program for all five survey questions. To incorporate the experience level of each expert, I weighted success scores from question 5 (relative success) with expert experience to reflect a more realistic point of view of relative success of each mitigation program. In other words, results from more experienced individuals counted for more in the results than those with less experience.

I used 2-way analysis of variance (ANOVA) to detect differences concerning selection of mitigation programs (11 types) among expert groups (3 types), followed by Holm-Sidak's multiple comparisons test (Zar 2009). I plotted residuals to assess normality of data (see Chapter 2 Appendix A).

I performed a chi-square analysis using Fisher's exact test for each question to test for independence of responses among the occupation groups (Zar 2009). My null hypothesis was that the relative frequencies are the same for all occupation groups, which remained the same for all questions. My alternate hypothesis was that there is a significant difference among occupation groups under the different contexts of the questions posed. To execute these tests, I treated responses as categorical variables.

To develop a strategic matrix (e.g. Naylor 1983) for future application, I plotted frequency of use of each mitigation program against weighted success score for each question. I viewed these plots in two ways: overall and individual occupation group. I designed a matrix based on rankings of each mitigation program according to weighted success and expert group, and presented results according to the context of each question.

For all statistical results, was required to determine significance.

2.3 Results

2.3.1 Expert profiles

Table 2.1 displays the expert characteristics based on experience profiles. Average profile scores overall were high for experience with large-scale industrial projects (96% of respondents), experience with the Canadian EA process (88%), experience with black bears (86%), and decision-maker for mitigation programs (86%). The average profile score overall was lower for experience with hydroelectric projects (57%). Within each occupation group, high profile scores differed slightly among the categories but experience with hydroelectric projects varied the most among the groups; decision-making had the second greatest variability (Table 2.1).

Table 2.2: Summary of profiles of interviewed experts with knowledge of wildlife mitigation in Canada.

	Occupation Group			
Experience category	Overall N = 49 *n* (%)	Environmental Consultant N = 18 *n* (%)	Government N = 19 *n* (%)	Other (Academic and ENGO) N = 12 *n* (%)
Black bears	42 (86)	16 (89)	16 (84)	10 (83)
Large-scale industrial projects	47 (96)	18 (100)	18 (95)	11 (92)
Hydroelectric projects	28 (57)	13 (72)	11 (58)	4 (33)
CEAA	43 (88)	17 (94)	16 (84)	10 (83)
Decision-maker for mitigation	42 (86)	17 (94)	16 (84)	9 (75)

2.3.2 Choice of mitigation program when faced with uncertainty with respect to the status of the wildlife population

Overall, the preferred mitigation program choice when the status of the wildlife population was uncertain was ‘zoning and mapping for wildlife’ (average frequency of use was 57.8%) (Figure 2.1). Although the frequency of responses of the different occupation groups were different (Fisher exact test, $P = 0.031$), the effect of different types of occupation did not depend on the type of program (two-way ANOVA, $F_{[20]} = 0.753$, $P = 0.770$). Also, the differences in mean values among the different occupation groups was significant (two-way ANOVA, $F_{[2]} = 7.443$, $P = <0.001$). Specifically, the choices of mitigation program when faced with uncertainty with respect to wildlife status were significant between consultant versus government ($P < 0.001$) and consultant versus academic/ENGO ($P = 0.004$). However, academic/ENGO versus government was not significant ($P = 0.842$). Also, the differences in mean values among the types of mitigation program was significant (two-way ANOVA, $F_{[10]} = 18.142$, $P <0.001$).

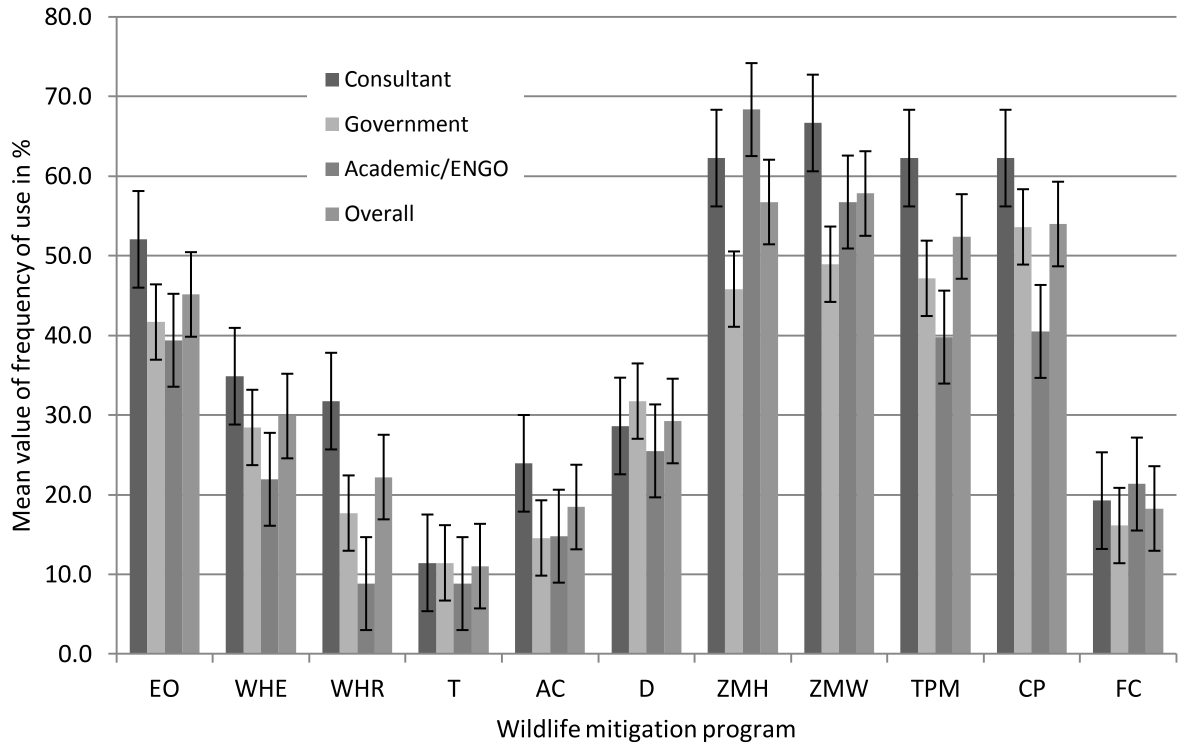

Figure 2.1: Frequency of wildlife mitigation program use by environmental consultants, government personnel, and academic/environmental non-government organization personnel (ENGO) in Canada when faced with uncertainty with respect to the status of the wildlife population. Mitigation programs are education and outreach (EO), wildlife habitat enhancement (WHE), wildlife habitat replacement (WHR), translocation (T), aversive conditioning (AC), deterrents (D), zoning and mapping for human-associated structures (ZMH), zoning and mapping for wildlife (ZMW), temporal plans and modifications (TPM), conservation and protection (CP), and fiscal compensation (FC). Error bars with standard error are displayed.

2.3.3 Choice of mitigation program when faced with uncertainty with respect to project effects

Overall, the preferred mitigation program choice under the context of uncertainty with respect to project effects was ‘zoning and mapping for wildlife’ (average frequency of use was 55.8%) (Figure 2.2). Although responses of the different occupation groups were different (Fisher exact test, $P = 0.035$), the effect of different types of occupation did not depend on the type of program (two-way ANOVA, $F_{[20]} = 0.617$, $P = 0.901$). The differences in mean values among the different occupation groups was significant (two-way ANOVA, $F_{[2]} = 7.280$, $P < 0.001$). Specifically, consultant versus government ($P < 0.001$) and consultant versus academic/ENGO ($P = 0.005$) were significant when faced with uncertainty with respect to project effects. However, academic/ENGO versus government was not significant ($P = 0.779$). Also, the differences in mean values among the types of mitigation program was significant (two-way ANOVA, $F_{[10]} = 13.509$, $P < 0.001$).

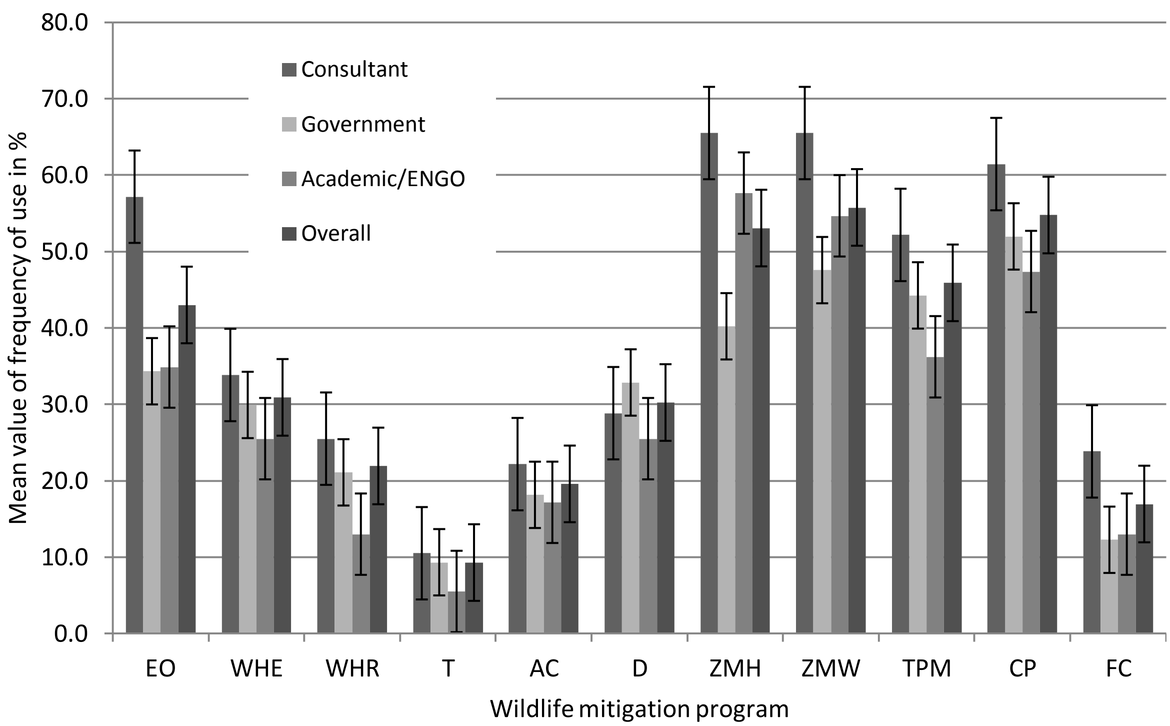

Figure 2.2: Frequency of wildlife mitigation program use by environmental consultants, government personnel, and academic/environmental non-government organization personnel (ENGO) in Canada when faced with uncertainty with respect to project effects. Mitigation programs are education and outreach (EO), wildlife habitat enhancement (WHE), wildlife habitat replacement (WHR), translocation (T), aversive conditioning (AC), deterrents (D), zoning and mapping for human-associated structures (ZMH), zoning and mapping for wildlife (ZMW), temporal plans and modifications (TPM), conservation and protection (CP), and fiscal compensation (FC). Error bars with standard error are displayed.

2.3.4 Familiarity with mitigation program

Overall, the preferred mitigation program choices related to familiarity of program were 'zoning and mapping for wildlife' (average frequency of use was 61.5%) and 'zoning and mapping for human associated structures' (average frequency of use was 61.1%) (Figure 2.3). Although responses of the different occupation groups were different (Fisher exact test, $P = <0.001$), the effect of different types of occupation did not depend on the type of program (two-way ANOVA, $F_{[20]} = 0.622$, $P = 0.897$). The differences in mean values among the different occupation groups was significant (two-way ANOVA, $F_{[2]} = 11.864$, $P < 0.001$). Specifically, consultant versus academic or ENGO ($P < 0.001$) and consultant versus government ($P < 0.001$) were significant. However, academic or ENGO versus government was not significant ($P = 0.131$). Also, the differences in mean values among the types of mitigation program was significant (two-way ANOVA, $F_{[10]} = 13.606$, $P < 0.001$).

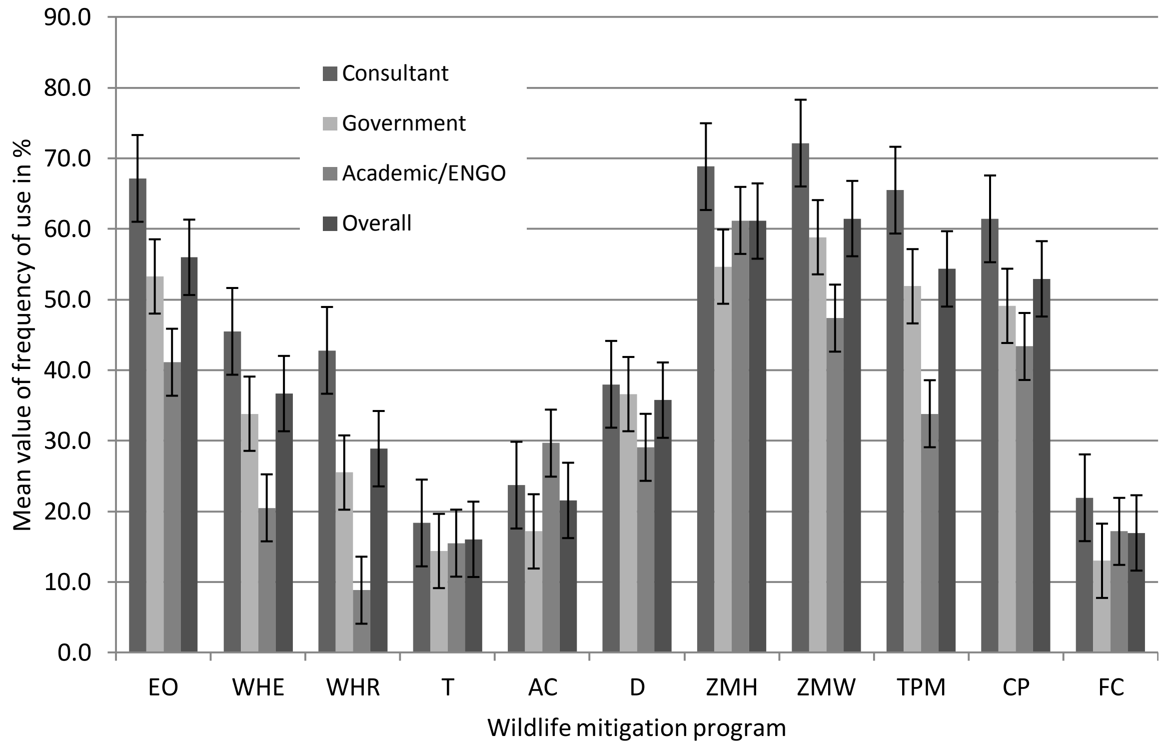

Figure 2.3: Frequency of wildlife mitigation program use by environmental consultants, government personnel, and academic/environmental non-government organization personnel (ENGO) in Canada based on familiarity with mitigation program. Mitigation programs are education and outreach (EO), wildlife habitat enhancement (WHE), wildlife habitat replacement (WHR), translocation (T), aversive conditioning (AC), deterrents (D), zoning and mapping for human-associated structures (ZMH), zoning and mapping for wildlife (ZMW), temporal plans and modifications (TPM), conservation and protection (CP), and fiscal compensation (FC). Error bars with standard error are displayed.

2.3.5 Budget limitations

Overall, the preferred mitigation program when faced with budget limitations was ‘education and outreach’ (average frequency of use was 54.9%) (Figure 2.4). Although responses of the different occupation groups were different (Fisher exact test, P = 0.010), the effect of different types of occupation did not depend on the type of program (two-way ANOVA, $F_{[20]}$ =

0.846, P = 0.657). The differences in mean values among the different occupation groups was significant (two-way ANOVA, $F_{[2]} = 8.074$, $P < 0.001$). Specifically, consultant versus government ($P < 0.001$) and consultant versus academic or ENGO ($P = 0.005$) were significant when faced with budget limitations. However, academic or ENGO versus government was not significant ($P = 0.469$). Also, the differences in mean values among the types of mitigation program was significant (two-way ANOVA, $F_{[10]} = 12.712$, $P < 0.001$).

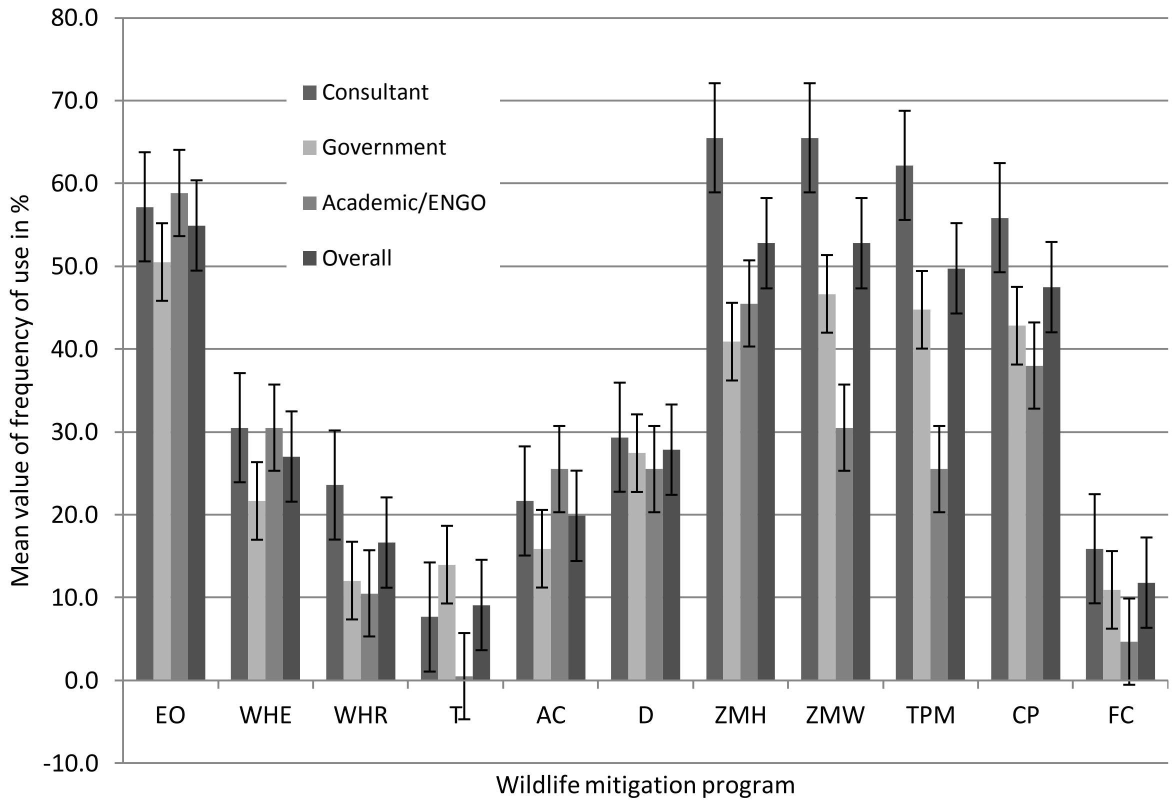

Figure 2.4: Frequency of wildlife mitigation program use by environmental consultants, government personnel, and academic/environmental non-government organization personnel (ENGO) in Canada when faced with budget limitations. Mitigation programs are education and outreach (EO), wildlife habitat enhancement (WHE), wildlife habitat replacement (WHR), translocation (T), aversive conditioning (AC), deterrents (D), zoning and mapping for human-associated structures (ZMH), zoning and mapping for wildlife (ZMW), temporal plans and modifications (TPM), conservation and protection (CP), and fiscal compensation (FC). Error bars with standard error are displayed.

2.3.6 Relative success of mitigation programs in offsetting project effects

Overall, all occupation groups were similar in perceived success for mitigation programs with the exception of 'zoning and mapping for human associated structures', 'zoning and mapping for wildlife', and 'temporal plans and modifications' (Figure 2.5). Consultants tended to answer higher on the success scores for those three mitigation programs. Academic/ENGO were generally less willing to give a high success score when responding to perceived success and subsequently had lower scores (see Chapter 2 Appendix B for additional figures demonstrating frequency of program use versus weighted success score, by mitigation program and by occupation type). Overall, 'conservation and protection' (2.06) was rated as the most successful mitigation program, though results were only significant when compared to translocation ($P < 0.001$), fiscal compensation ($P < 0.001$), aversive conditioning ($P < 0.001$), and wildlife habitat replacement ($P < 0.001$). Overall success scores were within the range of 0.88 and 2.06, with translocation having the lowest score.

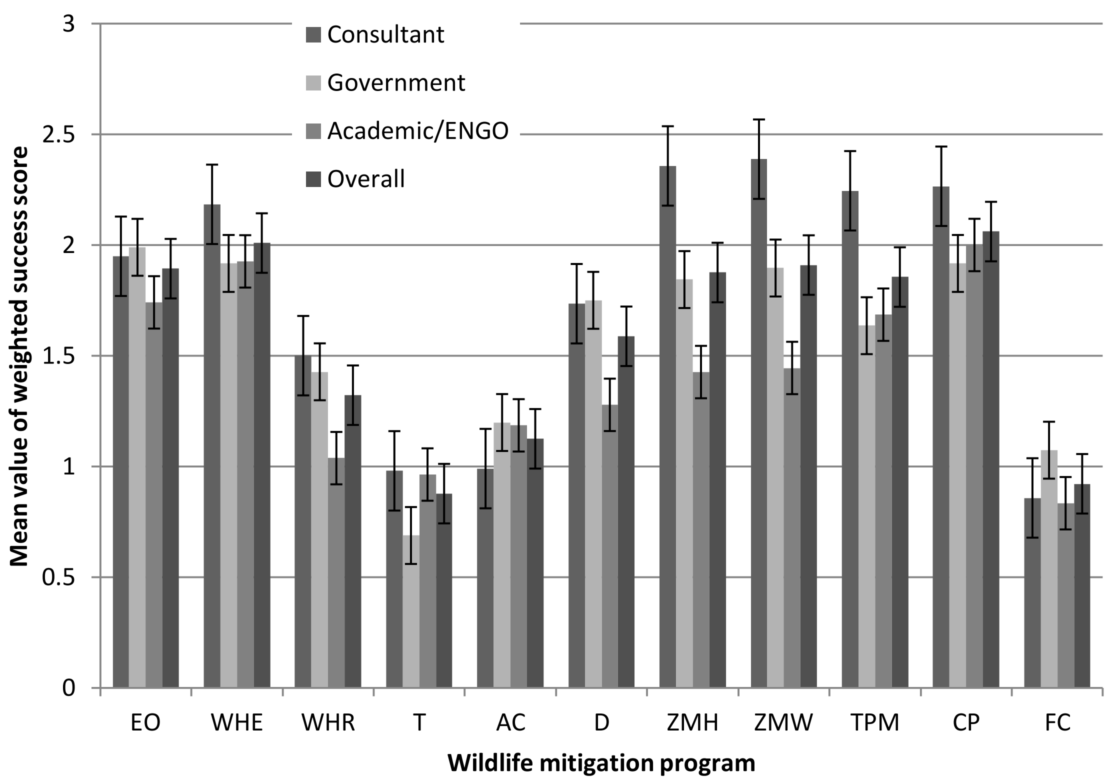

Figure 2.5: Relative weighted success of wildlife mitigation programs as perceived by environmental consultants, government personnel, and academic/environmental non-government organization personnel (ENGO). Weighted success score refers to initial scores chosen by each individual from definitely unsuccessful (0) to definitely successful (4) and weighted with their respective experience score. Mitigation programs are education and outreach (EO), wildlife habitat enhancement (WHE), wildlife habitat replacement (WHR), translocation (T), aversive conditioning (AC), deterrents (D), zoning and mapping for human-associated structures (ZMH), zoning and mapping for wildlife (ZMW), temporal plans and modifications (TPM), conservation and protection (CP), and fiscal compensation (FC). Error bars with standard error are displayed.

Responses of the different occupation groups were not found to be significantly associated (Fisher exact test, $P = 0.214$), and the effect of different types of occupation did not depend on the type of program (two-way ANOVA, $F_{[20]} = 1.025$, $P = 0.431$). However, the differences in mean values among the different occupation groups was significant (two-way

ANOVA, $F_{[2]} = 3.637$, $P = 0.027$). Specifically, consultant versus academic/ENGO ($P = 0.014$) and government versus academic/ENGO ($P = 0.019$) were significant. Consultant versus government was not significant ($P = 0.903$). Also, the differences in mean values among the types of mitigation program was significant (two-way ANOVA, $F_{[10]} = 10.426$, $P < 0.001$).

2.3.7 Strategic Matrix

A positive relationship between use of mitigation program and its success score was noted for all contexts (see Chapter 2 Appendix B: Figures B.1 to B.8). However, consultants were consistently more willing to assign higher success scores in all four contexts ($R^2 = 0.8116$, $R^2 = 0.7588$, $R^2 = 0.8598$, $R^2 = 0.7816$) and thus use those programs more often than the more conservative academic or ENGOs ($R^2 = 0.211$, $R^2 = 0.3868$, $R^2 = 0.2448$, $R^2 = 0.5810$). Government personnel were consistently in the middle range between consultants and academic or ENGOs for all contexts ($R^2 = 0.6781$, $R^2 = 0.7138$, $R^2 = 0.7324$, $R^2 = 0.5498$). In terms of frequency of use and perceived success, Table 2.2 demonstrates a disparity between the practice and perception of mitigation programs. Only consultants demonstrated a consistency between choice of program use and perceived success. In other words, consultants relied on the programs they perceived to be successful. However, the results are variable, suggesting that direct relationships between success and frequency of use are complex and not easily explained. Using a generalized strategic approach, a combination of zoning and mapping for wildlife, education and outreach, and/or conservation and protection was recommended, with a tendency towards one or some of those depending on the specific context (Table 2.3).

Table 2.3: Results of interviews of experts in different occupation groups. Most favored mitigation program when presented with different contexts is shown alongside which program is considered successful in offsetting adverse environmental effects.

<table>
<tr><th></th><th colspan="2">Consultant</th><th colspan="2">Government</th><th colspan="2">Academic or ENGO</th></tr>
<tr><th>Context</th><th>Highest ranked mitigation program by frequency of use</th><th>Highest ranked mitigation program by weighted success score</th><th>Highest ranked mitigation program by frequency of use</th><th>Highest ranked mitigation program by weighted success score</th><th>Highest ranked mitigation program by frequency of use</th><th>Highest ranked mitigation program by weighted success score</th></tr>
<tr><td>Uncertainty with respect to status of wildlife population</td><td>Zoning and mapping for wildlife</td><td rowspan="4">Zoning and mapping for wildlife</td><td>Conservation and protection</td><td rowspan="4">Education and outreach</td><td>Zoning and mapping for human associated structures</td><td rowspan="4">Conservation and protection</td></tr>
<tr><td>Uncertainty with respect to project effects</td><td>Zoning and mapping for wildlife
Zoning and mapping for human associated structures</td><td>Conservation and protection</td><td>Zoning and mapping for human associated structures</td></tr>
<tr><td>Familiarity</td><td>Zoning and mapping for wildlife</td><td>Zoning and mapping for wildlife</td><td>Zoning and mapping for human associated structures</td></tr>
<tr><td>Budget limitations</td><td>Zoning and mapping for wildlife
Zoning and mapping for human associated structures</td><td>Education and outreach</td><td>Education and outreach</td></tr>
</table>

Table 2.4: Generalized strategic matrix with suggested mitigation programs for any occupation group. Broad mitigation approaches may be applied to any context at any stage of mitigation development and should be considered first. Specific mitigation approaches may be applied to the particular context presented. This strategic matrix is based on results of interviews with experts with knowledge of wildlife mitigation from different occupation groups (e.g. consulting, government, and academic/ENGO).

<table>
<tr><th>Context</th><th>Broad mitigation approach</th><th>Specific mitigation approach</th></tr>
<tr><td>Uncertainty with respect to status of wildlife population</td><td rowspan="4">Zoning and mapping for wildlife
Education and outreach
Conservation and protection</td><td>Zoning and mapping for wildlife</td></tr>
<tr><td>Uncertainty with respect to project effects</td><td>Zoning and mapping for wildlife</td></tr>
<tr><td>Familiarity</td><td>Zoning and mapping for wildlife</td></tr>
<tr><td>Budget limitations</td><td>Education and outreach</td></tr>
</table>

2.4 Discussion

2.4.1 Context-based selection of mitigation programs

The frequency of use of different wildlife mitigation programs to offset adverse environmental effects from large-scale industrial projects can be understood by examining the decisions among experts to favor specific programs under different contexts. This study shows that all occupation groups generally selected ‘zoning and mapping for wildlife’, ‘zoning and mapping for human associated structures’, and ‘conservation and protection’ more frequently when faced with uncertainty with respect to the status of wildlife populations or project effects. ‘Zoning and mapping for wildlife’ or ‘human associated structures’ were more familiar to all occupation groups, whereas ‘zoning and mapping for wildlife’ or ‘human associated structures’ and ‘education and outreach’ were selected more favorably when faced with budget limitations.

These results may reflect how the situational context of phases of EAs in terms of time and knowledge may influence willingness to select particular mitigation programs. For example, earlier phases of EAs generally have less baseline knowledge collected or experts are pressured into forming their opinions to provide a preliminary best guess at outcomes. Although many studies exist that examine types of industrial projects and their effects on wildlife (e.g. Ashenhurst and Hannon 2008; Johnson *et al.* 2005; Lovich and Ennen 2013; Mahoney and Schaefer 2002; McLellan 1990; Semeniuk *et al.* 2012), at times uncertainty may be unavoidable (Duinker and Greig 2007; Geneletti *et al.* 2003). In these circumstances, the uncertainty with respect to either the status of wildlife populations or the project effects may be relatively high since experimental studies or models have not yet been implemented to unravel specific effects. The average reliance on 'zoning and mapping for wildlife', 'zoning and mapping for human associated structures', and 'conservation and protection' by all occupation groups demonstrates that experts take a conservative 'big picture' approach. 'Zoning and mapping' efforts require examining the spatial distributions of species and their habitats in relation to proposed project plans. 'Conservation and protection' efforts include investigating and evaluating the risks to species abundance and diversity, and ecosystems (Fleury and Brown 1997; Godin and Worm 2010). Adopting these approaches under the context of uncertainty with respect to population status and project effects allows experts to err on the precautionary side. Adopting the precautionary principle (consistent with the mandate of CEAA 2012 4.(2) and definition UN 1992) allows for a minimal amount of adverse effects while trying to ensure adequate protection is available before any project stages commence. Adopting these general mitigation strategies allows for an integration of more specific mitigation at a later date (e.g. changing protective boundaries, enhancing or restoring habitats, introducing corridors).

Considering an adaptive management strategy to complement the use of the precautionary principle may be another means to approach uncertainty. The application of adaptive management in the EA process is not new (e.g. Holling 1978; Noble 2000), although it is not (yet) a popular endeavor in Canadian EAs. In brief, adaptive management involves a formal prescription for i) investigating environmental management choices, while accepting and embracing uncertainty in results, ii) evaluating and monitoring changing ecological dynamics and iii) using the information arising from evaluations and monitoring efforts to adapt and learn (Lee 1993; Walters 1986). Attempts at uncovering trends in predictions through experimentation may be a welcome addition to the EA process. Adaptive policies can follow suit provided an adequate set of indicators are used to follow the status of wildlife population. However, adaptive management can only help in so far as experts are prepared to handle unexpected experimentation results.

The frequent use of ‘zoning and mapping for wildlife’ and ‘human associated structures’ by experts in different occupation groups when faced with uncertainty is consistent with the overall familiarity of these mitigation programs. ‘Zoning and mapping’ are methods that may be relatively inexpensive, easier to execute, and readily available compared to other mitigation approaches. ‘Zoning and mapping’ may be computer-based when access to GIS systems, journal databases, and communications systems is required. These items are easily accessible, which allows experts to conduct analyses and make recommendations with a reasonable amount of support.

When budget limitations were considered, the overall approach by experts in the government and academic/ENGO groups shifted to ‘education and outreach’, whereas consultants maintained their reliance on ‘zoning and mapping for wildlife’ and ‘human associated structures’. ‘Education and outreach’ endeavors can be costly, which may explain why consultants were less reliant on this approach. Also, it may be difficult to pass an ‘education and outreach’ budget by project proponents if results are not assured to be in the proponents favor as may happen with a controversial project. In contrast, academics have more opportunities to execute ‘education and outreach’ ventures since they are likely to have access to free rooms and audiovisual aids, less expensive brochure materials, a wide audience consisting of colleagues and students, and effective teaching practices. Similarly, ENGOs and government experts are likely able to secure rooms at government rates and access large networks of activists and media personnel. When budgets are limited, it may make economic sense to rely on networking to raise awareness of pending ecological damages. This may put pressure on proponents to reconsider or revise original plans (O'Faircheallaigh 2010).

2.4.2 Perceived success of mitigation programs

Mitigation program selection and success scores were significantly related for consultant and government groups, they were not as strongly related for academics and ENGOs. These results could reflect the hesitance of academics and ENGOs to a make a selection because of its hypothetical and indistinct nature. Many academics and ENGOs may not be confident in formulating an opinion that they feel they cannot support as objective investigations of the success of mitigation programs are limited in peer-reviewed literature. On the other hand, consultants are under extreme pressure from their clients to decide on a mitigation program that promotes completion of an EA, as well as provide a justification for their choice. The overall higher mean values of frequency of use for consultants support this explanation.

The mitigation programs associated with higher success scores are 'zoning and mapping for wildlife' and 'human associated structures', and 'conservation and protection', as they are also most frequently used by the different occupation groups under the various contexts presented. Weber and Allen (2010) provide a detailed account of property and ecological value assessments for road projects, and demonstrate how a ranking system can allow project leaders to prioritize areas for 'conservation and protection'. The authors stress the importance of using tools for modeling landscape networks based on conservation biology and ecology early in the planning process (when there is higher uncertainty) to maximize the potential for reducing adverse environmental effects of industrial projects. Weber and Allen (2010) and Messer (2006) also discuss cost-optimization strategies, recognizing that budgetary constraints are real. 'Zoning and mapping' and 'conservation and protection' are offered as cost efficient approaches that have a high propensity towards impact avoidance and reduction.

As expected, the frequency of use of 'translocation', 'aversive conditioning', and 'fiscal compensation' were associated with lower success scores. This makes sense considering that many EA practitioners within the three occupation groups rely on peer-reviewed literature, colleagues' opinions, and grey literature to support their recommendations. There are few sources that are available and accessible which discuss the results of translocations or relocations (Fisher and Lindenmayer 2000), and the ones that are available demonstrate a relatively low success rate even for a wide range of wildlife species (Dodd and Seigel 1991; Engelhardt *et al.* 2000; Griffith *et al.* 1989; Stamps and Swaisgood 2007; Wolf *et al.* 1996), and particularly in relation to human-wildlife conflicts (Butler *et al.* 2005; Germano and Bishop 2009). Fisher and Lindenmayer's (2000) review of the gamut of wildlife translocations, re-introductions, and supplementations shows a general failure at achieving primary goals of reducing human-wildlife conflicts, increasing conservation, or restocking wild populations. Further, translocations as part of mitigation are known not to be monitored adequately post-release, which is likely to deter any ecologist or biologist working within the EA process to concede an opinion of success (Edgar *et al.* 2005; Germano and Bishop 2008; Landriault *et al.* 2009; Rogers 1986a, 1986b; Teixeira *et al.* 2007).

'Aversive conditioning' may be similarly stigmatized, although a mixed amount of success is associated with this type of mitigation. Aversive conditioning, in the case of bears, involves negative reinforcement with the goal of long-term behavioural modification (Hopkins III *et al.* 2010). Mazur (2010) and Ternent and Garshelis (1999) caution that success of 'aversive conditioning' may be short-term when other management strategies are not adopted. The onus must be placed on education, outreach, and enforcement of appropriate mechanisms to reduce human-animal conflict (e.g. waste management policies, electric fences). Experts within the three occupation groups surveyed were cautious when considering the success of aversive conditioning given that a major factor in reducing human-wildlife conflicts in relation to developed areas is death of the individual animals (Ternent and Garshelis 1999). The negative publicity alone may strain future progress of an EA, despite intentions to rectify a scenario involving dead or injured animals (Leigh and Chamberlain 2008).

'Fiscal compensation' as a mitigation strategy was perceived to have little success by all occupation groups. This is consistent with the complexity involved in calculating net values of ecological systems and services (Villaroya and Puig 2010). Compensation has been included in government policies as a means of achieving a goal of no net loss of ecological landscapes (e.g. Fisheries and Oceans Canada 1986). Yet assigning monetary values to ecological components is not easy. Although de Groot *et al.* (2012) and Anielski and Wilson (2009) provide a standardized and systematic method for calculating monetary units for ecosystem services, they also caution that most values are independent of economic markets and should be treated as fixed benefits that cannot be exchanged. Other studies (e.g. Bonds and Pompe 2003; Briggs *et al.* 2009) investigated the role of credits or habitat banking, and follow compensation ratios that have been developed to facilitate loss and replacement trades. These studies conclude that while some habitats and ecosystem services may be interchangeable, most are impossible to replace or replicate elsewhere. Also, Briggs *et al.* (2009) suggest that purchasing as much land as possible or funding other projects are ineffective strategies of mitigation. These take away from conservation and restoration efforts and long-term visions of the habitat originally set for destruction or alteration. At minimum, developers are encouraged to fund compensation projects prior to development, construction and operation, and post a bond in the case that these projects are proven unsuccessful (Briggs *et al.* 2009). Convincing project developers of these courses of actions is difficult for any expert in the occupation groups surveyed. Thus, compensation as a mitigation approach may be neither favorable nor lucrative.

Choosing mitigation programs to alleviate adverse environmental effects is a critical topic in Canada, and participation is demanding on members of the three occupation groups surveyed. It is suspected that members of the academic community would have been more inclined to demonstrate critical perspectives than other interest groups such as industry members (e.g. oil and gas, shipping) who were not surveyed. None of the groups that were sampled demonstrated 100% reliance on any mitigation program. Moreover, none of the groups expressed an absolute success score, despite the fact that many experts had a complete or near-complete experience profile. It is likely that results from other interest groups would demonstrate similar tendencies.

2.4.3 Strategic matrix application to a case study

The generalized strategic matrix demonstrates a rudimentary approach to selecting mitigation programs based on context. This study shows that top choices are ‘zoning and mapping for wildlife’, ‘conservation and protection’, and ‘education and outreach’. This is supported by both frequency of use and overall perceived success scores. However, it should be noted that mitigation program use and development is a delicate matter and should be approached with caution and rigorous testing to offset adverse environmental effects from large scale industrial projects (Mills and Clark 2001). This strategic matrix is broad and simple, but provides a basis from which to explore further options.

The Nalcor Project, the real-world example used as a test case here, involves a broad range of impacts on many ecosystems, wildlife and their habitats, as well as a myriad of effects both adverse and positive that EA practitioners needed to consider (Nalcor 2009). Applying this strategic matrix would imply that experts should use zoning and mapping for wildlife, conservation and protection, and education and outreach in a broad sweep across all dimensions of the Project as mitigation. The black bear population of the region of the Nalcor Project is not well known and experts are faced with contexts similar to questions 1 and 2 of this study survey; uncertainty with respect to wildlife population status and project effects, respectively. Thus 'zoning and mapping' specific for black bear habitat (e.g. foraging habitat, home ranges, core areas, denning sites) is suitable as a first step to ensure Project activities are minimally disturbing to black bears. It should be noted that 'zoning and mapping' only address adverse effects if appropriate actions are undertaken in these mapped areas of impacts. Further, experts are likely faced with a budget limitation for a black bear study due to the low priority this species may have in EAs, even though it is listed as a KI within the VEC. Although black bears are valuable species in terms of intrinsic, biological, cultural, and socio-economic reasons (McGee 1987; OMNR 2009), often the general public (and therefore possibly regulators) pays little attention to the overall health of the black bear population (Bowman *et al.* 2001; Kellert 1994), particularly in the remote region of Labrador. Thus, expending limited funds on 'education and outreach' endeavors may be of little value since changing public perception requires a considerable amount of investment (of time and money).

Following the strategic matrix, the Nalcor Project should consider 'conservation and protection' efforts for the black bear as a broad approach to offsetting impacts. Considering the role of the black bear in ecosystems, the biological implications of securing habitat for this area-limited umbrella species may be high (Carignan and Villard 2001; Roberge and Angelstam 2004). As an umbrella species, the black bear may serve as an indicator of ecosystem health (Shardlow and Hyatt 2013). Theoretically, focusing on umbrella species helps EA experts delineate appropriate habitat for other species with similar ecosystem needs to safeguard against development (Hess and King 2002). However, the usefulness in understanding, promoting, and preserving black bears and their habitat to promote ecosystem-based management is limited if uncertainty is high with respect to which species and habitats would fall under the black bear umbrella (Simberloff 1998). For this reason, Simberloff (1998) warns against intensive management of a single umbrella species without attention to the rest of the ecological community. Nevertheless, Nalcor (2009) would benefit from taking an umbrella species approach to conservation given that distribution data are limited for many species in the Labrador region, and prioritizing sites for conservation, protection, and further research is judicious.

In designing more specific mitigation approaches, the Nalcor Project is advised to heed caution against considering the less successful and less used mitigation programs (i.e. translocation, deterrents, aversive conditioning). Human-bear conflicts may arise during particular stages of construction and operation (see specifics in Nalcor 2009), and efforts should be made to prevent problems given that aversive conditioning, and translocation are not methods considered suitable for offsetting adverse effects. These directly invasive methods are a last resort approach and this study shows that many experts from the three occupation groups have low confidence in their effectiveness.

2.4.4 Implications for future use of wildlife mitigation programs

Industrial development on a large-scale is important to the economic well-being of Canada (Government of Canada 2009). Anielki and Wilson (2009) report market values of $23.6 in Gross Domestic Product from mining, and oil and gas industrial activities and $19.5 billion in Gross Domestic Product for hydroelectric generation from dams and reservoirs in the boreal region. Despite this large financial gain from natural resource energy development, studies about mitigation program use and success are limited (Slotterback 2008). The precariousness of funding studies about environmental effects of large-scale projects due to politics, legalities, and other reasons may add to the concern that the application of mitigation programs may never be fully understood. Nevertheless, differences in selection of mitigation programs by occupation groups need to be accounted for in the EA process. Proponents of large-scale industrial projects looking to develop a rigorous, reliable, environmentally sound and defensible EA should become familiar with the drivers and patterns that are influencing consultants, government personnel, and academic or ENGOs working on their projects. Different occupation groups possess diverse opinions about wildlife mitigation programs. Thus programs that are selected based on experience, knowledge, and as much scientific information as possible will be most effective in offsetting adverse environmental effects.

To promote better understanding of mitigation programs by different occupation groups, partnerships and round table discussions should be encouraged to facilitate an exchange of opinion and knowledge. Experts need to discuss optimal strategies under specific contexts, and these sessions should be readily available to incoming professionals. The feasibility of providing funds to investigate the actual versus perceived relative success of mitigation programs should be considered. Specifically, success criteria should be developed for each mitigation program implemented in terms of effect eliminated, reduced, or ineffective. Since mitigation programs are rarely chosen in this manner, it is important to attempt to facilitate early discussions between experts that place social and ecological concerns in the highest regard.

2.5 Conclusion

In general, EA practitioners in the three occupation groups surveyed should not ignore the trends among different occupation groups in selecting projects to offset adverse environmental effects. Many common forms of wildlife mitigation may not actually be considered appropriate under any context. The reluctance of experts to consider mitigation programs as ‘definitely successful’ suggests an emerging paradigm of dissatisfaction, although ‘unsuccessful’ and ‘partly successful’ were chosen to varying degrees. This may indicate a need to revise existing mitigation development practices (if any). Further, to avoid the risk of unsuccessful implementation of some of the practices mentioned in this study, widespread and comprehensive wildlife mitigation development decision-making should be executed.

Considering that much of the success of mitigation practices may be based on opinion, it is risky for EA practitioners to ignore sentiments of different occupation groups, especially when the expression is one of disapproval. For example, if experts are recommending mitigation programs that are known to be frowned upon by other occupation groups, then experts may be able to address concerns and controversies to be able to guide a more appropriate implementation of mitigation practices. Alternatively, recognizing which common practices are no longer appropriate in specific contexts is also of utmost importance. EA practitioners may be better at pursuing and developing more relevant practices that are considered appropriate by all concerned occupation groups. However, it should be noted that approval should not be an ultimate driving force in the selection of mitigation programs. They should always be justified in research-based and peer-reviewed studies involving a wide range of stakeholders and ecological considerations.

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Chapter 2 Appendix A: Residual Plots

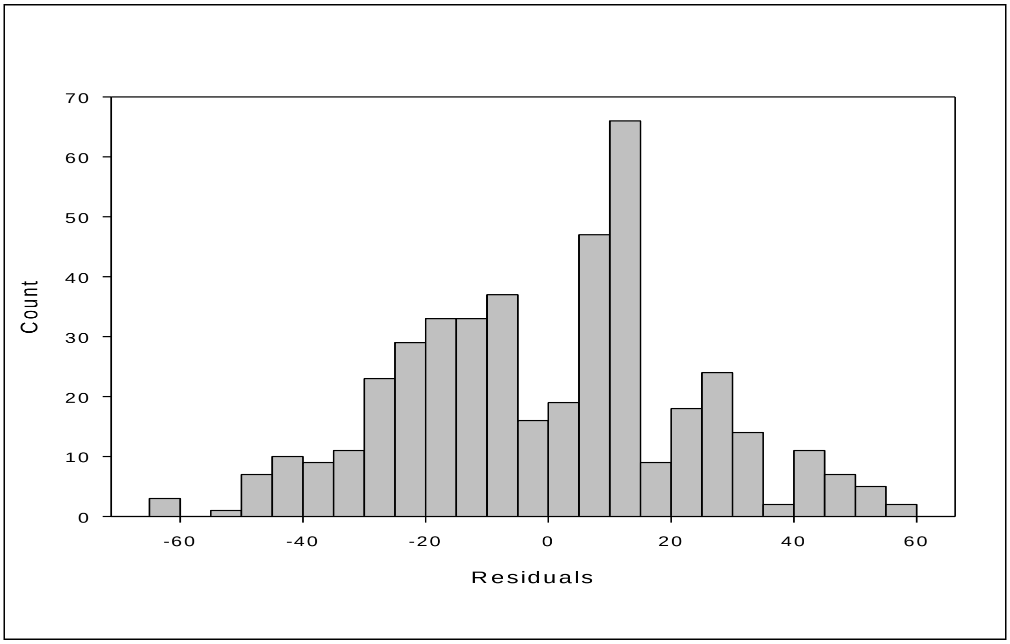

Figure 2.A.1: Residual plot from 2-way ANOVA for question 1.

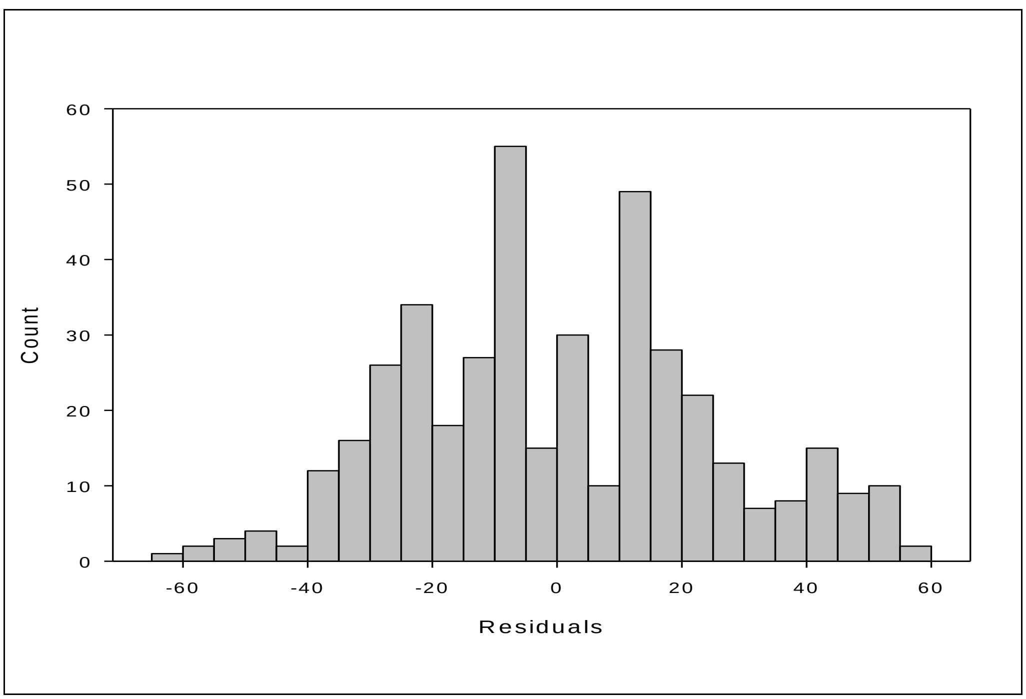

Figure 2.A.2: Residual plot from 2-way ANOVA for question 2.

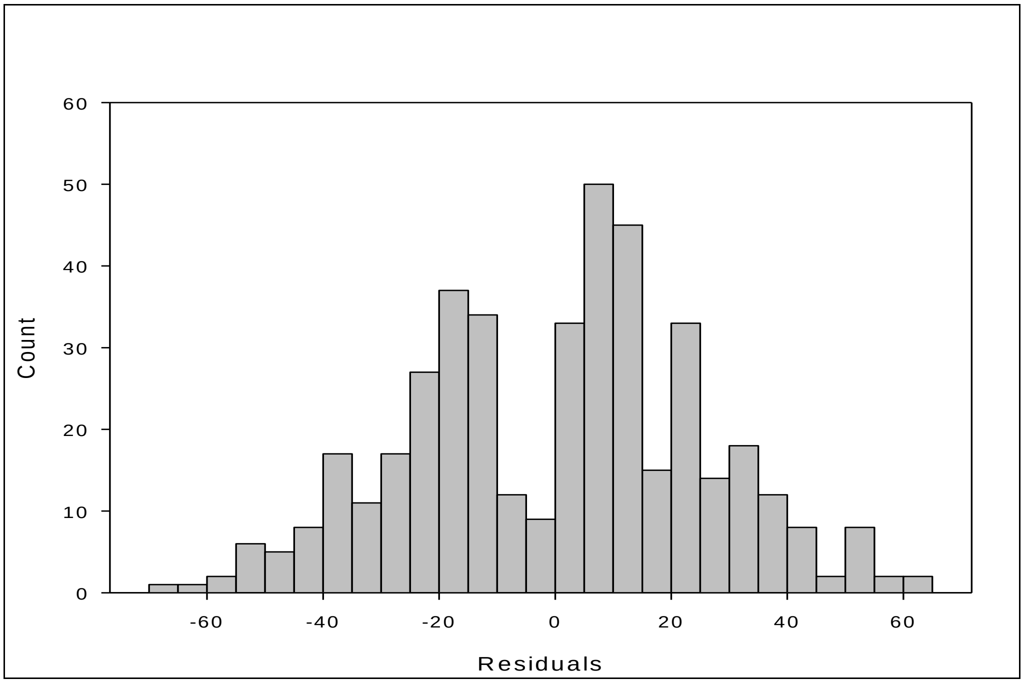

Figure 2.A.3: Residual plot from 2-way ANOVA for question 3.

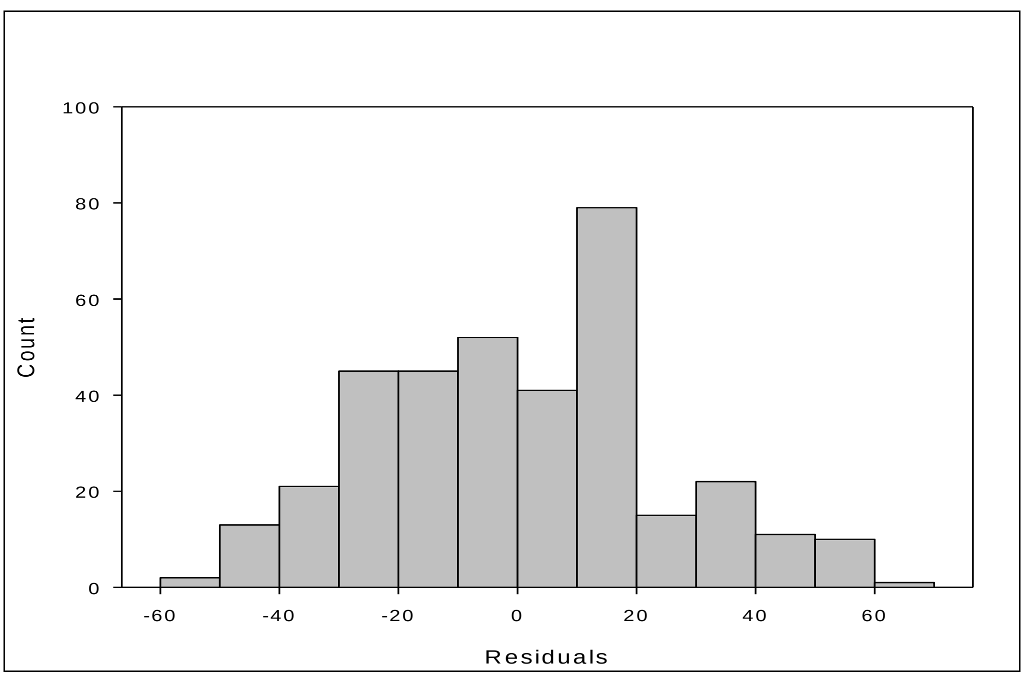

Figure 2.A.4: Residual plot from 2-way ANOVA for question 4.

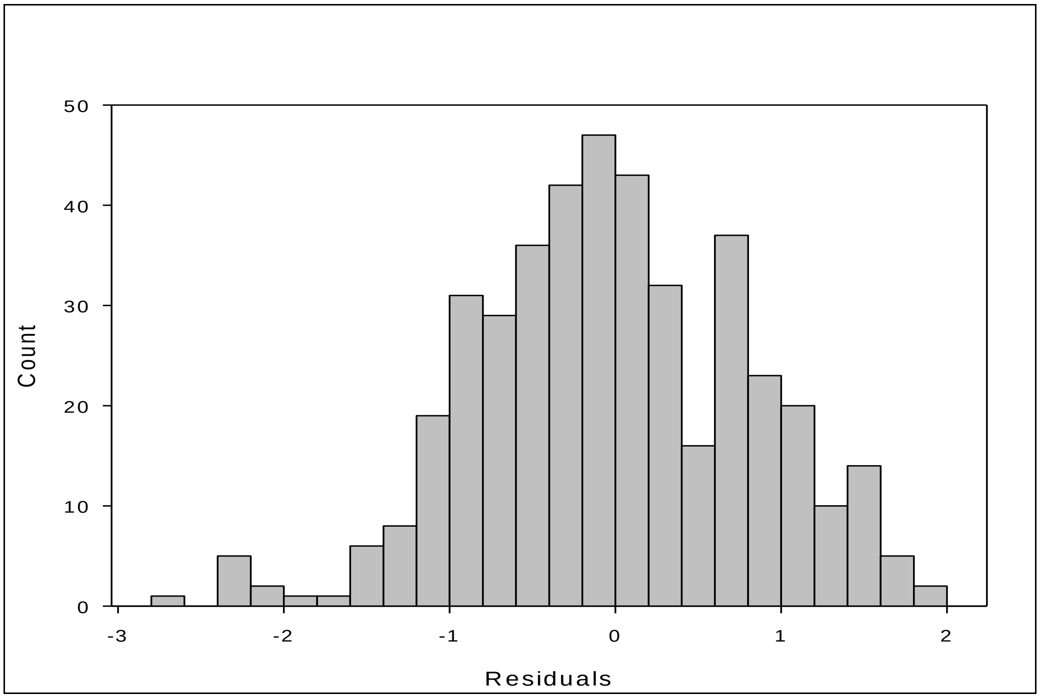

Figure 2.A.5: Residual plot from 2-way ANOVA for question 5.

Chapter 2 Appendix B: Frequency of use versus weighted success figures.

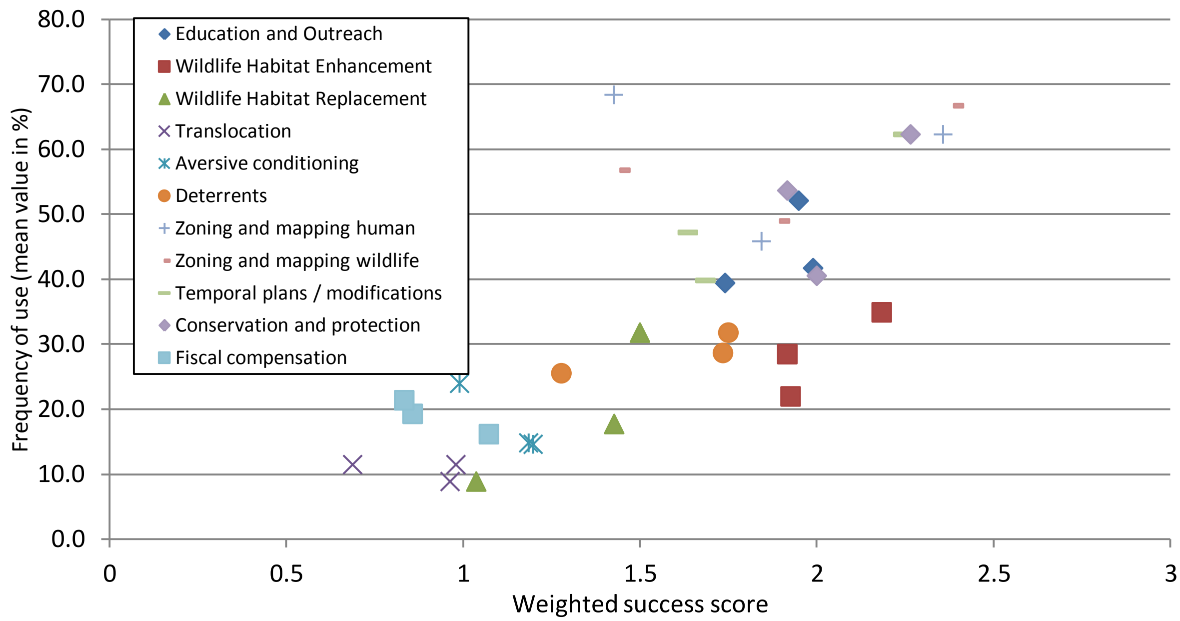

Figure 2.B.1: Overall mean frequencies of wildlife mitigation program use by experts surveyed in Canada versus relative success when uncertainty with respect to wildlife population is high. Weighted success score refers to initial scores chosen by each individual from definitely unsuccessful (0) to definitely successful (4) and weighted with their respective experience score.

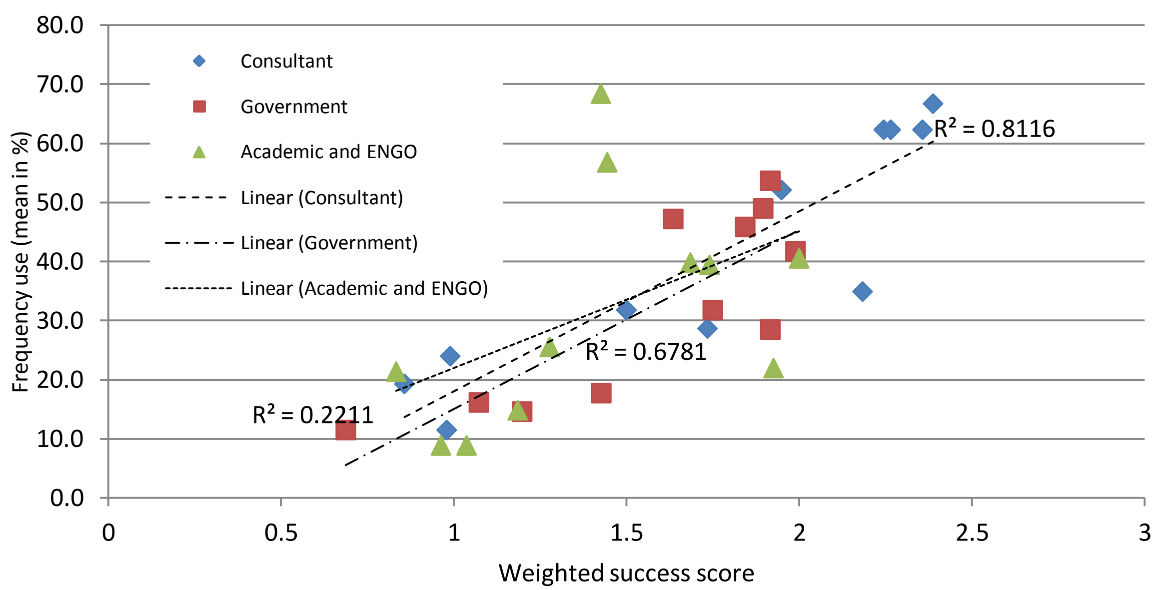

Figure 2.B.2: Mean frequencies of wildlife mitigation program use by consultants, government, and academic / environmental non-government organization personnel (ENGO) in Canada versus relative success when uncertainty with respect to wildlife population is high. Weighted success score refers to initial scores chosen by each individual from definitely unsuccessful (0) to definitely successful (4) and weighted with their respective experience score.

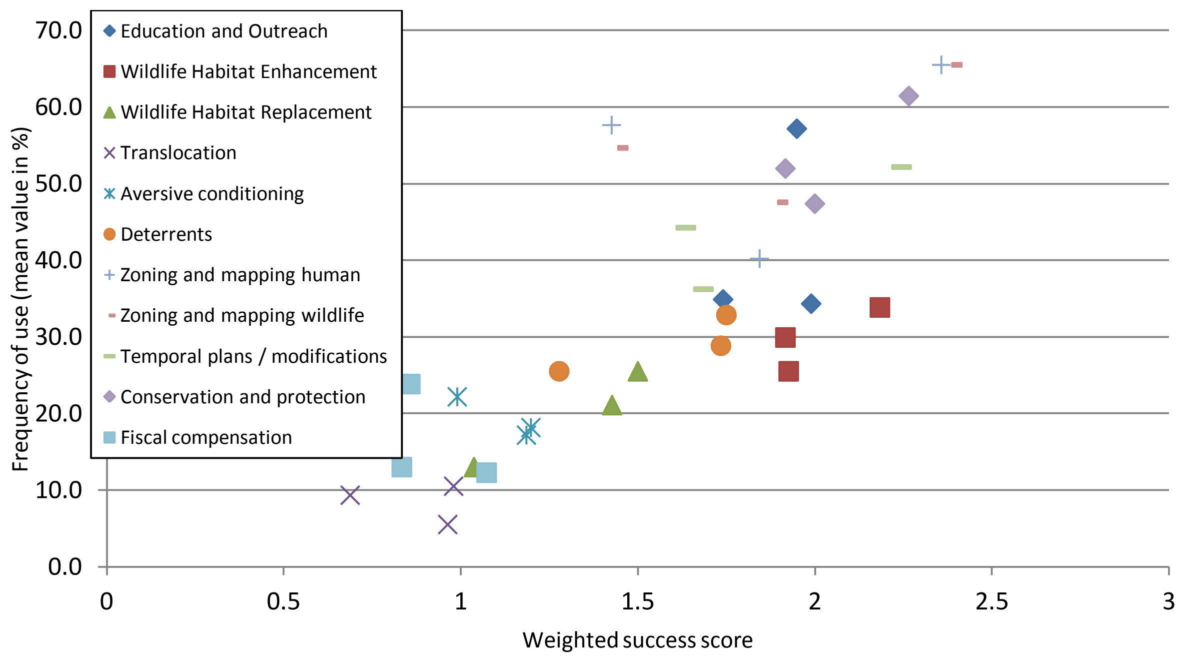

Figure 2.B.3: Overall mean frequencies of wildlife mitigation program use by experts surveyed in Canada versus relative success when uncertainty with respect to project effects is high. Weighted success score refers to initial scores chosen by each individual from definitely unsuccessful (0) to definitely successful (4) and weighted with their respective experience score.

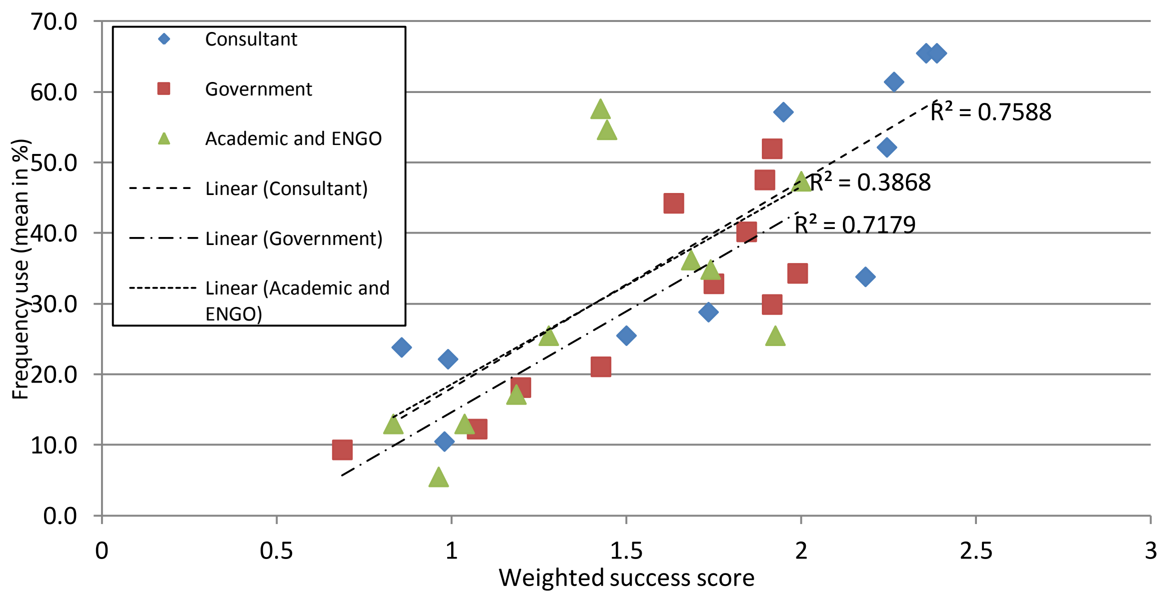

Figure 2.B.4: Mean frequencies of wildlife mitigation program use by consultants, government, and academic / environmental non-government organization personnel (ENGO) in Canada versus relative success when uncertainty with respect to project effects is high. Weighted success score refers to initial scores chosen by each individual from definitely unsuccessful (0) to definitely successful (4) and weighted with their respective experience score.

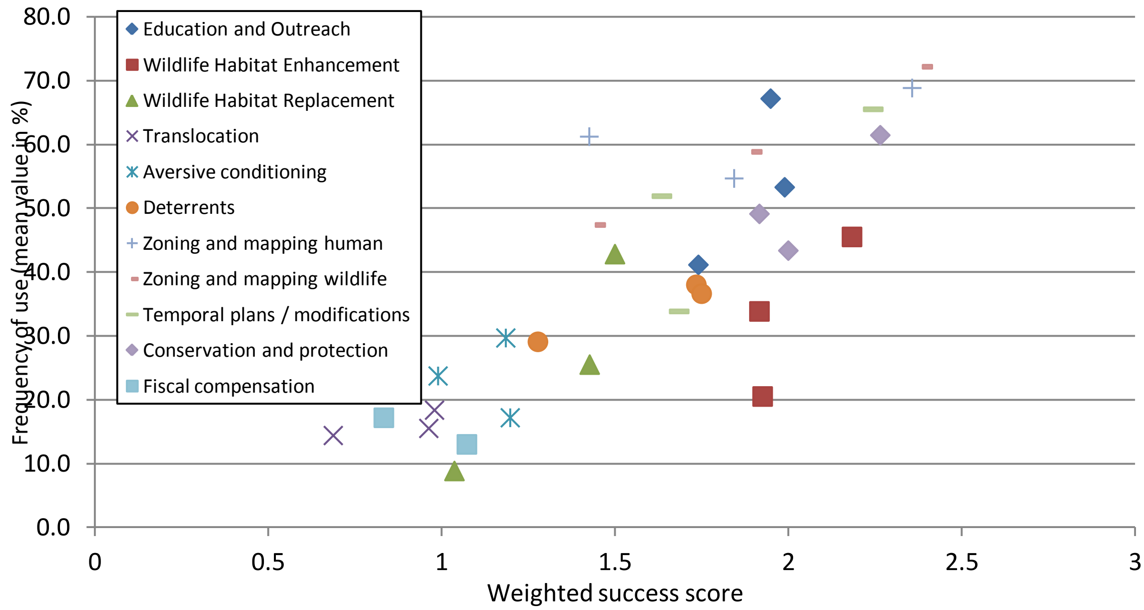

Figure 2.B.5: Overall mean frequencies of wildlife mitigation program use by experts surveyed in Canada versus relative success based on familiarity with mitigation programs. Weighted success score refers to initial scores chosen by each individual from definitely unsuccessful (0) to definitely successful (4) and weighted with their respective experience score.

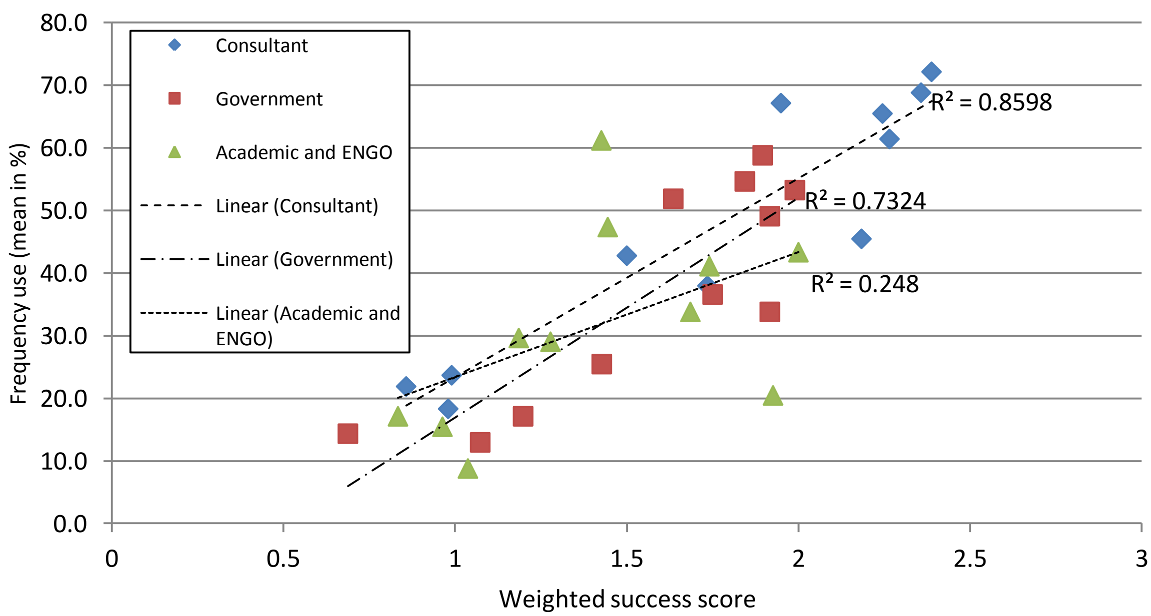

Figure 2.B.6: Mean frequencies of wildlife mitigation program use by consultants, government, and academic / environmental non-government organization personnel (ENGO) in Canada versus relative success based on familiarity with mitigation programs. Weighted success score refers to initial scores chosen by each individual from definitely unsuccessful (0) to definitely successful (4) and weighted with their respective experience score.

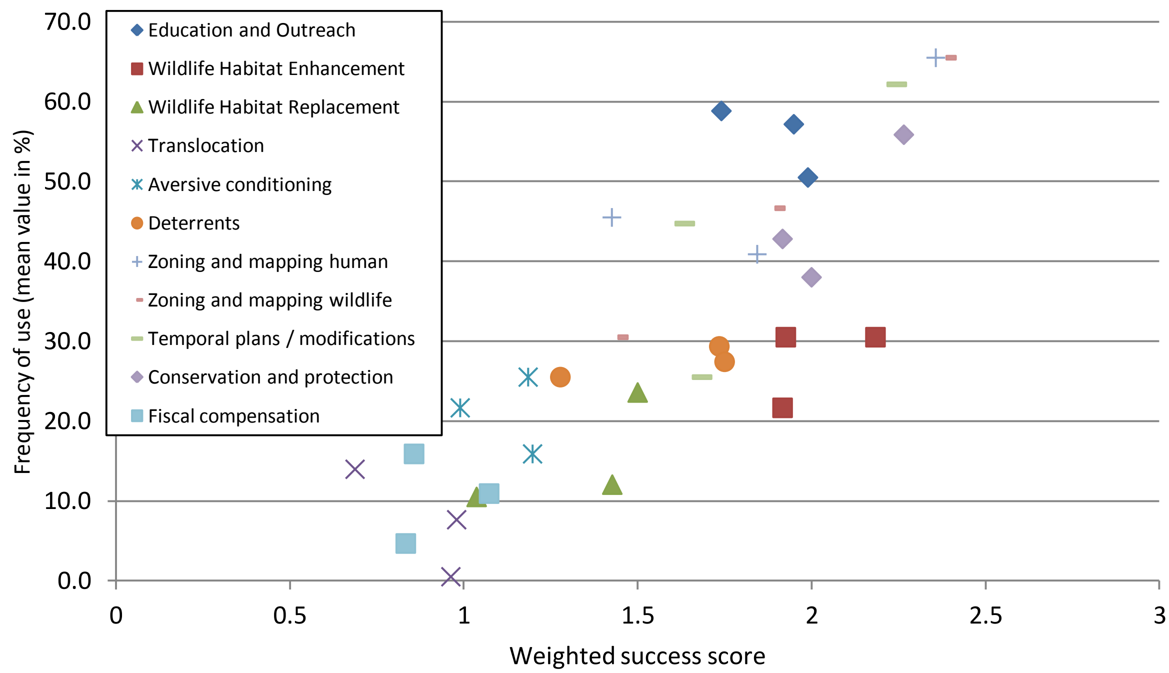

Figure 2.B.7: Overall mean frequencies of wildlife mitigation program use by experts surveyed in Canada versus relative success when faced with budget limitations. Weighted success score refers to initial scores chosen by each individual from definitely unsuccessful (0) to definitely successful (4) and weighted with their respective experience score.

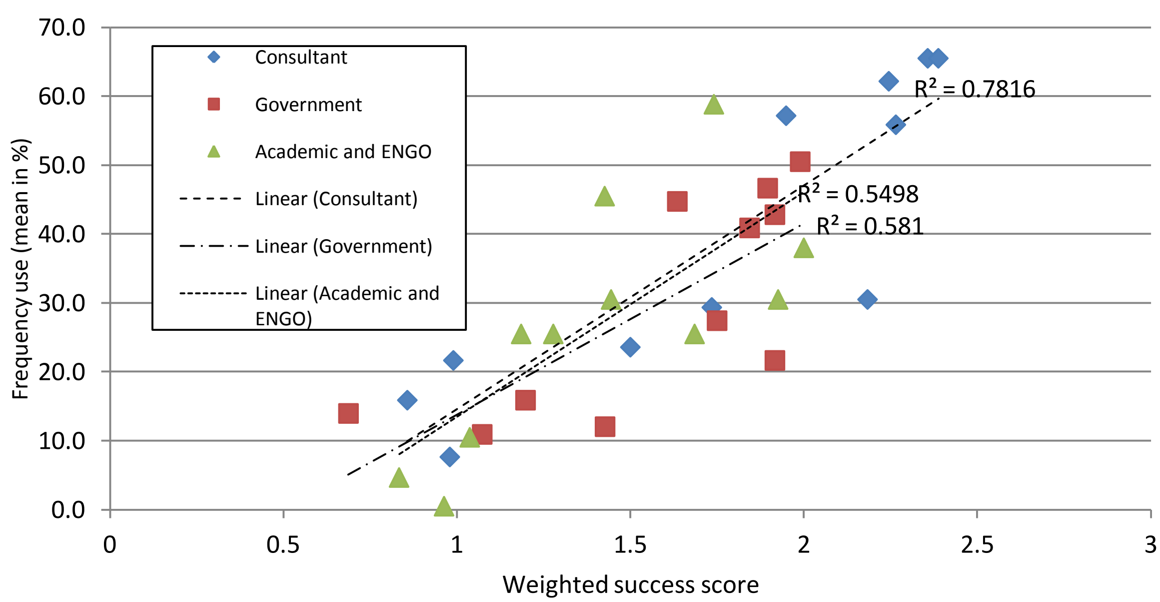

Figure 2.B.8: Mean frequencies of wildlife mitigation program use by consultants, government, and academic / environmental non-government organization personnel (ENGO) in Canada versus relative success when faced with budget limitations. Weighted success score refers to initial scores chosen by each individual from definitely unsuccessful (0) to definitely successful (4) and weighted with their respective experience score.

Chapter 3.0: An exploration of the relationship between telemetry and wildlife mitigation in the context of Environmental Assessments.

3.1 Introduction

Biophysical assessments form a crucial part of the Canadian Environmental Assessment (EA) process. Baseline studies concerning wildlife in and around the site of a proposed industrial development project are relied upon to inform impact studies and develop mitigation strategies. In general, the design of mitigation projects follows the assumption that effects from industrial development are understood and steps can be taken to offset or alleviate them. Effects analyses assess the degree of change between existing conditions and estimated post-EA disturbances. Essentially, comparisons are drawn between environmental states pre and post construction and operation phases of a proposed industrial development project (see CEAA 1992).

Within the effects analysis, mitigation may be embedded in project design, or it may be defined and listed as general or specific practices used to reduce, alleviate, or offset expected adverse effects (see CEAA 1992; CEAA 1993). Considering mitigation for wildlife and wildlife habitat, there is a range of tools available to investigate species presence and habitat use. The flexibility in the use of tools (e.g. literature reviews, spatial instruments) for such biophysical assessments is high. Yet, there are few guidelines or recommendations from regulatory authorities considering which tools are relevant and appropriate to gather data and from which to subsequently formulate mitigation projects.

A spatial tool prevalent in animal research is telemetry. In general, telemetry is used to understand species-specific traits (e.g, habitat use and dispersal patterns) and can be used to reduce the uncertainty in environmental assessments (Cooke 2008). In this chapter, I assess the utility of telemetry in mitigation using the *Environmental Impact Statement (EIS)* for the *Lower Churchill Hydroelectric Generation Project* (Nalcor 2009) (herein referred to as the Nalcor Project) and an associated baseline study of American black bears (*Ursus americanus*) as a case study (Minaskuat Ltd. 2009). Specifically, I provide current information on wildlife telemetry and apply a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis to evaluate its use in the derivation of mitigation programs used to offset or reduce environmental effects of an industrial project.

3.2 Background

3.2.1 Telemetry and the EA process

The word *telemetry* is rooted in Greek etymology and is broken down as *tele* meaning remote, and *metron* meaning measure (Barnhart 1988). Telemetry is used in many fields of study from physiology studies (e.g. Karesh 1999) to ecological research. Original telemetry applications in animal ecology date back to the 1950s and 1960s (e.g., time-depth recorders in pinniped studies, Kooyman 1965; other studies include Le Munyan *et al.* 1959; Marshall *et al.* 1962; Mech et al. 1965), and with technological advancements have reached a wider breadth and depth in scope and application (Cagnacci *et al.* 2010). Many uses of telemetry in wildlife studies relate to acquiring the position of an animal in space and time. Knowing the location of an animal provides for a detailed view of biotic and abiotic variables associated with a tagged or radiocollared individual (Cagnacci *et al.* 2010; Hooker *et al.* 2004). Further, understanding animal-habitat preferences at different scales can improve our understanding of animal-ecosystem relationships. Ultimately, this knowledge of ecosystem complexity is critical to understanding how wildlife responds to human activities that continually alter ecosystems spatially and temporally (Cagnacci *et al.* 2010).

Simplified, telemetry is a locational data gathering system that provides candid information for further use in research (e.g. behaviour and physiological parameters, habitat models; see Boitani and Fuller 2000). The role of telemetry in the EA process is to provide statistical power and biological significance to conclusions regarding animal movements and predicted project effects. Animal movements understood from telemetry can inform the scale of interpretation in EAs with respect to population surveys. Thus, cause and effect impacts (e.g., to animal distribution) from project activities can be further explored. For example, telemetry studies were used to assess changes in haul out distribution of harbor seals (*Phoca vitulina*) due to the presence of offshore wind farms (Dietz *et al.* 2003). Telemetry studies were also used to assess changes in fish migration due to hydroelectric facility activities (Scruton *et al.* 2002), and changes in habitat use of American martens (*Martes americana*) (Payer and Harrison 2003) and grizzly bears (*Ursus arctos*, Nielsen *et al.* 2004) in relation to forestry cutting patterns. These studies and others demonstrate that information collected through telemetry as part of baseline programs (i.e., pre-development) can be incorporated into environmental effects programs associated with industrial projects.

Various technologies exist for telemetry in animal ecology studies including Very High Frequency (VHF)-based technology, satellite, and Global Positioning System (GPS)-based. VHF-based telemetry was the original application in the 1960s before the advent of satellite and GPS-based modes. VHF-based telemetry involves the use of radio receivers in the field to pinpoint animals fitted with transmitters emitting specific radio frequencies (Craighead 1982). Satellite telemetry involves satellites to transmit location data sent by the telemetry unit on an animal to receiving stations on Earth (Mech and Barber 2002). GPS-based telemetry is a remote tracking system that allows animal locations to be determined with the use of multiple satellites and data collection systems (Cagnacci *et al.* 2010; CLS 2011). The goals of all three telemetry modes remain unchanged in their theoretical frameworks of uncovering the *hows* and *whys* of animal movements, resource selection, competition, mortality, and reproduction; in other words, elements related to understanding an animal's ecological fitness (Cagnacci *et al.* 2010).

A central question in telemetry studies is whether animals spend more or less time in specific habitats compared to what might be expected according to availability of those habitats (Rogers and White 2007). In other words, telemetry can look at the selective behaviors of animals. However, telemetry results demonstrate site preference, and do not necessarily indicate critical habitat areas (Rogers and White 2007). For identification of critical habitat types, researchers may need to conduct other types of studies such as manipulative and/or correlative experiments (e.g. Claudet and Fraschetti 2010). Telemetry is relied upon to illustrate individual animal habitat use, which is extrapolated to larger species-specific populations (e.g. Perrow *et al.* 2006). The use of telemetry in EAs follows this same framework in so far as project scientists undertake environmental baseline studies to acquire animal-specific knowledge (Clarke *et al.* 2003). Mitigation programs that are reliant on telemetry necessarily presume a deep understanding of habitat use and ecosystem intricacy.

However, I have observed that the use of telemetry information to quantify environmental effects is not as straightforward as EA practitioners would like. Though the theory of telemetry relies on the basic understanding of animal habitat use, the multitude of methods of analysis and reporting can confound the results of effects assessment. The common goal of telemetry analytical methods is to advocate home ranges as 95% of the overall intensity of habitat use. This is known as the Utilization Distribution of lands (or water for aquatic organisms) (Seaman and Powell 1996). Generally, home ranges are defined as areas used by an individual animal for daily life activities such as foraging, mating, and nurturing young, and include core areas and crucial space use such as denning sites for bears (Burt 1943; Larkin and Halkin 1994). In telemetry applications, core areas of home ranges are defined as those areas most frequented by an animal in a statistically clumped manner (Powell 2000). In general, maintaining objectivity is a key element for demarcating home ranges of animals; the process must be repeatable and accurately portray the overall use of space without succumbing to Type I and Type II errors (see Table 3.5 for definition) (Marcot 1998; Van Emden 2008).

Although it is a powerful informational tool, telemetry in wildlife mitigation is not an apparent or obvious discipline with readily available protocols for use in EAs. This lack of guidelines may be associated with the imposition involved in detailing all telemetry-related decisions that few users have the time to outline. Nevertheless, as the results of telemetry are funneled into data sources, along with literature reviews, and expert-based estimates, wildlife mitigation may be said to be dependent on telemetry studies (if they are undertaken) under the presumption that the results are relevant to the expected environmental effects of an industrial project. The deduction that occurs from baseline telemetry results in visualizing environmental effects of industrial projects. These visualizations (e.g., satellite imagery) aid in designing adequate mitigation. This process is the critical step that requires checks and balances to ensure environmental sustainability is a main goal, as required by the *Canadian Environmental Assessment Act* (CEAA) (1992).

Scientific uncertainty may be reduced with telemetry since the data may provide accurate and precise real-time information (though unlikely with VHF telemetry; Obbard 2013 pers. comm.), provided all parameters are stable and telemetry units are functioning properly. For example, the Integrated Ocean Observing System (Moustahfid *et al.* 2011) allows researchers to establish baseline conditions with respect to marine animal movements and migration patterns in anticipation of future anthropogenic disturbance. Scientists involved are able to formulate models on marine habitat usage and improve marine spatial planning with the use of telemetry observations and applications. In other cases, telemetry is one of the only practical options for addressing questions related to fine-scale movements (Rogers and White 2007). Other authors (Cooke 2008; Hooker *et al.* 2007) state that telemetry is a chief contributor to the understanding of an animal's biology, behaviour, calculation of survivorship, spatial ecology, energetics, and physiology.

In contrast, the practical use of telemetry to inform EA mitigation is questionable at times due to the subjectivity involved when applying telemetry data to effects analysis. The telemetry analysis literature is an extensive collection of studies that demonstrate a variety of complex methods and programs (see Chapter 3 Appendix A for a review of telemetry parameters); it is easy for an EA practitioner or project scientist to become lost in a review of the multitude of papers (e.g. Harris *et al.* 1990 provide a literature review on techniques and challenges). For example, estimates of home ranges (e.g., Girard *et al.* 2002; Manly et al. 1993; Smith and Schaefer 2002) can be the result of a convoluted set of mathematical variables in telemetry software (see Chapter 3 Appendix A). These software variables are difficult to navigate, particularly if project scientists are trying to decide on appropriate species-specific parameters that are defensible ecologically, academically, and professionally, in an EA context. It would not be surprising if project scientists accepted results without being fully aware of their true meaning (let alone all the challenges involved with effects analysis, Baker and Rapaport 2005; Canter and Sadler 1997), and especially if under time and budget constraints.

3.3 A SWOT analysis of telemetry in an EA process

Many authors (e.g., Hebblewhite and Haydon 2010; Cagnacci *et al.* 2010; Gau *et al.* 2004) have already undertaken the task of weighing the pros and cons of telemetry in animal ecology, but none have examined the role of telemetry in baseline studies of EAs. Using the Nalcor Project (Nalcor Energy 2009) as a case study, I examined the use of telemetry in the realm of species-specific mitigation development. Mitigation development is the term I used to describe the act of drafting mitigation programs to address adverse environmental effects from proposed industrial projects. Specifically, I assessed the utility of telemetry in mitigation development using the Lower Churchill case and associated telemetry study used for black bear (*Ursus americanus*) (conducted by Minaskuat Inc. 2009). Although I was directly involved in the Minaskuat Inc. (2009) telemetry study and Nalcor Energy EIS (2009), I used only publicly available documents in this chapter. I exhibited how telemetry is applied under the auspices of the EA process, which is stated to be a public, transparent, and accountable process (CEAA 2006).

I conducted a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis (Johnson *et* al. 2008; Weihrich 1982) to examine the role of telemetry in mitigation development. The SWOT analysis incorporates a breakdown of the elements of telemetry for the purposes of creating a strategic matrix that assesses the conditions under which telemetry is a practical and useful tool for wildlife mitigation. Though commonly found in business practices, the use of a SWOT analysis is gaining popularity in a natural resource management context (e.g. Diamantopoulou and Voudouris 2008; Kajanus *et al.* 2012; Paton *et al.* 2004; Robins and Dovers 2007).

SWOT analysis is a means to frame benefits and costs in a clear and repeatable exercise in three main phases illustrated in Figure 3.1. For this work, I first defined and catalogued elements of telemetry that are applicable to a mitigation development context. Second, these elements were tabulated to identify interactions. Third, interactions of the elements were tabulated to formulate strategies under specific costs or benefits settings. These strategies were further examined as a whole, and strategic approaches were identified to guide the development of the conditions under which telemetry is an applicable tool for mitigation development.

Phases of a SWOT analysis

Phase 1: Catalogue and Definitions

Category	Item	Definition	Justification
Strength	S1, etc.	S1, etc.	S1, etc.
Weakness	W1, etc.	W1, etc.	W1, etc.
Opportunity	O1. etc.	O1. etc.	O1. etc.
Threat	T1, etc.	T1, etc.	T1, etc.

↓

Phase 2: SWOT Interaction Matrix

Matrix	Strength	Weakness
Opportunity	S1 x O1, etc.	W1 x O1, etc.
Threat	S1 x T1, etc.	W1 x T1, etc.

↓

Phase 3: SWOT Strategic Matrix

Matrix	Strength	Weakness
Opportunity	Strategy, etc..	Strategy, etc..
Threat	Strategy, etc..	Strategy, etc...

Figure 3.1: Three phases of a SWOT analysis. Adapted from Johnson et al. (2008) and Weihrich (1982).

3.4 Dimensions of mitigation: magnitude, reliability and adaptability

Telemetry is used in wildlife habitat models to understand animal movement patterns. I hypothesized telemetry to be an appropriate fit for wildlife mitigation development in EAs, under particular conditions. To formulate these conditions, I examined the dimensions of mitigation that are applicable to the settings of EAs. To that end, I explored the dimensions of magnitude, reliability, and adaptability in the context of telemetry and wildlife mitigation (i.e., black bear in the Nalcor Project). Magnitude of telemetry in mitigation refers to the spatial and temporal scope of a project, which is applied to the extent of mitigation required to address adverse environmental effects (Sadar 1996). Reliability refers to the dependability of telemetry as a relevant tool to address the needs of mitigation development (e.g., confident data). Adaptability refers to the flexibility and renewability of telemetry as a useful tool in a process that requires some elasticity to account for unexpected results. I discussed these dimensions of mitigation to provide the basis for optimizing the use of telemetry in the mitigation development phases of the EA process. Thus, in concert with the results of the SWOT analysis, the discussion of the dimensions of mitigation is used to formulate the conditions under which telemetry can be used in mitigation programs in other EAs, provided they are similar in scope to the Nalcor Project (2009).

3.5 Methods

3.5.1 Study Profile

The Nalcor Project produced three volumes of text released to the public domain on March 9, 2009 and was approved for project completion on March 15, 2012 though controversy is ongoing (Nalcor Energy 2012). The second volume (*Volume II: Biophysical Assessment*, Nalcor Energy 2009) contained the environmental effects assessment, including the analysis of the terrestrial environment. The Nalcor Project (2009) fell under the CEA Act (1992), and the EIS was composed following common guidelines for EAs (i.e., after Beanlands and Duinker 1983). Beanlands and Duinker (1983) recommended the selection of Valued Ecosystem Components, which are elements of the natural and human world considered valuable to the public (e.g., coastal forests, shorebirds, as indicated Lechine and Peterson 2007). Key Indicators (i.e., species) within Valued Ecosystem Components were selected for their presence and reflection of environmental conditions (see Beanlands and Duinker 1983, CEAA 1996, Hegmann *et al*. 1999). Nalcor Energy (2009) divided the effects assessment into existing knowledge and evaluation of potential impacts for each Key Indicator (e.g., black bear) within each Valued Ecosystem Component (e.g. terrestrial ecosystems) according to three main issues: change in habitat, change in health, and mortality. Nalcor Project phases were construction, operation, and maintenance. Activities within project phases were evaluated for their possible interaction with Key Indicators. These evaluations were described and referred to throughout the assessment. I highlighted these interactions in Tables 3.1, 3.2, 3.3, and 3.4.

Nalcor Energy (2009) defined magnitude of environmental effect as the "extent of change from the baseline state" (Volume IIB, p.5-16). Nalcor Energy (2009) chose values of extent of change as: "low" meaning <5 percent, "moderate" meaning >5 and <25 percent, and "high" meaning >25 percent. The extent of change was based on the "assessment area population or habitat [that] will be exposed to the effect" (Volume IIB, p.5-16). Nalcor Energy (2009) further defined effects criteria using magnitude and duration. Magnitude was the geographic extent or physical area where interactions were expected. Duration was the generation time over which the effect was to occur. Similar minimum and maximum criteria of "low", "medium", and "high" as described above were applied. The criteria used for assessing level of interaction between the Nalcor Project and Key Indicators was used to conclude that while most effects were adverse, they were also not significant. Determination of significance (see Lawrence Environmental 2000; Lynch-Stewart 2002) was limited to residual effects. Residual effects were those effects considered after mitigation was incorporated into project design and that would cause a decline to sustainable populations, in this case to black bears of the region.

Nalcor Energy (2009) identified project activities and physical works that are anticipated to interact with each Key Indicator, including black bears. Table 3.1 demonstrates Nalcor Project items according to each Nalcor Project phase with specific attention to those activities and elements that Nalcor Energy expected to interact with black bears. Although ranks were provided, the methodology for ranking criteria and decision-making was unclear in the Nalcor Energy (2009) reports. Yet, a description for "measurable parameters for terrestrial environment Key Indicators" was included in later sections (see section 5.4, Nalcor Energy 2009). The measurable parameters were intended to guide each effects assessment as they related to a change in habitat, change in health, or mortality for each Key Indicator. It was unclear whether the parameters were related to the interaction analysis - the examination of the interface between each Key Indicator and Nalcor Project activity. Also, the origin of the three elements named measurable parameters (change in habitat, change in health, and mortality) chosen as the core for the effects assessments was unknown.

Table 3.1: Summary of Project interactions with black bears adopted and modified from Nalcor Energy (2009). Rankings indicate level of interaction according to the need for an environmental effects assessment. "Nil" indicates the assessment was not required, "Low" indicates effects were anticipated and can be mitigated through standard environmental protection measures. "High" indicates effects required a thorough investigation with an effects assessment.

Project Phase	Interaction Rank of Project Phase with Black Bears
Construction: • upgrading and constructing site access roads; • site preparation and construction of site buildings; • excavation for and installation of generation components; transmission line construction; • camp operations; • quarrying and borrowing; • reservoir preparation; • impounding; • transportation and road maintenance	High
Operation and maintenance: • water management and operating regime; • site waste management; • inspection, maintenance, repairs along transmission line; • transportation / presence and maintenance of access roads	
Accidents and Malfunctions: • dam failure • forest fire	
Construction: • concrete production; • site water management; • vehicular traffic on-site	Low
Operation and maintenance: • operation of generation facilities; • employment	
Construction: • employment; • expenditures	Nil
Operation and maintenance • expenditures	

The measurable parameters described by Nalcor Energy (2009) included basic definitions for each of the three effect categories: 1) change in habitat was measured by assessing the proportion of primary habitat altered or lost, mainly due to reservoir creation; 2) change in health was measured by comparing the life history of black bear to the life history of osprey (*Pandion* *haliaetus*). Osprey was used as a relative indicator due to its position in the aquatic food web since the change in health in this EA was noted to be primarily related to methyl mercury presence in aquatic ecosystems following impoundment; and 3) change in mortality was measured by determining the number of individual losses in relation to the total population in the assessment area. Specific criteria for assessing changes to each of the measurable parameters are listed in Table 3.2. Nalcor Energy (2009) did not specifically indicate which criteria applied to which effect category and thus the reader must assume that all criteria may apply to any of the effect categories. Nalcor Energy (2009) did not list the derivation of these criteria, or offer specific definitions beyond what is shown in Table 3.2.

Table 3.2: Criteria used to determine effects of the Project on the Key Indicator Black Bear by Nalcor Energy (2009).

Measurable Parameter / Effect Category	Criteria Used to Determine Change	Description of Criteria
Change in habitat Change in health Mortality	Nature	Adverse, positive, or neutral long term environmental effects on the key indicator
	Magnitude	Extent of change from baseline, in terms of amount of population or habitat exposed to effect: Low: less than 5% Moderate: 5 to 25% High: more than 25%
	Geographic extent	Actual area where interaction is likely to occur: Site-specific: within Project footprint. Local: within greater Project area Regional: throughout greater Project area and beyond
	Duration	Time of effect: Short-term: less than one generation Medium term: one or two generations Long term: several generations Permanent
	Frequency	Number of times Project will have an effect: Once Sporadically, irregular intervals Regular basis, regular intervals Continuous Unlikely to occur
	Reversibility	Adverse effect is: Reversible Irreversible
	Ecological context	General characteristics of area with respect to existing levels of human activity: Undisturbed: area not adversely affected Disturbed: area previously affected or still present
	Level and degree of certainty of knowledge	Low High
	Likelihood	Unlikely to have a significant adverse residual effect Likely to have a significant adverse residual effect

The measurable parameters (change in habitat, change in health, and mortality) provided a means for Nalcor Energy to determine if a deviation from baseline conditions was expected and if efforts should be made to address such deviations. In other words, the measureable parameters were the criteria used to determine if mitigation schemes should be developed. It should be noted that some mitigations were not specifically identified in EA documents (e.g., usually occurring in early discussions between EA practitioners and project proponents). Thus, where possible and where known, mitigation schemes were considered in the SWOT analysis (Tables 3.3 and 3.4).

Table 3.3: General mitigation practices described in Nalcor Energy (2009) (Volume II Part B, page 5-35, with additional specific effects management measures on page 5-36 in relation to Project activity). Mitigation categories are the same as those in Chapter 1 Table 1.1..

Project Activity	Potential Effect Relevant to Black Bear	Standard Mitigation / Design Relevant to Black Bear	Mitigation Category
Site Personnel and Environmental Awareness	Mortality	No harvesting policy. No firearms. No pets. Environmental Awareness Sessions. Tailgate Environmental Briefings/Tailgate Safety.	Education and outreach
Surface Disturbance	Change in habitat.	Project design – limits surface disturbance, use existing disturbed areas as much as possible. Sensitive periods for animals are incorporated into Project schedules.	Zoning/mapping for human associated structures. Temporal plans and modifications.
Access Roads	Change in habitat. Mortality.	Restricted access roads. Posted speed limits. Road infrastructure included in impoundment area.	Zoning/mapping for human associated structures.
Noise	Change in health.	Regular vehicular maintenance.	Zoning/mapping for wildlife
Rehabilitation Following Construction	Change in habitat.	Rehabilitation Plans. Project EPP. Natural revegetation applied where possible. Restoration of natural drainage areas. Reestablishment of stable gradients. Compacted land will be loosened. Grading for permanent drainage and reduction of erosion. Temporary access roads reverted, scarified for regeneration. Temporary bridges removed. Roadside ditches filled in.	Wildlife habitat enhancement. Zoning/mapping for wildlife.
Blasting	Change in	Blasting mats applied.	Zoning/mapping

Project Activity	Potential Effect Relevant to Black Bear	Standard Mitigation / Design Relevant to Black Bear	Mitigation Category
	habitat.	Blasting patterns and procedures to minimize shock, landscape defacement, and instantaneous peak noise levels. Blasting scheduled outside of winter months to protect denning bears.	for human associated structures. Zoning/mapping for wildlife. Temporal plans and modifications.
Construction Camps – Waste Management	Change in health. Mortality.	Environmentally acceptable sewage effluent practices. Bear-proof containers, and proper food storage management. Regular transport of waste to town landfills. Electric fencing around selected sites.	Education and outreach. Zoning/mapping for human associated structures.
Hazardous Materials	Change in health. Mortality.	Fueling facilities and practices in accordance with regulations.	Zoning/mapping for human associated structures.
Quarries and Borrow Pits	Change in habitat. Mortality.	Project EPP and Rehabilitation Plans.	Zoning/mapping for human associated structures.
Transmission Line Vegetation Management	Change in habitat. Change in health.	Herbicides will be applied by hand from the ground. Herbicides applied to stumps of trees.	Zoning/mapping for human associated structures.

Table 3.4: Summary of the specific effects analysis with respect to the key indicator, Black Bear, as described in Nalcor Energy (2009). Measurable parameters are described on page 5-14, and existing knowledge on page 5-21. General mitigation practices are described on page 5-35, with additional specific effects management measures on page 5-36. Mitigation categories are the same as those derived in Chapter 1 Table 1.1. Mitigation sources are derived from an analysis of the Nalcor Energy (2009) text.

Potential Effect	Description / Method	Black Bear Effect Analysis Summary	Specific Mitigation Described for Black Bear	Mitigation Category	Mitigation Sources
Change in habitat	Primary habitat altered or lost. Project footprint considered less than 200km^2. Available alternative habitat looked at. Enhancement of	Loss of primary spring/summer habitat: 90km^2. Loss of primary fall/winter habitat: 101.5km^2. Number of displaced bears from primary	Vegetation management along transmission line for primary habitat (p.5-69). Proper waste management procedures at	Wildlife habitat enhancement. Wildlife habitat replacement. Education and outreach.	Habitat management: telemetry used to calculate habitat use. Waste management: best practices.

Potential Effect	Description / Method	Black Bear Effect Analysis Summary	Specific Mitigation Described for Black Bear	Mitigation Category	Mitigation Sources
	other habitat such as hardwood and marsh expected.	habitat: 40-52. Bears attracted to Gull Island camp site.	camps.		
Change in health	Life histories examined and compared to the key indicator Osprey, to provide relative perspective. Individual osprey are considered vulnerable to a change in health due to their dependence on the aquatic food web and the results of bioaccumulation.	Methyl mercury exposure expected to be limited and not at levels that will impact health. Bears attracted to camp sites, and interact with contaminants.	Proper waste management procedures at camps: personnel training, electric fencing, and nuisance bear program in effect.	Education and outreach. Deterrents. Aversive conditioning.	Health concerns: unknown. Waste management: best practices.
Mortality	Number of fatalities directly associated with the Project represented as a proportion of the total population in the Project assessment area	Vehicle collisions. Increased access to hunting/trapping opportunities. Euthanization of nuisance bears habituated to camp sites. Displacement of bears and exposure to predation. Drowning due to inundation; vulnerability considered high during Nov-Apr, and present during May-Oct.	Posted speed limits. Busing of personnel, driver training and awareness. Personnel forbidden to hunt or trap on site; restricted access roads. Access roads to be rehabilitated post-EA. Nuisance bear program (e.g. deterrents, site management, relocation, and euthanization as last resort). Flooding schedule sometime between Aug and Oct, outside of denning period.	Education and outreach. Wildlife habitat replacement. Deterrents. Aversive conditioning. Temporal plans and modifications.	Telemetry used to estimate denning period.

Tables 3.3 and 3.4 show a summary of the general and specific mitigation practices that are extrapolated from Volume B (Nalcor Energy 2009) in relation to black bears. I categorized each mitigation scheme according to the eleven mitigation programs in Chapter 1 Table 1.1. In general, Nalcor Energy's (2009) mitigation programs are not well described except in cases where a brief outline is provided to demonstrate standard mitigation practices applied to different Nalcor Project activities. Mitigation schemes are a core element behind the link between knowledge and understanding of the Key Indicators and Nalcor Project effects. Little is known about the local Labrador black bear populations (see Chaulk *et al*. 2005) in terms of estimates of density, carrying capacity, dispersal patterns and other crucial life history elements so the work by Minaskuat Ltd (2009) is an important contribution. A brief description of this study is provided in Chapter 3 Appendix A. However, it is unclear how the specific details of the telemetry analysis components (i.e. minimum convex polygons and kernel analyses) from Minaskuat Inc. (2009) were incorporated directly into the mitigation components in Nalcor Energy (2009).

For each effect category, Nalcor Energy (2009) determined whether general and specific mitigation measures applied to each Key Indicator (KI), including black bear, were adequate to render any residual adverse environmental effect as "not significant". Nalcor Energy (2009) stated that a high level of certainty of knowledge associated with the residual environmental effects predictions was based on an implicit understanding of baseline conditions and Nalcor Project interactions with each Key Indicator (p.5-78). The significance rating of environmental effects of the Nalcor Project's activities on black bears was directly linked with the use of mitigation programs to offset adverse effects. Throughout Volume IIB, Nalcor Energy described general and specific mitigation schemes to address potential impacts of the Nalcor Project. Though some mitigation schemes were not described as such, and others were referred to as environmental effects measures, I considered all possible mitigation initiatives with respect to the black bear effect analysis even if not specifically described as mitigation. I categorized the general and specific mitigation schemes as per the eleven mitigation programs that I identified and defined in Chapter 1 Table 1.1, to demonstrate how each scheme can be understood within the range of mitigation possibilities for black bears.

3.5.2 SWOT Analysis

I conducted a SWOT analysis to evaluate the magnitude, reliability and adaptability of telemetry to wildlife mitigation projects in EAs. I cataloged and defined items relating to each SWOT category. I provided justifications for each item to describe their classification as an S, W, O, or T. Strengths and weakness were identified as internal variables. Internal variables may be of high priority as they ultimately determined whether telemetry was a strong tool for mitigation (independent of the pressures of the external environment, following the methods of Weihrich 1982). External factors that may influence the use of telemetry in impact assessment studies were identified as opportunities and threats.

3.5.3The SWOT Interaction Matrix

The SWOT Interaction Matrix was a portrait of the interactions between the items listed in Table 3.5 (Weihrich 1982; Wheelen and Hunger 1995). I listed the internal and external items from each S, W, O, and T categories in the quadrants of the Interaction Matrix. I then determined if there possible points of exchange between each item. The worst-case scenario of exchange between items was based on a failure of telemetry and mitigation. A failure of mitigation was presumed to result in injured, ill, or dead bears to the extent that the survival of their population was jeopardized.

Following Weihrich's (1982) methodology, a "+" was used to indicate a match or an interaction and a "0" was used to indicate a very weak or nonexistent interaction between two items in the matrix. The "+" symbol was not used to indicate a positive interaction; this symbol only referred to an interaction that warranted further attention in the SWOT Tactic Matrix.

3.5.4 The SWOT Tactic Matrix

The purpose of the SWOT Tactic Matrix was to advance the Interaction Matrix to a strategic planning level (Weihrich 1982). Four end results were summarized: the SO, ST, WO, and WT Tactics (Weihrich 1982). The SO Tactic was considered the optimal status for the Nalcor Project since both strengths and opportunities were maximized (Kurttila et al. 2000; Weihrich 1982). I demonstrated the tactics that may allow EA practitioners to plan an internal application of telemetry as a benefit in the external environment to achieve the Nalcor Project's desired goals of minimizing its environmental impact through mitigation practices. The ST Tactics were those features that allowed an optimization of strengths to handle threats from the external environment. The WO Tactics were presented as opportunities for a proponent to engage systematic improvements; however, internal factors such as costs may hinder the success of such pursuits. The WT Tactics were potentially unstable states. In this unstable WT quadrant, telemetry should be abandoned since internal weaknesses can do little to nothing to overcome external threats.

3.6 Results

3.6.1 SWOT Definitions and Interaction Matrix

A listing of each SWOT was presented without priority sequence in Table 3.5. Each SWOT item was defined to provide a background and rationale. To reduce ambiguity, indistinctness, confusion, and doubt, items were not repeated in different categories. A total of 17 SWOT items were listed as follows: four strengths, seven weaknesses, four opportunities, and two threats.

Table 3.5: SWOT items and definitions

SWOT ITEM		DEFINITION	JUSTIFICATION
Strength 1	Relevant data	Data are considered relevant in terms of its representation of an animal's true behavior. The use of telemetry allows an animal to disperse and act more free and 'normal' due to the remote nature of data acquisition. The possibility of gathering data that are transient and sporadic in nature (e.g. a diseased animal) is increased and considered an added benefit of long term data collection. (Morton *et al.* 2003). Data collection via telemetry are also unimpeded by human observers and their biases. For example, data can be collected throughout time intervals that in the past researchers may not have been able to acquire (e.g. winter, darkness, migratory paths). (Hebblewhite and Haydon 2010).	Relevant data increases the validity of telemetry as an information tool for wildlife studies.
Strength 2	GPS telemetry	The use of GPS in telemetry enhances accuracy and precision of location data including habitat, movement, and predation and mortality events (Bacon *et al.* 2011; Girard *et al.* 2006). GPS technology allows remote recording and can also tabulate data for transmission at a later time when satellites are located directly above (Cagnacci *et al.* 2010; Cohn 1999; Girard *et al.* 2006). GPS-based systems use satellites as transmitters with receivers located in the telemetry units attached to an animal. The data is retrieved	The use of GPS boosts the utility of telemetry in terms of an augmented sense of reliability of data. GPS units require large batteries and are attached to animals by collars, which can be dissuading to researchers. However, technological advancements are

SWOT ITEM		DEFINITION	JUSTIFICATION
		through unit removal or remote download. (Mech and Barber 2002). In contrast, satellite systems involve the use of a platform transmitter terminal to emit a high frequency signal to satellites which apply the Doppler effect to calculate an individual animal's location. Platform transmitter terminals require large batteries and are attached to animals by collars, harnesses, subdermal anchoring, harpoons, or bonding to fur (Mech and Barber 2002; Taillade 1992).	always in the making for lighter and more efficient collars as GPS becomes the overall preference among animal research projects.
Strength 3	Dispersing animals	Telemetry in relation to impact assessment may best be applied to animals that are highly variable in terms of dispersal (Prichard *et al.* 2003). Knowledge of seasonal, annual, and multi-year movements is largely enhanced with telemetry.	Previously, ecological knowledge of dispersing animals was limited to animals that can be safely and practically ground-truthed for researchers. The use of telemetry allows investigators to acquire knowledge from a remote location, provided all things related to a functioning transmitting collar are working correctly.
Strength 4	Baseline study	Telemetry is a conduit for baseline studies involving wildlife, especially mobile and dispersing animals (Prichard *et al.* 2003). These baseline studies are vital to understanding industrial, development, recreational, and climate change effects on wildlife (Dyer *et al.* 2001; Hebblewhite and Haydon 2010; Sawyer *et al.* 2006).	Baseline studies provide the basis for assessing industrial effects on wildlife and wildlife habitat. Telemetry studies in general are the foundation of ecological and resource availability studies.
Weakness 1	Temporal and spatial scope	Telemetry is best applied over a large spatial dimension, depending on the dispersal patterns of the studied animal. Telemetry studies should expect to last as long as possible; for example, battery life for a collar placed on a large mammal (e.g. bear) is often set for 1.5+ years. However, telemetry is limited by the temporal and spatial distribution of sampling effort, e.g. accessible areas to researchers (Lewis *et al.* 2009).	Large and long temporal and spatial studies can lead to difficulties in locating collared animals, and in the worst case, a total loss of the animal.

SWOT ITEM		DEFINITION	JUSTIFICATION
Weakness 2	Small sample size	Often, a small sample size is a reality of telemetry studies, which can occur due to costs (Clark *et al.* 2006), and unforeseen realities of field work (e.g. equipment errors, malfunction, loss) (Hebblewhite and Haydon 2010; Prichard *et al.* 2003; Tomkiewicz *et al.* 2010). Researchers need to prioritize between sampling effort per individual or sampling size (Girard *et al.* 2006). A large sample size is ideal for data reliability, to reduce the impact of errors inherent with small sample sizes (Garton 2007), as well as to asses habitat use in areas rarely used by the species in question (Girard *et al.* 2006).	Population inferences from small sample sizes are less reliable and robust (Hebblewhite and Haydon 2010). Diagnostic time is needed to overcome or compensate for an unexpected loss of data (Perrow *et al*. 2006).
Weakness 3	Costs	A GPS collar can cost between $1,000 and $8,000, depending on specific items such as battery size, materials, data access communication, and complexity (Clark *et al.* 2006; Hebblewhite and Haydon 2010). A transmitter can cost around $3,000, with an Argos receiver around $1,500 per year (Cohn 1999). A VHF collar can cost between $200 and $600 (Tomkiewicz *et al.* 2010), however human and aircraft resources are needed to collect data which can add significant costs (Girard *et al.* 2006).	GPS collars require a sizeable amount of funding which can prevent many proponents from agreeing to use this tool to inform their impact assessments. VHF collars are more affordable, but require more human resource cost. However, there is a large reduction in accuracy and precision of data from VHF studies.
Weakness 4	Expert use to reduce user error	Behavioral data from satellites needs interpretation from conventional wildlife biologists, preferably with field experience to ground truth the data. Fieldwork and ground-truthing can add significant costs to projects. (Cagnacci *et al.* 2010; Cohn 1999). GIS background and experience is needed to process the data in relevant software, with the use of specific software applications. Also, some researchers may simply be not familiar with telemetric techniques that are available to best address their research question (Cooke 2008). NB: While less time in the field equates to cost-savings, Hebblewhite and Haydon (2010) caution that technology cannot substitute real experience and knowledge of the natural world.	The realities of a executing a thorough telemetry study can catch up to a project with the need to ensure experts from appropriate fields (e.g. ecology, wildlife biology, GIS) are on board.

SWOT ITEM		DEFINITION	JUSTIFICATION
Weakness 5	Collaboration	A combination of telemetry location data and other studies such as those using traditional ecological knowledge, physiological studies, ecological studies, and resource availability studies is often necessary to provide the "whole picture" perspective necessary for decision-making (Hebblewhite and Haydon 2010; Prichard *et al.* 2003).	Coupling telemetry studies with other ongoing studies can be time-consuming. A desire to avoid collaboration to save time and money may occur and impede the future of a project.
Weakness 6	Errors	Five main types of errors are prevalent in telemetry data: 1) spatial inaccuracy, 2) missing data, 3) duplicates, 4) field conditions, and 5) Type I and Type II errors. Spatial inaccuracy refers to location errors that are obviously mistaken (e.g. onshore for a marine animal), collected after mortality of the collared animals, collected prior to animal tagging, and outlier points within the animal's area but outside the calculated pattern of succession. Missing data refers to points expected in a succession but which are not present in the dataset. Though missing data in current GPS technology is rarely a problem (Obbard 2013 pers. comm.). Duplicates refer to sequential data points that are replicates in time. (Cagnacci *et al.* 2010; Eberhardt and Cadwell 1985; Prichard *et al.* 2003). Field conditions refer to characteristics that cause positional errors such as topography, weather, canopy cover, and animal behavior (Montgomery *et al.* 2010). Type I and Type II errors relate to confidence intervals and assumptions in research. Type I errors involves calculating false positives, while Type II errors involve calculating false negatives. (Marcot 1998). Further to errors, the illusion of precision refers to a false reliance on data to infer major conclusions when these should not be applied steadfastly (Hebblewhite and Haydon 2010).	The ability to correctly predict habitat and resource use by wildlife is diminished with imprecise and erroneous data.
Weakness 7	Large datasets for individual animals	Collars are set to transmit data at regular intervals, which can vary greatly depending on the needs of the researcher and the animal in question. Large datasets are generated due to collar transmission that occurs over long periods of time, which is an ideal goal of wildlife studies.	Large datasets can be cumbersome to manage, and can be easily improperly handled if too many project workers are involved in the data

SWOT ITEM		DEFINITION	JUSTIFICATION
		(Cagnacci *et al*. 2010).	processing. Mismanagement of large data is a reality of EAs performed by consulting firms that rely on many different departments in various locations to handle large components of projects.
Opportunity1	Impact assessment	Telemetry results are used to evaluate environmental effects of various industrial projects, for example wind farms (e.g. Perrow *et al.* 2006).	Expanding the use of telemetry beyond its intended purpose is an external opportunity that proponents can take advantage of to gather insights into the *whys* and *hows* of their project outcomes.
Opportunity 2	Advancements in technology	Many companies (e.g. Lotek Wireless, Newmarket Ont.) are improving their telemetry products in terms of progress in accuracy and precision, which inevitably leads to more reliability on results. Advancements in technology may lead to upgrades of various components (Clark *et al*. 2006). For example, batteries may be available in solar format for all animals, and will not be limited by size (Cagnacci *et al.* 2010). Other sectors employing telemetry (e.g. medical industry) will also lead to improvements in technology.	Enhanced telemetry may lead to a better understanding of wildlife and their relationships with their ecosystems.
Opportunity 3	Free market	Telemetry products are subject to a free market, and thus prices are driven by current economic trends. As prices drop over time, telemetry products and components will become more accessible to various project proponents. (Cagnacci *et al*. 2010).	As more project proponents are able to apply telemetry as an informational tool; telemetry will improve in utility, practicality, and reliability.
Opportunity 4	Conservation	The progress in ecological knowledge of wide-ranging wildlife has been enhanced significantly by telemetry studies in terms of foraging patterns, dispersal routes, and population distribution. Conservation projects have been able to reap the benefits of enhanced ecology through direct means such as reworking harvest management practices, implementing habitat (e.g. corridor, core area) protection, and cooperating across border (e.g. from	Conservation initiatives are crucial to environmental sustainability, particularly when beseeched as mitigation projects to offset industrial environmental effects.

SWOT ITEM		DEFINITION	JUSTIFICATION
		municipal to international) lines. (Chester 2006; Hebblewhite and Haydon 2010; Venkataraman *et al*. 2005).	
Threat 1	Animal welfare	Possible distress to animals is related to: 1) physical / physiological effects of having a semi-permanent device attached or fitted, 2) stress associated with trapping, handling, or housing events, 3) wounds and abrasions associated with traps, or improperly fitted devices and restricted movement, 4) disadvantage from conspecifics due to presence of foreign objects, inability to forage, thermoregulate, or groom (Cochran 1980; Morton *et al*. 2003).	Although many wildlife studies are approved by ethics and animal welfare committees and/or provincial and territorial government boards, many members of the public do not agree with such approvals and may have a bias against government and Western practices (e.g. see Inuma TV 2010, min 34.46; MOE 1998)
Threat 2	Hypothesis reformulation	The null hypothesis of telemetry studies in relation to environmental effects may lead to conclusions that indicate the wildlife study has no relevance to the proposed industrial project. Project proponents may pressure EA practitioners towards accepting the null hypothesis that indicates there is no effect between the industrial development project and the wildlife species and habitat in question. Reformulating a hypothesis during a study can result in baseline data being ignored in favor of accepting conclusions prior to the end of a study. Specifically, telemetry data may never be applied to mitigation programs in the case where these data are used to demonstrate that adverse environmental effects were not a cause for concern in the first place.	Rescinding an original hypothesis and adapting a new one as a study is ongoing is not an accepted practice in peer-reviewed science.

The SWOT Interaction Matrix (Table 3.6) demonstrated the interrelationships among items listed in Table 3.5. A list of explanations for each interaction was presented in Chapter 3 Appendix B. A total of 40 interactions were identified and 26 non-interactions.

Table 3.6: The SWOT Interaction Matrix. A "+" refers to a matched interaction (not necessarily positive), "0" refers to a weak or nonexistent interaction (adapted from Weihrich 1982). Each item listed, S1, W1, etc. corresponds to the item listed in Table 1.

SWOT Interaction Matrix			STRENGTH				WEAKNESS						
			Relevant data	GPS telemetry	Dispersing animals	Baseline study	Temporal and spatial scope	Small sample size	Costs	Expert use to reduce user error	Collaboration	Errors	Large dataset
			S1	S2	S3	S4	W1	W2	W3	W4`	W5	W6	W7
Opportunity	Impact assessment	O1	+	+	+	+	+	**0**	**0**	+	+	**0**	+
	Advancements in technology	O2	+	+	+	+	+	**0**	+	+	**0**	+	+
	Free market	O3	**0**	+	**0**	**0**	**0**	**0**	+	**0**	**0**	**0**	**0**
	Conservation	O4	+	+	+	+	+	+	**0**	**0**	+	**0**	**0**
Threat	Animal welfare	T1	**0**	+	+	+	**0**	**0**	+	**0**	+	**0**	**0**
	Hypothesis reformulation	T2	+	+	+	+	**0**	+	+	+	+	+	**0**

3.6.2 The SWOT Tactic Matrix

Interactions from Table 3.6 were explored to examine strategic choices. Summaries of the most palpable strategic options were provided in the SWOT Tactic Matrix (Table 3.7). Each cluster of interactions was analyzed in terms of ways that internal characteristics can overcome external stresses. For the SO and WO quadrants, a cluster of 13 interactions was identified per quadrant and discussed. For the ST and WT quadrants, a cluster of 7 interactions were identified per quadrant and discussed. The interactions were discussed in Table 3.7, which ultimately demonstrated the set of circumstances under which telemetry can be optimally used in wildlife mitigation development.

Table 3.7: Summary of SWOT Tactics. Each SWOT item is matched with the respective interaction to elicit strategic planning.

		STRENGTH		WEAKNESS
OPPORTUNITY	O1: S1, S2, S3, S4	Continue to apply powerful tools such as GPS telemetry in baseline studies used to assess environmental effects of industrial development on wildlife and wildlife habitat. Apply telemetry results further in the mitigation design process.	O1: W1, W4, W5, W7	Integrate planning as part of the EA process to expect and manage components of an impact assessment such as large datasets. Bring experts on board with the project early in the planning phase, and anticipate which studies will form part of the collaborative effort.
	O2: S1, S2, S3, S4	Stay abreast of advancements in technology. Seek training opportunities, review options and dialogues for personnel to be a part of to be able to make key decisions in the use of appropriate technology to specific projects.	O2: W1, W3, W4, W6, W7	Require that advancements in technology offer insights and ways to handle large datasets, reduce errors, and provide user-friendly interfaces. Pressure new devices to be more amenable in terms of costs, for example optimize the use of free software applications when designing data functionalities.
	O3: S2	Allow free market forces to influence GPS technology in the sense of smoothing the progress of making available a user-friendly, cost effective, reliable, and high-quality product.	O3: W3	Allow free market forces to reduce the costs of telemetry studies through competition, availability trends (e.g. supply and demand).
	O4: S1, S2, S3, S4	Apply GPS technology for dispersing animals in baseline studies to collect relevant data for conservation purposes. Apply conservation principles to mitigation programs, and use the results of telemetry in baseline studies to further promote conservation.	O4: W1, W2, W5	Insist on adequate and continuous funding, if needed, to ensure proper sample sizes in an animal research study. Default to the precautionary principle and allow conservation goals to take advantage of a project's large temporal and spatial scope.
THREAT	T1: S2, S3, S4	Follow established animal care protocols and consult with wildlife officials and veterinarians on species-specific issues with respect to telemetry studies. Document concerns and problems in baseline studies for future reference.	T1: W3, W5	Account for animal health practices and anticipate problems in budget allocations for telemetry studies. Invite different perspectives and consult with group leaders (e.g. First Nation chiefs and elders) on how they see fit for best practices with respect to animal research.
	T2: S1, S2, S3, S4	Establish well-formulated hypotheses at the study design phase and apply the most appropriate type of telemetry study to produce relevant data.	T2: W2, W3, W4, W5, W6	Invite experts early on in the study design phase to review hypotheses and methodology. Reduce costs by minimizing errors in data through consulting with researchers on similar projects.

3.7 Discussion

3.7.1 A strategic approach for applying telemetry to wildlife mitigation development.

The SWOT analysis is a method of strategic planning for an enterprise to evaluate its strengths and opportunities for the purposes of overcoming weaknesses and threats (Terrados *et al* 2007; Weihrich 1982). In this case, the SWOT analysis was presented as a means of assessing the relative applicability of telemetry as a tool in mitigation development. Tables 3.6 and 3.7 provide strategies in a format that emphasizes SOs overcoming WTs, however some conditions do not allow SOs to prevail such that WTs are negligible. The following discussion draws attention to those aspects of applying telemetry to mitigation development that are multifaceted and indistinct.

The SO quadrant (Table 3.7) draws out the most compelling aspects of the internal and external environments of telemetry in relation to wildlife mitigation development in the EA for Nalcor Energy (2009). The progress of GPS technology in recent years has increased its functionality and its use in wildlife studies has seen a widespread application from baseline to physiology studies (Rodgers 2001; Sampson and Delgiudice 2006; Smith and Cary 1997). Harnessing and promoting the breadth and depth of GPS technology for telemetry purposes is a wise approach for developers such as Lotek (Newmarket, Canada), Advanced Telemetry Systems (Isanti, MN), Televit/TVP Positioning AB (Lindesberg, Sweden), and Telonics Inc. (Mesa, AZ), all the while demonstrating that telemetry is a conduit for gathering relevant data. Providing a low-cost and user-friendly product of good quality is necessary to encourage widespread use of telemetry, particularly for analyses of habitat use in areas appointed for industrial development.

Though the SO quadrant demonstrates promising aspects of telemetry in wildlife studies, the WO quadrant exhibits obstacles to overcome. Fortunately, most industrial development projects that are of a large spatial and temporal scope can expect to generate a substantial profit relative to their investment for the EIS, and thus are able to budget for the cost of telemetry studies. In remote, inaccessible, and wild areas such as Labrador that have little academic and government investment in animal population trends, telemetry studies offer the means to gather important baseline information from which population trends can be assessed (e.g. Mace and Waller 1998). Conducting these studies as part of the EIS process is achievable provided the end goal is environmental sustainability (as noted in CEAA 2012 and 1992). Conservation efforts need to be directly related to project effects insofar as they are designed to offset adverse effects. Thus, conservation efforts should be able to take advantage of the large scopes that define the project. With large spatial and temporal scopes, however, the likelihood of a project affecting multiple users of the area is high. Thus an intricate network of collaboration is needed to uncover the whole picture, with many types of studies (e.g. multiple wildlife telemetry studies, traditional ecological studies, physiological studies) conducted simultaneously. For example, Lewis *et al.* (2009) provide evidence for a synthesis of indigenous knowledge and telemetry studies as a means for enhancing the limited knowledge base of beluga whale (*Delphinapterus leucas*) ecology. Lewis *et al*. (2009) manage to demonstrate that both Scientific (e.g., telemetry) and Traditional Ecological Knowledge data can be complimentary provided shortcomings are well understood.

Notably, to execute collaborative studies concrete planning is needed to overcome the large volume of data resulting from telemetry studies, as well as other research endeavors occurring on behalf of project proponents. Experts in respective fields need to be engaged early in the process to facilitate data management, impact assessment, and counsel on appropriate practices for mitigation development (Du *et al*. 2010).

Considering the EA mitigation settings, telemetry is still a viable tool for animal movement analysis. Telemetry is looked upon favorably by EA practitioners to facilitate environmental effects assessment of large-scale industrial projects (and those likely with budgets that can incorporate expensive baseline studies). Consulting firms of EA practitioners pride themselves on having qualified personnel on staff to handle any subject matter that arises when a project is proposed. Consulting firms often handle field operations, office protocols, public consultations, and scientific report writing. Consulting firms also assist with project and engineering designs, modifications, and alternatives. This work is done to fulfill their obligations to project proponents with respect to securing a path for project approval. Although a firm may be able to handle a great deal of topics through their large network of team members, there are dire consequences to consider. For example, the colloquial expression "too many hands in the same pocket" may apply.

The Minaskaut Inc. (2009) interim report for black bear demonstrates the results of the telemetry study used as a background for the environmental baseline study. Though some key members of the team are laid out in the report, the reality is that many other staff members involved in the study remain unnamed. For example, some of the staff members that are not listed are associates of the GIS department involved with data processing of the black bear telemetry files. Due to the tedious tasks involved in data processing, many members at different times (e.g., over several years) were involved at one point or another, even though the report only shows limited and pending data. The staff members (named and unnamed) were involved with selecting parameters, running software extensions, deciding on faulty data, securing clean data, and reporting results. While it may be possible to track important decisions that involved electronic communication (e.g. emails not yet deleted, meeting minutes), some decisions were left *ad hoc* and unreported. This is not uncommon in studies published in scientific peer-reviewed literature. Through no fault of any one person or persons at any consulting firm, the results may be disconnected with the final EA submission. However, as discussed by Glasson *et al.* (1997), a change in the quality of EAs can occur as more experienced professionals raise the benchmarks of standards. Disconnects between reality and EA documents may no longer by overlooked. For example, in some regions, consultants are accredited and thus held to high expectations of performance (e.g. the Institute of Environmental Management and Assessment in the United Kingdom, IEMA 2013) (Glasson *et al.* 1997).

Even with the best of intentions from experts providing advice to project proponents and EA practitioners, external threats to applying telemetry to wildlife mitigation development need to be taken into consideration and weighed against the internal strengths. Animal welfare concerns from the general public and scientific community are an external threat, well-documented and debated (Bekoff and Hettinger 1994). Protocols exist for chemical immobilization and other handling activities (e.g. guidelines are available that describe the minimum weight for an animal able to wear a collar, Kreeger 2012; Nielsen 1999). Various reviews (e.g. Hawkins 2004; MOE 1998) offer technical details for telemetry studies as a means of standardizing techniques to reduce animal suffering and errors of the types listed in Table 3.5. Essentially, it is the strength in numbers of past studies as well as the need to always seek improvement in methods that drives the formation of best practice protocols. Adhering to best practices is easiest when experts are consulted early in the EA process, but with caution to circumvent errors and avoid hypothesis reformulation (Table 3.5). Generally, the ultimate goal of EA practitioners is to advance an EA through the regulatory process unimpeded such that a project may be approved in a timely fashion. A common bias is to assume that the end project design will have insignificant residual (e.g. lingering post-mitigation) adverse effects.

Hypothesis reformulation is the inclination to modify an original hypothesis (e.g. a project will have negative impacts on a wildlife species) towards a particular bias as pressure mounts to formulate favorable conclusions (e.g., a project will not have negative impacts on wildlife species) (see Kutsukake and Castles 2001). Mitigation projects may be either embedded in project design as a means of accounting for hypothesis reformulation, or mitigation projects may never be fully developed as true project impacts are overlooked, ignored, or obscured. The latter set of circumstances is most alarming in areas that have potential for great environmental losses. For example, remote and inaccessible areas where ecological trends are not well understood may have a high potential for environmental loss due to industrial development (Foote 2012). Unfortunately, there are little to no internal strengths (Table 3.7) that can overcome the threat of hypothesis reformulation other than requiring that the most appropriate studies are drafted, executed as originally planned, peer-reviewed, and project proponents are held accountable to end results. The EA process is far from considering a regulatory change that can manifest this type of accountability, as currently the Canadian EA process does not have steadfast provisions for inquiries into results of baseline studies as well as mitigation development. However, the use of adaptive management may be a sound practice to overcome the perils of hypothesis reformulation. Adaptive management is a multifaceted approach to resource management that is acknowledged as a good fit for addressing environmental impacts in EAs from industrial development projects (Noble 2000). Experimentation is an inherent component of adaptive management and provides the mechanisms of learning and adapting policies to account for adverse effects or beneficial outcomes (Noble 2000). In this manner, adaptive management can allow alternative studies to begin where others have ended. This effectively removes the danger of irresponsible hypothesis reformulation and extends it to a useful learning process.

The combination of internal weaknesses and external threats create complex situations that may cause a downward spiral into inevitable demise if not properly addressed. Telemetry studies may be controversial at times, and inviting different perspectives into the EA process as legislatively required (see CEAA 1992, sections 18, 21.2, and 58) opens the door to hearing crucial points of view. For example, recent testimonies from Inuit elders demonstrated their perturbed opinions of scientific studies on polar bears (*Ursus maritimus;* Isuma 2010). Telemetry studies are viewed by elders as invasive and disturbing of individual animal fitness; ear tags are believed to affect hearing ability for hunting, and neck collars and immobilizing drugs are believed to affect mating and survivorship. Given these strong opinions of telemetry studies, collaborative efforts to complete these studies may be hindered unless such community elders are consulted well beforehand and brought directly into the research process. Admittedly, enabling early participation is much easier said than done as personal histories, biases, socioeconomic settings and conflicts, and general dismay with research or the proposed project can complicate the desire and will to contribute (Dietz and Stern 2008). Though etiquettes and sets of rules for consultation may be drafted, it is crucial to have all parties understand one another's background and culture prior to engaging in discussions. In this manner, discussions may progress towards compromise. There is currently a wealth of research and examples published on stakeholder consultation, negotiation, consensus-building, and facilitation (e.g. Doelle and Sinclair 2006; Fitzpatrick and Sinclair 2003; Robson and Kant 2007; Sinclair and Diduck 2001), but it should be noted that some endeavors may never be realized as some stakeholder settings are not amenable to progressive negotiations and consultations due to unresolved issues (e.g. land claim disputes) (Hipwell *et al.* 2002).

3.7.2 Dimensions of mitigation that can be achieved with telemetry: magnitude.

Mitigation projects for wildlife require a broad scope of application in terms of spatial and temporal extent. Successful mitigation may be defined as those projects that are able to offset adverse environmental effects from industrial endeavors, considering the magnitude of effects at the species level. Albeit somewhat arbitrary, at least a quantifiable measure of change is explicitly determined through which Nalcor Energy can be held accountable if environmental effects are deemed to be of consequential magnitude beyond what is expected in the EIS. Although Nalcor Energy (2009) lists general and specific mitigation items in Tables 3.3 and 3.4, the details of the mitigation items are lacking that would demonstrate how exactly the magnitude of effects anticipated through the effects prediction are precisely handled. As a side note, Nalcor Energy's values for minimum to maximum duration of effects are not traceable to scientific methods in peer-reviewed journals. Nevertheless, when designing appropriate mitigation projects it is important that the relative magnitude of mitigation match the same spatial and temporal extent of the expected effect to the species in question. Any mitigation efforts that are less in magnitude compared to the results of the effects assessment are likely to fail in their objective of offsetting effects in terms of species-specific changes in habitat, health, and mortality. Ideally, mitigation efforts should reach beyond the magnitude of effects to ensure environmental sustainability.

The role of telemetry in terms of spatial and temporal magnitude is generic in the sense that animal movement data informs the scale of interpretation of understanding populations; a wider range of telemetry data spatially and temporally presumably allows for a wider scope of understanding. Thus, mitigation projects require the largest magnitude possible of telemetry data such that multiple seasons or years of animal distribution and activity are available to correlate with short and long-term disturbances from industrial projects. Effective mitigation is possible with a solid understanding of baseline conditions, followed by a high degree of certainty with respect to impact prediction of an individual project upon wildlife and wildlife habitat. GPS telemetry offers a unique level of spatial and temporal data gathering ability with an acceptable level of precision and accuracy (Cooke 2008). This detailed degree may be challenging to obtain with traditional survey methods such as scat analyses, mark-recapture studies, area and/or time samples, and transect surveys (Braun 2005). When used properly (i.e. avoiding pitfalls of Table 3.5), telemetry applications can identify critical habitats and delineate geographic ranges of species at definite scales such as site-specific, regional, continental, and migratory over the course of detailed time intervals of hours, days, and years (Cooke 2008). In an archetype of telemetry, a continuous stream of data without gaps would be available from an animal throughout multiple periods of its lifecycle. Ideally, this information would be useful for detecting species-specific trends that can be applied to the population level (Clark *et al.* 2006; Cooke 2008; Mace and Waller 1998). Telemetry informs mitigation through the provision of baseline information but also through the need to determine habitats and sensitive periods (e.g. denning) that need extra attention for protection or improvement in mitigation projects. For example, if habitat is deemed to be fragmented during the course of an industrial development project, telemetry can inform which types of areas are crucial to a species and thus require provisions for some type of conservation.

Unfortunately, a wide range of telemetry data sufficient to cover the magnitude required for adequate mitigation is difficult to acquire given the costs of equipment and user-related challenges (see Tables 3.5 and 3.7). Researchers/project managers are wise to question the respective representation of telemetry data. The resulting number of collar deployments is almost guaranteed to be a small fraction of the overall population, and diversity of age class, sex, and personality should be kept in mind (Lewis *et al.* 2009). In general, individual animal variability can affect any animal research study. Similarly, the power of telemetry data is reduced by individuality, even when sample sizes of actual animals with functioning collars are high. Individual animal variability is a challenge since assigning causality of a behavior change to the population level may not be a true reflection of population trends. For example, bears are complex and attentive animals that are capable of learning from experience. Bears exhibit behaviors that can be committed to memory; adult females teach cubs when an advantage can be gained (e.g. new food source) (Mazur and Seher 2008). Insights may be difficult to gain from modeling average responses in bears since individuality may skew trends, and conclusions may not be applicable to the overall population (or species) (Powell *et al.* 1997).

It is still possible and worthwhile to delve into telemetry data to reveal patterns from individuals. These patterns can inform models that are plausible and testable for predicting changes to populations. In particular, movement data on a case by case basis are informative in so far as the data reflects a pattern that makes sense for a species. For example, Minaskuat Inc. (2009) discussed Bear 1096 as likely habituated to known food sources within the Town of Happy Valley-Goose Bay, Labrador (see Minaskuat 2009; Nalcor Energy 2009). Bear 1096 was trapped in town,collared in September 2006, and relocated 120 km west of the community. The telemetry results indicated that this male, Bear 1096, spent only 3 days at his release site and set on a return path to Town following his denning period over the winter months. Bear 1096 traversed difficult terrain and avoided traps to access a known food source to him in Town. This bear suffered the fate of habituated bears labeled as ‘nuisance’. Relocation did little to help this bear, and he was destroyed in July 2007.

The fate of bears involved in conflicts with humans, such as Bear 1096, is not uncommon as habituation to food sources often leads to problems of safety and personal protection (of the bear and involved humans) (Hopkins III *et al*. 2010). The telemetry results of Bear 1096 acknowledged that food sources and other tempting products around campsites need to be monitored carefully and bear-proofed adequately to avoid undue harm to bears (e.g. Hopkins III *et al.* 2010; Landriault *et al.* 2000). Unfortunately, lethal methods may be deemed necessary when aversive conditioning and deterrents no longer work (Hopkins III *et al.* 2010; Hristienko and McDonald 2007).. Human-bear conflict management as a mitigation program is more of a necessity that should be part of Nalcor Project design and for all industrial development endeavors within bear territories. As such, telemetry is an adequate tool for establishing the magnitude of such areas.

3.7.3 Dimensions of mitigation that can be achieved with telemetry: reliability.

Mitigation projects need to be dependable in terms of their ability to offset adverse environmental effects. The role of telemetry in the dimension of reliability of wildlife mitigation is a precarious one since telemetry provides the means for the characterization of individual animals, with room for subjectivity. Telemetry can provide a snapshot of how much individual animals will stray from the mean (e.g., how far an individual disperses from supposed core areas). Thus, telemetry can provide an overall picture of animal behavior that can be applied towards a better understanding of diversity (Cooke 2008). Mitigation efforts (e.g., conservation) that take into account individual variation of species displayed in telemetry results are better off for achieving their protection and preservation purposes. However, mitigation projects are inept at taking into account a large proportion of variation due to the need for an immediate process of developing mitigation projects. The immediacy is related to the need to complete an EIS in a timely manner. These short timelines result in a disregard for the need to fully research the ecology of the project area, which leads to an incomplete effects assessment and unsuitable mitigation. To this end, mitigation development is most likely based only in part on telemetry results and in part on expert opinion, past projects, creativity, and trial and error. Nevertheless, unsuitable mitigation through a lack of accounting for individuality in animals can lead to adverse effects (whether anticipated or not) of an industrial project, which defeats the EA and mitigation development process altogether.

Other aspects of reliability of mitigation that depend on telemetry for design and development are related to the details of dependability of telemetry data. Acquiring reliable telemetry data is an arduous task and can be directly related to performance of hardware components. Telemetry hardware involves items such as batteries, antennae, electrodes, o-rings, waterproof and shatterproof casings, collar materials, and other pieces that are combined in a form-fitted animal collar expected to be worn and to function for long periods of time. Gau *et al.* (2004) demonstrate that confidence in these parts to be operating at all times is impractical; the authors deployed 71 collars and were able to retrieve 58. Of the 58 recovered, only 38 performed to the computed schedule, 20 had a partial failure, and 13 were complete failures. Just prior to deployment, the authors had 10 other collars that malfunctioned and were returned to the manufacturer. Similarly, at the time of writing of Minaskuat Inc. (2009), 3 collars were dropped and retrieved, 2 collars were still active, 2 collars were dropped and not retrieved, 1 collar was lost, and 3 bears had been killed and collars retrieved.

Partial and complete failures of telemetry collars can occur for different reasons: improper collar-antenna orientation, weak or malfunctioning VHF beacon, timing shifts, and battery failure (e.g. Alibhai and Jewell 2001; Estes-Zumpf and Rachlow 2007; Johnson *et al.* 2002; Strauss *et al.* 2008). The worst consequence is not the loss of data but rather the recognition that those collars with complete failures after deployment are not retrievable, unless the researchers encounter the individual animals by chance or opportunity (Gau *et al.* 2004). Not only does the difficulty lie within the ability of the collar to communicate with the satellite, but Gau *et al*. (2004) remind researchers that location precision and accuracy is affected by satellite geometry. In May 2000, the United States government turned off a systematic feature of satellites known as Selective Availability. Selective Availability was deliberate timing error prevalent in the GPS system (Office 2000). The reliability of location data is presumed to be enhanced without Selective Availability, but GPS remains a system that may be subject to error at the whim of government handling. To circumvent failures with collars, Gau *et al.* (2004) and Schwartz and Arthur (1999) suggest researchers need to find the optimal collar performance as it may be subject to the length of deployment time. For example, these authors advise retrieving collars on bears after each field season and before the denning period; however these additional field operations would increase costs significantly to a study and stress to individual animals.

Telemetry studies can be said to fall under the auspices of science-based processes with the expectations of being repeatable, testable, and scrutinized. However, there are facets of telemetry studies that are subjective that can affect the reliability of subsequent mitigation projects, similar to results that become questionable in science-based research. As described earlier and in Chapter 3 Appendix A, the parameters and treatments used to generate MCPs and/or kernel estimates are based on judgments made by investigators. Hopefully these parameters are selected on the basis of the research question that is being asked. The subjectivity behind decision-making of these parameters renders it difficult to demonstrate that results are reflective of true patterns (or false trends) (Chaulk 2001).

Alternatively, these hardware and software problems listed above are less of an issue affecting reliability if proper study design is implemented from the beginning. This includes ensuring budgets are in place to adequately handle such challenges (e.g. funds for higher samples, malfunction buffers, and ground personnel). Ultimately, it is the responsibility of project managers to ensure study components are cared for to increase the probability of satisfactory and reliable results. Further, in the case of the consulting firm-project proponent partnership, the obligation to adhere to proper science protocols (e.g. sample sizes, software parameters) with sufficient funds falls on the proponent. This is largely due to the proprietary agreements that stipulate that proponents (not the consultant or the public domain) own the data, results, and reports. Thus, it follows that if proponents are the owner of these components, they have the responsibility of ensuring that animal telemetry studies conducted on their behalf are adequately funded so that consultants have the ability to hire staff familiar with telemetry datasets and appropriate analyses. An increase in the reliability of telemetry results in turn leads to an improvement of mitigation design. Relative to the overall budgets of industrial development, these costs are relatively minimal to the proponent (e.g., mitigation costs in a wind development project in Kansas were calculated as 0.57% of development costs, Obermeyer *et al.* 2011.).

Considering the ability to produce a replicable study is faltered by the amount of inconsistency that is possible with each telemetry endeavor, the reliability of telemetry in mitigation is not stable and the reproducibility of results may be open to criticism. This finding, however, is largely the result of systematic problems, and less the result of failed technology.

3.7.4 Dimensions of mitigation that can be achieved with telemetry: adaptability.

Adaptability in mitigation is a crucial component to overcoming unexpected challenges and problems, provided mitigation projects are designed to accommodate and incorporate future changes as new information arises. Provided all telemetry hardware components remain functional and original research questions have been addressed, adaptability of telemetry can be considered to be adequate. Telemetry data are collected per program schedule, and considering all aspects to be working as expected, these schedules can be modified to record different components as needed. For example, some collars are able to receive new schedules for data collection via upload through a handheld device or cell phone (Wisdom *et al.* 2006). The ability to reprogram data collection methods is essential for telemetry studies correlated with animal interactions with humans and human associated infrastructures, specifically as an industrial project progresses into construction and operation phases. Telemetry can offer insight into animal displacement as a result of altered habitats, including mortality-specific threats (Cooke 2008). Further, telemetry may be used for cause and effect studies related to population changes and connectivity, reproductive biology and potential, and home range shifts, in association with altered landscapes (Cooke 2008).

Conceptually known as Before, After, Control, and Impact (BACI), these types of studies offer a means for measuring effects of industrial projects using pre-development project information as a baseline from which to gauge changes during- and post-development project settings (Smith *et al.* 1993). Telemetry has a strong niche in BACI studies as it helps define critical habitats, while providing a means for monitoring changes directly and indirectly related to development projects. Direct changes include those exemplified by Nalcor Energy (2009) (see Tables 3.2, 3.3, and 3.4) such as change in habitat, health, and mortality. Indirect changes include those related to biological and environmental variables that may be independent of a project but can still be collected by telemetry sensors such as relative physiological condition (e.g. foraging activity, energetics, heart rate, body chemistry), and abiotic factors such as temperature (Cooke 2008). Recognizably, sensor technology still has a long journey ahead in providing a consistent relay of information. Nevertheless, the ability to modify the type of information (e.g. sensors, time intervals) that is gathered is a worthy component of telemetry in mitigation following the phases of BACI studies. Insofar as mitigation is used to offset expected impacts of a BACI study, the adaptability of telemetry allows mitigation itself to remain amenable to unexpected impacts as well. For example, suppose bear denning behaviour is not expected to be affected by reservoir impoundment of the Nalcor Project due to the understanding that bears do not frequent a particular area for that purpose. During denning periods, it may be acceptable to reduce the telemetry data collection time intervals to save battery and reduce data storage needs. Following impoundment, it would be imperative to verify this conclusion. If the initial expectation is found to be erroneous and bears are in fact displaced and disturbed during their denning period, the telemetry schedule can be reprogrammed. The adjusted schedule should collect frequent location and environmental data to further understand the change in bear behavior and habitat needs. Subsequently, mitigation projects would need to account for this unexpected impact and telemetry can provide a source of data to help facilitate mitigation design and monitoring.

3.7.5 Conditions for telemetry as a practical, useful, and applicable tool for mitigation development.

Considering the relevance of telemetry to mitigation development is debatable in terms of its reliability but yet suitable in terms of its magnitude and adaptability, the conditions under which telemetry is a practical, useful, and applicable tool for mitigation need to be clarified. Table 3.7 provides the general strategic planning viewpoint, and the following discussion based on the SWOT analysis demonstrates the conditions under which telemetry is most likely to be a successful tool. Success is measured by the ability to offset adverse environmental effects from industrial projects (provided a project is similar in scope and intent to Nalcor Energy 2009):

- Species-specific issues: telemetry studies need to be species-focused and species-specific matters need to be fully understood. Considering the case for black bears, several reviews provide guidance and explain limitations of various hardware designs such as ear tag transmitters (Serveen *et al.* 1981), implantable transmitters (Jessup and Koch 1984), and expanding breakaway collars (Strathearn *et al.* 1984) as they relate to a species' life history. For example, bears require collars with hardy transmitters and attachments that can withstand harsh and varying environmental variables such as cold winters, hot summers, and water immersion (MOE 1998). In addition, telemetry studies for bears need to contemplate the number of data points required to sufficiently exemplify home range size, and whether the number of collared individuals is representative of conclusions that can be drawn from collected data (MOE 1998). These statistical considerations should be deliberated prior to the beginning of a telemetry study, with a commitment to input as much effort as possible to collect collars from animals regardless of statistical power at the end of the study. Furthermore, given that little is known regarding the effect of collars on animal behaviour and fitness, telemetry studies should take into account any observed changes to animal survivorship and report any inappropriate conditions (MOE 1998).
- Large budget: a relatively large budget is required to account for initial costs and commitments of telemetry studies (MOE 1998), and to allow for unexpected costs. Gau *et al.* (2004) recommended that telemetry studies should accept a loss of resources in both time and money as part of the standard application of telemetry. For example, failed collars will cause a significant increase in research costs and troubleshoot time, which should be factored directly into original budgets for telemetry studies. Other unexpected costs are related to the implementation of mitigation projects, and their adaptability to

account for changing ecosystems. For example, a mitigation project that enhances foraging habitat may not be used by the species for whom the project was intended. Additional investigations or altering telemetry studies would need to be put in place to understand this new information, and the mitigation project may need to be altered, which can further increase costs.

- Support network with trust: an extensive support network is needed to maintain adaptability of mitigation projects, with telemetry as a tool that is dynamic and informative. A support network in terms of subject-specific experts (e.g. ecologist, engineers, hydrologists) including community elders and representatives (e.g. First Nations leaders, Aboriginal chiefs, community associations such as fish and game groups, and environmental groups) enables the failing or failed aspects of mitigation projects to be addressed thoroughly with as much stakeholder input as possible. Stakeholder input is invaluable (and required, CEAA 2012) to sustainable natural resource development. An extensive support network can delve into research aspects that can be obscure at times since generally, experts aim to keep abreast of latest research on topics related to their area of expertise. In fact, Gau *et al.* (2004) advocate patience and tolerance of losses in terms of time and money as a requisite for animal studies (e.g. telemetry) as others in the same field may solve similar problems. As solutions become transferable, experts are more apt to apply them in difficult scenarios if a supportive network is willing to abide by principles of trust, confidence, and respect. It is the initial establishment of reverential principles for communication and working conditions within a network of experts and elders that may avoid multistakeholder procedural difficulties such as untimely decisions due to miscommunication or conflict. For example, in cases where decision-making is imminent, trust amongst members of a fluid and transparent network would allow decisions to be made in a timely manner with sufficient confidence that all alternatives were considered in a well thought out process with all stakeholders' perspectives in mind. Granted that such a functional network is difficult and almost impossible to establish at times, every effort must be made to secure support for mitigation projects. Stakeholders may depend on these mitigation projects to reduce and offset adverse effects to the environment that each stakeholder is keen to protect, invest, or endorse.

- Willingness to change: the strength of character that allows individuals to be open and willing to change can be difficult in project development settings. Flexibility to address unexpected changes in ecosystems is necessary to move forward from lessons learned. Yet maintaining this flexibility is a challenge to incorporate systematically unless adaptability is a principle that is established in the development process. The ability to incorporate new information as it arises is the key to maintaining a dynamic mitigation program, particularly given that telemetry can be established as a continuous study over large areas which can provide essential data for observing ecosystem changes.

3.8 Conclusion

This chapter provides a SWOT analysis as a means to collect insights into the appropriateness of telemetry to wildlife mitigation. Though the link between telemetry and wildlife mitigation development is not an explicit association, this type of application can be heralded in impact assessment studies as a steadfast, advanced, and informational use of technology. Telemetry may unearth important patterns in animal ecology that otherwise would take many more years of ground-truthing to obtain. Yet it is important to note that while telemetry may be a conceptually simple tool in that its objectives are to provide specific and accurate spatial data, the integration of telemetry into wildlife mitigation development is a complex undertaking. Understanding the disadvantages and advantages of applying telemetry to mitigation is crucial to ensure that adequate attention is paid to the perils of telemetry and no animal suffers from a poor decision. Further, knowing how weaknesses and threats may be overcome with the optimal use of strengths and opportunities is necessary for strategic planning. The interactions derived when components from each SWOT are tabulated form the basis of tactical applications. These results along with the discussion of the dimensions of mitigation are combined to shape the conditions under which telemetry is a useful, relevant, and applicable tool for mitigation. In other words, applying the SOs to overcome the WTs is an ultimate goal that must be achieved to instill confidence in the results of telemetry from which to develop suitable mitigation programs.

This study comes at a time when criticisms of the Nalcor Energy EIS (2009) from various groups (e.g. Aboriginal, environmental) are rising as the Nalcor Project continues and passes through the phases of the EA process (see Bundale 2012; CBC 2012; White 2012). In reality, it is only a matter of time before members of the public scrutinize specific components of the EIS and undertake critical analyses. A large baseline study such as the black bear telemetry endeavor for Nalcor Energy (2009) has considerable potential to exceed expectations and surprise the Canadian public in achieving environmental sustainability. By navigating through and addressing the disadvantages of telemetry, a project proponent can use the advantages to further the objective of unearthing true baseline conditions. It is through the commitment to alleviate any changes to these baseline conditions by developing representative mitigation programs that a project proponent can ensure adverse effects were handled in a responsible and accountable manner.

Telemetry as a spatial tool in animal research has come a long way, and this chapter demonstrates that its relevance to mitigation is appropriate provided certain risks are known and handled well. Its use in the EA process is not new, but telemetry needs further investment to realize its potential in wildlife mitigation projects. Notably, it is the large-scale industrial projects that are likely to have the budgets to allocate to telemetry throughout a project as effects are predicted, tested, and confirmed. Alleviating adverse effects would only become easier when the impacts are better understood; essentially, a cycle of knowledge and investment comes to light when large-scale industrial project proponents and members of the public are content with the level of environmental sustainability achieved in a post-EA setting.

Recognizably, there are no legislative, scientific, or other dogmatic requirements to report any decision-making parameters. Consulting firms are privy to company proprietorship and firms are allowed to develop their own set of protocols, which may set one firm apart from the next. However, accountability for effects assessments are needed when natural resource development occurs to ensure the pledge to environmental sustainability is upheld at all times. The disconnect between the environmental baseline telemetry study of the black bears of the Lower Churchill River watershed and the resulting effects assessment with mitigation commitments can be remedied as it remains a systematic issue. This systematic problem needs to be addressed sooner than later, especially if and/or when regulators set out to follow through with legislative requirements of evaluating mitigation commitments for their effectiveness in offsetting adverse environmental effects from industrial projects.

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Chapter 3 Appendix A: Telemetry parameters and the Minaskuat Ltd. (2009) study

Many literary sources offer various techniques for telemetry analysis (e.g. Gautestad *et al.* 1998; Horne et al. 2007; Hurlbert and French 2001; Moser and Garton 2007), with most suggesting either polygons, kernels, or a combination of both techniques. Both techniques involve procedures that can be complex and imprecisely defined since neither technique has a common protocol with clear guidelines to follow.

Polygons are usually delineated with a 95% minimum convex polygon (MCP), which signifies the outer limits of an individual animal's movements (Hayne 1949; Powell 2000). MCPs are sensitive to exterior data points and outliers can influence delineations, hence the exclusion of 5% as outliers. These 5% outliers can be attributed to exploratory animal behavior (Powell 2000). On the other hand, interior data points do not affect MCPs and habitat preferences are associated with overlaying habitat types from satellite imagery or other vegetation data sources with animal movements.

Kernel home range estimators are used to represent probability of area use, and are usually based on normal (Gaussian) kernels (in other words, a normal shape of the probability distribution around each data point; Rodgers and Kie 2011; Rodgers and Carr 2008). Kernel estimates describe the intensity of use. Thus choosing a parameter known as bandwidth (h) is critical to representing Utilization Distribution correctly. For example, data may be undersmoothed or oversmoothed, so an optimal smoothing parameter is needed to ensure home ranges are not disjointed or oversized (Gitzen *et al.* 2006; Rodgers and Kie 2011; Rodgers and Carr 2008). Generally, the optimal smoothing (h_{ref}) parameter is not known prior to running analyses (Worton 1989), and two methods are known to select the appropriate h. The Least Squares Cross Validation (LSCV) score searches for the minimum bandwidth possible, which may result in a disjointed home range as it can undersmooth the data (Gitzen *et al.* 2006).

Another method known as the *ad hoc* smoothing parameter can be applied, which requires adjusting home ranges by changing *x* of h_{ref} in the software parameters. When the home range begins to break up, the immediate step before hand is the correct home range using *x* of h_{ref}. While simple and repeatable, this ad hoc method is crucial to note when reporting results since some software programs (see Larkin and Halkin (1994) and Lawson and Rodgers (1997) for a review) will not notify the user when a LSCV score is unattainable, and thus the *ad hoc* method is necessary. Another element to establishing kernel estimators is the use of fixed or adaptive kernels. While fixed kernels apply the same smoothing parameter for all data points, adaptive kernels allow for larger values of *h* (in other words, more smoothing) at the outer edges of data point distribution. In general, the choice of fixed or adaptive kernels has less impact on results versus the crucial choice of how the smoothing parameter was obtained (Gitzen *et al.* 2006).

Lawson and Rogers (1997) provide comparison studies of home range sizes using different software programs and methods. The authors used five software packages to compare home range calculations at different levels of data resolution, and found striking dissimilarities. For example, at the 95% resolution, the results of the kernel analysis ranged from 14.45 to 39.95 km^2, and the results of the MCP analysis ranged from 39.96 to 65.37 km^2. The authors could not dissect the decision-making algorithms in the software programs around key elements (e.g. choice of smoothing parameters, methods for excluding the 5% outliers). Thus, the need for and development of a supplementary program capable of outputting home range analyses at the level of competency for peer-review was borne as the Home Range Extension (HRE) created to function within ArcGIS (see Rodgers and Carr 1998, and Rodgers and Kie 2011). The HRE extension was developed to be able to report h_{lscv} / h_{ref} as a numerical value for the user to understand how the smoothing parameter was attained, as a relationship with h_{lscv}. In addition to bandwidth issues, Lawson and Rodgers (1997) cautioned that grid cell resolution could have an effect on home range estimates as well. The authors indicated that a coarse grid cell resolution almost always results in larger estimates, but grid cell size can also level off at a particular setting that needs to be confirmed by the program user. Another method of handling telemetry data has surfaced in recent years to handle accurate spatial data when time between data points is uncertain (Horne *et al.* 2007). The method of Brownian Bridges provides a means of analyzing animal travel paths based on the individual's start and end points, the time between these points, and rate of movement (see Horne *et al.* 2007; Sawyer *et al.* 2009).

In short, multiple settings for different parameters need to be established by telemetry analysts, and the most important decision-making element is to decide what is biologically reasonable and meaningful for the species in question (Kie *et al.* 2010). Also, a crucial component is to report which software packages, methods, and input values were used, and it should be kept in mind that even changing home range analysis software and values during the course of a study could invalidate results and entire research efforts.

The telemetry study conducted by Minaskuat Inc. (2009) used a combination of calculations of minimum convex polygons and kernel analyses to convey core areas of the local black bear population that may be affected by the Project. The data from GPS telemetry collars of four bears are presented, with the respective MCPs as follows: 1) male bear, 1,220 km^2, 2) female bear, 36 km^2, 3) male bear, 237 km^2, and 4) female bear, 18 km^2. Data from two of the four bears were further analyzed with habitat types for the 25 percent isopleths (in other words, core area) kernel areas. The female bear, 36 km^2 MCP, indicated a preference for dense coniferous forests followed by open and sparse coniferous habitat types. The male bear, 237 km^2, indicated a preference for herb habitat, followed by dense and open coniferous forests. Denning sites were analyzed and ground-truthed for all four bears. Preferences for sparse, dense, and open coniferous forests were noted. Ages of the bears were also reported (teeth extraction and classification through external laboratory analysis): 1) male bear (1,220 km^2 MCP), age 6+ years; 2) female bear (36km^2 MCP) age 5 years; 3) male bear (237 km^2 MCP), age 3.5 years; and 4) female bear (18 km^2 MCP), age 2.5 years.

It is unclear how the details of the MCPs and kernel analyses from Minaskuat Inc. (2009) were incorporated directly into the mitigation components in Nalcor Energy (2009). Notably, the burden of fault lies within the systematic setting of too many team members working under pressure to adhere to time and budget constraints. All too often, junior professionals are tasked with creating functioning drafts of results and reports to be edited by more senior professionals, with the main thought and decision-making processes unreported and completely lost in the shuffle. For example, how the standard and general mitigation practices were developed (Tables 2 and 3) is not presented in Nalcor Energy (2009). Moreover, the telemetry parameters described earlier that are selected by project staff that are necessary to include in methods and results is also unaccounted for, except perhaps in the notes of those personnel immediately involved with data processing for Minaskuat Inc.

Chapter 3 Appendix B: SWOT Interactions

Table 3.C.1: SWOT Interactions in Table 6 Explained.

SWOT Item-Interaction: Justification
O1-S1 Relevant data is imperative to conducting adequate impact assessments. O1-S2: GPS technology is not necessarily correlated with impact assessments, however the use of such an advanced tool improves the precision and accuracy of information used to assess environmental effects. O1-S3: Ecological knowledge of dispersing animals is vital to impact assessments provided these species are present in the project area. O1-S4: Impact assessments are next to impossible without baseline studies
O1-W1: Impact assessments are relative to proposed project areas that may necessitate large and long temporal and spatial scopes. O1-W2: A small sample size is only relevant to impact assessments if inadequate results of an effects assessment are related to a small sample size. O1-W3: Costs of telemetry are only related to impact assessments in the sense that the proponent carries the burden of the study. Telemetry costs should not affect the execution of the impact assessment since funding for each should be provided from different sources, yet under the same project umbrella. O1-W4: Expert use of telemetry is related to impact assessments in so far as experts review overall results and conclusions as part of the quality control and assurance process. O1-W5: Collaboration is an essential part of impact assessments without which the overall environmental impact statement may be weak and inapplicable. Collaboration in telemetry contributes to the comprehensive knowledge base required for good quality effects assessments. O1-W6: Errors in telemetry could have drastic effects on impact assessments if information is unreliable to the point of being discredited. However, no such cases are known to have occurred in the past, and this event is highly unlikely. O1-W7: Large datasets are inherent in impact assessments, and practitioners often have adequate means for data management. Telemetry datasets should not be much of an imposition to maintain. However, some companies experience a high turnaround for employees, in which case data may be lost, manipulated, or rendered inaccessible.
O2-S1: Relevant data is closely linked to advancements in technology. O2-S2: GPS telemetry was not possible without O2-S3: Enhancing ecological knowledge of dispersing animals is feasible with advancements in technology. O2-S4: Advancements in technology help support and refine environmental baseline studies. O2-W1: Advancements in technology are largely called upon to handle large projects in terms of temporal and spatial scopes. O2-W2: Advancements in technology will not likely be a solution for solving issues related to small sample sizes. O2-W3: Advancements in technology can have positive and negative impacts on costs depending on which elements are affected (e.g., improved batteries can add cost, a reduction in materials can decrease cost). O2-W4: Advancements in technology can have positive and negative impacts on dependency on experts. For example, an increase in complexity in software and hardware components may require more experts. Alternatively, advancements may lead to more user-friendly elements of a telemetry study. O2-W5: The need for collaborating telemetry with other studies will always be a necessity for a complete study regardless of future technological improvements. O2-W6: Advancements in technology can have positive and negative impacts on errors. Technological enhancements can either create more errors or solve problems depending on the specific factors that are being worked on. O2-W7: Advancements in technology are likely to increase resulting datasets as more options are added to a study. For example, collars nowadays are able to gather information related to more than just dispersal

SWOT Item-Interaction: Justification
and can include sensory information related to temperature, mortality, and other physiological and environmental variables.
O3-S1: Free market forces do not have linkages with relevant data other than requiring a reliable product to be available to project managers running telemetry studies. O3-S2: GPS telemetry will be sought after as it becomes more available with decreasing costs in a free market economy. O3-S3: Free market forces do not interact with dispersing animals. O3-S4: Baseline studies do not interact with free market forces except in the sense that environmental consulting companies are often involved in a bidding process to conduct baseline studies. Regardless of the bidding process however, the need for baseline studies involving telemetry is a component independent of free market forces.
O3-W1: Free market forces are not relevant to telemetry temporal and spatial scope. Free market forces are however relevant to overall project need in the greater scheme of environmental sustainability. O3-W2: Free market forces are not interact with sample sizes of a study employing telemetry. O3-W3: Free market forces affect costs and drive a product's trading value. O3-W4: Free market forces do not interact with the need for experts engaged in a telemetry study. O3-W5: Free market forces do not interact with the need for collaborating studies to strengthen the results of a telemetry study. O3-W6: Free market forces do not interact with errors that are commonly associated with telemetry analysis. O3-W7: Free market forces do not interact with large datasets that are products of telemetry studies.
O4-S1: Conservation is proportional to relevant data in the sense that appropriate conservation projects can be determined more effectively with data directly pertaining to a specific species. O4-S2: Conservation programs can be enhanced with GPS telemetry, however they can be designed and implemented independent of telemetry studies. O4-S3: Conservation initiatives for dispersing animals are difficult yet crucial to preserve biodiversity and essential habitat. O4-S4: Baseline studies are an important element to conservation projects, particularly in Before, After Control, Impact type studies.
O4-W1: Conservation projects can benefit from large temporal and spatial scopes due to the potential for sites or initiatives set aside and managed for conservation purposes. O4-W2: Conservation projects are not particularly related to small sample size except in the sense that an opportunity for habitat or species protection may be missed if data are not processed appropriately and population trends are misunderstood. O4-W3: Conservation initiatives should not be affected by costs of telemetry studies since funding for either path related to an environmental impact statement should be derived from different sources. O4-W4: Conservation initiatives are not related to expert use of telemetry except in the sense that misinterpretation of data could result in a lost opportunity to establish adequate conservation measures. O4-W5: Conservation initiatives are linked to collaborating studies in telemetry since most conservation projects could not be successful without a full understanding of all the ecological, physiological, biological, and socioeconomic aspects of the area. O4-W6: Conservation initiatives are not related to errors in telemetry except in the sense that misinterpretation of data could result in a lost opportunity to establish adequate conservation measures. O4-W7: Conservation initiatives are not related to the upkeep and handling of large datasets.
T1-S1: Animal welfare during a telemetry study is not related to the data obtained from the collars. T1-S2: Animal welfare is related to the advent of GPS telemetry, similar to VHF telemetry. The physical placement of the collar and data sensors is important aspects of an appropriate telemetry study. If a collar is misplaced on an animal, data collection may not be possible or the results may not be representative of the animal's behavior without a collar. Data sensors such as temperature, mortality, etc. are more capable with GPS telemetry.

SWOT Item-Interaction: Justification
T1-S3: Animal welfare can be gained for dispersing animals during a telemetry study. Physical observations of an animal can help understand physiological conditions of individuals of the study. T1-S4: Animal welfare during a telemetry study can inform baseline studies in the sense that field observations can become a part of the knowledge base of an animal's body condition, and habitat.
T1-W1: Animal welfare is not related to large sample sites. T1-W2: Animal welfare is not related to small sample sizes. T1-W3: Animal welfare may be related to costs of a telemetry study only in the sense that provisions for animal care and concern should be embedded in the budgets. T1-W4: Animal welfare is not related to expert use of telemetry software and processing. T1-W5: Animal welfare is only related to the collaboration of studies in the sense that project team members should be aware of the latest research on animal condition during and subsequent to immobilization, and during the entire period an animal is to carry a collar. T1-W6: Animal welfare is not related to errors associated with telemetry data collection and processing. T1-W7: Animal welfare is not related to the large datasets that are the products of telemetry.
T2-S1: Integrative hypothesis testing may manipulate the use of relevant data for specific project purposes. T2-S2: GPS telemetry is used to test a specific hypothesis and the results may be ignored or used in an appropriate manner with integrative hypothesis testing. T2-S3: Integrative hypothesis testing may misinform information gathered regarding dispersing animals. T2-S4: Integrative hypothesis testing may adjust procedures used to perform baseline studies.
T2-W1: There no relation between integrative hypothesis testing and spatial and temporal scopes of a study since a change in hypothesis can occur regardless of scope of project. T2-W2: Small sample size may a direct cause for integrative hypothesis testing. T2-W3: Depending on the cause and outcome of integrative hypothesis testing, cost-savings may be a benefit. T2-W4: Depending on the cause and outcome of integrative hypothesis testing, experts to review adaptive science schemes need to be on board to validate such changes. T2-W5: When telemetry studies are used to inform other studies part of the EA process and vice versa, adapted conclusions will unavoidably affect and influence other studies. T2-W6: Integrative hypothesis testing may be an error in and of itself. T2-W7: Large datasets are irrelevant to integrative hypothesis testing as they are more of a product of telemetry itself.

Chapter 4.0: Using qualitative interview data to improve wildlife mitigation policy in Canada

4.1 Introduction

Wildlife species and their habitats are affected by various industrial projects (e.g. hydroelectricity, Mahoney and Schaefer 2002; mining, Donato *et al.* 2007; oil and gas, Burke *et al.* 2012; wind energy, Lovich and Ennen 2013). Mitigation practices in Environmental Assessments (EA) are meant to offset adverse effects. In Canada, EA professionals are required by the *Canadian Environmental Assessment Act* (CEAA 2012) to present mitigation plans and programs to offset effects. However, the ways in which mitigation practices can alleviate adverse effects (e.g. avoid, eliminate, reduce, etc.) are complicated, risky, inconsistent, vague, and uncertain (CEAA 2012; Matthews *et al.* 2009; Zedler 1996). For example, several studies (e.g. Clevenger and Waltho 2000; Gunson *et al.* 2011; Lewis *et al.* 2011) demonstrated species-specific considerations that should be taken into account by those building road underpasses and other structures intended for wildlife use. These species-specific issues may be overlooked by project engineers if they are unaware of such important ecological studies. This oversight may be due to a disconnect between science, practice and policy, which results in inadequate provisions for wildlife in mitigation plans. Other similar projects may follow suit, which leads to a precedent of inadequate mitigation. Thus, clarity with respect to the development and use of appropriate mitigation practices is required to navigate the legislated EA process and ensure effective mitigation.

Assessments of adverse environmental effects from industrial projects are performed by EA professionals in various occupation groups, depending on the nature of the proponent and the project. These assessments are derivatives of effects analyses in the larger context of the EA process and are generally fuelled by examinations of environmental baseline studies in concert with industrial project designs. EA professionals need to differentiate between changes in wildlife and their habitats as a result of natural (e.g., ecological) or anthropogenic (e.g., industrial projects) forces. Focusing on the latter, EA professionals use approaches to mitigate changes that may occur from the proposed development. In doing so, EA professionals become knowledgeable in wildlife mitigation practices. For the purposes of this study, these EA professionals are also known as wildlife mitigation experts. Importantly, wildlife mitigation experts are prevalent in environmental consulting firms, government departments, academic institutions and environmental non-government organizations (ENGOs). Environmental consultants (C) (e.g. personnel at firms such as Dillon Consulting Limited, LGL Limited, Stantec Consulting Limited) are hired by proponents of projects from industrial firms or governments (such as Enbridge, Nalcor Energy; see online CEAA registry) to pilot EAs including all aspects from baseline data collection, to effects analyses, to final EA submission. Government (G) personnel are sometimes proponents for development projects, or regulators receiving EAs and responsible for EA approvals and project permits. Academics and ENGOs ("O" herein signifies both groups) are involved as either independent specialists or advisors, and may be tasked with drafting components of EAs.

Motivations for developing mitigation plans in the EA process among the three occupation groups remain the same: to alleviate adverse environmental effects. However, the efficacy of mitigation may differ because of a paucity of data on the success and failures of mitigation practices. Wildlife mitigation experts' knowledge may contribute crucial information for understanding the current status of mitigation and identifying possibilities of improvement.

Specifically, expert knowledge is vital to uncover trends in mitigation practices since actual observations and relevant data may be limited or unavailable (i.e., undocumented).

In this study, I use qualitative interview data from wildlife mitigation experts to demonstrate that improvements to mitigation practices are imperative to addressing the main goal of CEAA, namely environmental sustainability (CEAA 2012). I demonstrate that an appropriate wildlife mitigation policy needs to be in effect to minimize further unknowns or negative effects due to industrial development.

4.2 Methods

4.2.1 Sampling and data collection

I solicited experts in Canada based on specialized backgrounds in wildlife mitigation specific to the EA process. I located pools of experts within federal and provincial government databases, environmental consulting firms, and professional organizations (e.g., the International Association for Bear Research and Management). I first contacted experts by email to request an interview and I sent survey questions prior to the interview as a Microsoft Office Word (Version 2007) attachment. I arranged phone interviews and I audio-recorded each session. Prior to beginning the interviews, I obtained participant consent to fulfill York University's human participant research protocol.

I collected demographics for each expert using five questions. The first question required experts to identify their occupation as environmental consultant, government employee, or academic and/or environmental non-government organization employee. If an expert identified two occupations, I held further discussions to identify the primary occupation. The remaining questions were 'yes' or 'no', which were: experience with large-scale industrial projects, experience with the Canadian EA process, and decision-maker for mitigation.

4.2.2 Experts' knowledge interviews

Qualitative interviews with the experts were structured around the definition and use of wildlife mitigation programs. Interviews were conducted using a semi-structured process; experts could identify other topics to discuss (Brod *et al*. 2009; Patton 2002; Ritchie *et al.* 2003). The survey involved five open-ended questions regarding 1) the definition of mitigation, 2) the decision to use and implement mitigation, 3) the upkeep of mitigation programs, and 4) the role of mitigation in the EA process.

I analyzed responses to questions by cross-tabulation and calculating Chi-square statistics to examine differences in proportions by occupation groups.

I audio-recorded, transcribed and imported interviews into the qualitative data analysis software Nvivo (QSR International Pty Ltd. Version 10, 2012). I created case summaries for each individual, which outlined the main issues and themes, essential information from each target question, items of a peculiar or special nature, items of a common nature, and new or remaining questions. I coded the interview transcripts to allow for cross-case comparisons for each of the four main questions, and I followed Braun and Clarke's (2006) methodology for inductive thematic analysis. In brief, I searched for patterns of meaning within the collective data of interviews, and sought themes to reflect reality. Braun and Clarke (2006) provided a means to maintain a consistent analysis by developing a parallel writing process while interacting iteratively with the data. In this manner, themes were induced throughout the entire coding, analysis, and writing processes.

I use participant quotations in this chapter to illustrate common themes or alternative perspectives. I omit all names to protect the identity of participants and I use identifiers next to excerpts in the following manner: government personnel (G), environmental consultant (C), and academic or ENGO personnel (O). Academics and ENGOs are grouped together based on their collective interest to challenge the EA process without necessarily generating a profit through project completion.

4.3 Results

4.3.1 Surveys

I sent 222 emails to prospective experts, and I conducted 48 interviews by telephone over the period of August 2011 to August 2012. Some experts declined interviews based on busy schedules although I remained flexible to accommodate field schedules, vacations, and other experts' commitments. Other contacts declined as they felt they were not suitable candidates, and offered other candidates for interviews. Among the experts that agreed to participate, the interviews lasted between 35 and 120 minutes. All interviews were audio-recorded and transcribed digitally.

4.3.2 Expert profiles and survey results

Table 4.1 displays the experts' characteristics based on experience profiles. Across occupation groups, experts had the most experience with the Canadian EA process, and decision-making for mitigation programs. Within each occupation group, overall profiles differed slightly among the categories but decision-making had the most variability (Table 4.1).

Table 4.1: Summary of experience of participants with knowledge of wildlife mitigation in Canada.

	Occupation Group			
	Overall N = 48	Environmental Consultant N = 18	Government N = 18	Other (Academic / ENGO) N = 12
Experience category	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Large-scale industrial projects	47 (98)	18 (100)	17 (94)	11 (92)
CEAA	42(88)	17 (94)	15 (83)	10 (83)
Decision-maker for mitigation	41(85)	17 (94)	15 (83)	9 (75)

Results from each question differed in terms of number of ideas presented by each expert. Thus, the denominator in the cross-tabulations differed between each question. With respect to defining mitigation, experts offered definitions that either included handling an effect or eliminating an effect. Handling an effect assumed that an effect can be lessened or reduced but never eradicated, whereas eliminating an effect assumed an effect can be removed and thus fully addressed. Differences among occupation groups were not significant (χ^2 = 1.09, df = 2, P = 0.58), Occupations groups cannot be said to approach the definition of mitigation in distinct manners.

Regarding the decision to use and the choice of mitigation program, some experts referred to specific methods of choosing while others were *ad hoc*. However, differences between occupation groups were not statistically significant (χ^2 = 4.05, df = 2, P = 0.14). Similarly, there were no significant differences in the problems (i.e. costs versus systematic issues) identified in the upkeep of mitigation programs by occupation groups (χ^2 = 1.367, df = 2, P = 0.50).

Regarding differences among occupation groups in how they perceive mitigation programs, some experts believed the current system is better than nothing, while others believed inadequacies were detrimental. However, differences among occupation groups were not significant ($\chi^2 = 3.32$, df = 2, $P = 0.19$).

4.3.3 Improving wildlife mitigation policy in Canada

In Canada, industrial development will likely continue to have adverse effects upon wildlife, which means there are continued opportunities to improve mitigation policy and practices. Identifying which opportunities were common among experts in the realm of wildlife mitigation was a complex matter. To achieve this goal, I identified five main themes in this paper which emerged from the interview data. The themes are: 1) dichotomous definitions of mitigation; 2) a grim reality; 3) questionable knowledge base; 4) gaps in policy; and 5) back-to-basics: a vision for better mitigation. These themes are based on 213 total codes, which is the sum of codes from the four open-ended questions (see Chapter 4 Appendix A for codes) that I identified through iterative reviews of the data (Braun and Clarke 2006). I used codes such as “accountability”, “dealing with effect”, “last resort”, and “flexible”.

i) Dichotomous definitions of mitigation

Participants defined and described how to handle wildlife mitigation, as they believed to be current and correct according to their experience and expertise. A major point of difference among participants was the use of the terms “effect(s)” and “impact(s)”. Though most participants used the word “impact(s)” (23/48), and a few used “effect(s)” (7/48), many participants used the terms interchangeably (18/48). For consistency in this paper and with legislation (CEAA 2012), only ‘effect’ will be used herein, except when direct quotes from participants are used. Environmental ‘effect’ signifies “any change that the project may cause in the environment” including to wildlife and its habitat (CEAA 2012).

Although few experts (4/48) referred directly to the CEAA definition, most had explanations of how to address effects with similar concepts to the legislated definition. The terminologies of addressing effects varied from a singular use or combination of any these terms: “reduce”, “lessen”, “minimize”, “avoid” “alleviate”, “eliminate”, “offset”, “prevent”, “counteract”, “modify”, “control”, and “make less bad”. Three participants, one from each occupation group, pointed out that often effects could not be eliminated nor mitigated against. For one of these participants: “development shouldn’t be allowed in some areas because you can’t mitigate them adequately” (O11). Defining mitigation for these three participants was difficult since it necessitated conflicting ideas. These three participants could not provide a clear definition since they had a disbelief in mitigation altogether.

One participant noted the difference between achieving “no effect” and “no significant effect” (C6): the CEAA objective to achieve non-significance is only necessary for a CEAA-triggered project (C6). The numerous ways of viewing “significance” was an additional problem for C6, since assigning a number to “significant effect” is subjective. Secondarily, how can professionals be assured that the number is assessed appropriately? For example, C6 used a fish example and stated that a significant effect might be that 10% of the population in a stream was affected negatively. C6 also wondered about the relative value of “10%”: “are we certain that it is only 10% and not 12%?”

Another point of difference was in what participants saw as actually being mitigated (e.g., “ecosystems and/or species”, “environment”, “natural feature”). The participants that did not provide a context constructed a definition in terms of projects, developments, or actions instead of some part of the natural world. Examples included: “measures put in place to reduce or minimize the impact, unavoidable impacts of the project you're putting in place" (C7), and "an action to overcome detrimental impacts of another action" (G3). One participant referred to restoring the "ecological heartbeat" (O8), and another mentioned a systems-approach to mitigation and stated that ecosystem services require high consideration. This same participant wanted to include "adaptation" as part of the definition to recognize that landscapes are changing and "either mitigation blends into adaptation or mitigation is part of a bigger picture that includes an adaptation aspect" (O5).

The notion of excluding or including compensation in the definition of mitigation was a common occurrence in the interviews. Though only one participant specifically stated the line between compensation and mitigation is "blurred" (C17), others expressed concerns with the concept of "compensation". Several participants (10/48) favored including compensation although it is a "last resort" (G15), because it might make things "less bad" (O10). One participant spoke of compensation as an alternative but still within the scope of mitigation (C9). Another participant included compensation as part of the definition but only as applicable to "no net loss programs" (O6), while another stated that no net loss is a "lofty goal" and it cannot be achieved, even in other legislation (e.g. Fisheries Act 1985) (C8).

Several participants (6/48) were opposed to including compensation and described it as a "red herring" (C14), or not interchangeable with mitigation (G9). Two participants expressed dismay with compensation: "how can we financially compensate an irreplaceable ecosystem?" (O11), "because you're not actually getting at it, if you're paying off a community to shut them up, that's not mitigating the harm, in my opinion" (O7). Another participant took a cautious approach to excluding compensation and noted that the two are part of a "bimodal continuum" (C16). In other words, it was either mitigation or compensation, and the two ideas are at different ends of the same spectrum. However, C16 admitted to being pessimistic about regular mitigation practices and thought compensation might offer something in terms of protected area creation or expansion.

In terms of the timing of mitigation, the occurrence of mitigation became an after-thought for some participants as they contemplated the overall process. The sequence of activities was mentioned several times "avoid first, reduce, compensate" (C18), and two participants expressed that mitigation was the actual measures applied in design and in the field but the priority remains avoidance (C5, C9). Others also referred to mitigation within the design processes and one consultant cautioned that much of the work that goes into mitigation is behind the scenes in discussions and design phases (C18). Though two participants refer to mitigation as being on-site, site-specific, and localized (G18, G19), two participants recognized that off-site projects were legitimate (C9, O10). C9 illustrated the general pattern of confusing ideals by offering a unique statement: "neither mitigation nor compensation requires direct ties to the project". Alternatively, C11 described that a holistic perspective was preferred to the expected hierarchy of avoid, minimize, and compensate (e.g. CEQ 2000; SARA-CEAA 2010; Kiesecker *et al.* 2010).

ii) A grim reality

A widespread concern among experts was that mitigation drafted in EA documents was simply to push forward a project to obtain approval. One consultant revealed this reality: "I have been very critical of rubber stamping mitigation that goes on. It's done by some people in my profession" (C3). C3 even went as far as to suggest that mitigation may have some "green wash" to it, and many mitigation proposals were "pie-in-sky" techniques. C15 noted colleagues who are recommending the bare minimum to get a project approved: "the consultant is recommending what they think is appropriate to kind of usher the company through the legal requirements but not really going beyond that". Notably, two participants pointed out that some development projects should not proceed as they are not appropriate, yet with mitigation they are passed through (C1, O11). In this case, mitigation acts as a “get out of jail free card” (O11). On a positive note, G16 suggested that there is a range of companies from those that try to “do the right thing” to “bandits” who get away with everything. Companies that endeavor to achieve better outcomes are either “philosophically” motivated to do so, or pushed by “Mother Nature or government to do so” (G16). G16 credited industry partners with innovation even though G16 recognized that industry may be “forced” to come up with creative and passable solutions for their effects in sensitive ecological environments. O5, however, maintained a skeptical point of view consistent with bare minimums and may not agree that novel solutions exist. O5 believed there must be better mitigation programs available than what has come forth. There must be programs that actually “start to cure these impacts”.

Getting a project approved may also rely heavily on relationships among proponents, regulators, and others working on EAs, despite the ‘goodness of fit’ of mitigation. C18 described situations where similar projects were proposed in the same areas, yet comments and opinions may be drastically different between regulators and stakeholders such as First Nations groups. C18 attributed this difference to the strength (or weakness) of relations between the different parties involved in the projects, which created challenges in navigating through the EA process. C18 noted “…because the process is the same, the project is the same, but the whole write up and everything should be the same, but yet we constantly are adapting to what’s asked of us.” The strain of relationships is not only between members of different groups (e.g. consultants, regulators, proponents, stakeholders) but occurs within the same occupation group. G16 was contrite in “airing dirty laundry” and mentioned that “old time hostilities” within government ministries prevented uniformity among approvals and practices. G16 claimed that some government personnel believed they work with industry to endorse their projects, while others take on a "broader view" that considers both industry needs and environmental sustainability (e.g., conservation and protection).

Costs and resource availability were prevailing concerns that most participants brought forth in the interviews. G7 admitted that "we can talk our way through anything, we can hypothesize mitigation until the cows come home", but if mitigation is too costly or "socially unacceptable", mitigation will never occur despite the fact that the development project had already been approved. Once a project was approved, mitigation projects and their conditions are "ignored" (O7) as a result of monitoring and follow-up costs. Several participants illustrated that funds for monitoring of mitigation were tied to the development project, and once the project was complete, these funds were "gone" as well (C8, C9, G6, O7, O12). C8 discussed looking for "scraps" of money to "see how good we were" at proposing appropriate mitigation, since the proponent and the project were both "gone". C16 was frustrated with proponents that scoffed at mitigation and monitoring, and mentioned "getting verbally abused by them because anything that we say slows them up" and time is money. Perhaps not alone in this sentiment, C16 wanted to see a "habitat biologist or a conservation officer come by and, if necessary shut them down for a day or two. It definitely gets things back in order because it's expensive to shut people down". Similarly, G6 wanted authoritative action towards commitment to funding mitigation and suggested that costs of "…monitoring [be] tied to legislative approval".

The question of adequate monitoring, aside from costs, came into play when participants discussed upkeep of mitigation. Many participants questioned the presence of mitigation altogether: "….with respect to specific implementation [of mitigation], it's often not [there]" (C4). When mitigation was (believed to be) present, the effectiveness of monitoring was central to the issue of adequacy and participants brought in several issues. Because companies were allowed to monitor and report on the mitigation progress themselves, the lack of "objectives, targets, metrics, and functions" was problematic since interpretation of results varied largely between government regulators receiving these reports and the proponents or operators submitting them (G19). G19 also mentioned that while it may be currently feasible to have independent assessments of mitigation measures the effectiveness of mitigation is rarely, if ever, established. O6 noted that "monitoring is key but effective monitoring is the key question". C14 remarked that even education programs related to mitigation require scrutiny and gave credit to researchers that investigated effectiveness of education. C14 thought that education as mitigation is overused and is only effective when the audience is properly understood (e.g., in terms of cultural diversity, age, economic status, connection to land). On measuring the effectiveness of mitigation, C14 suggested we need to "learn more from what has not worked, and be innovative about what might work".

One way to change the mindset from monitoring to effective monitoring was suggested by C6 who saw many programs established that were merely "surveillance" and not monitoring. For example, surveillance does not require the scientific metrics that a monitoring program might demand (C8), such as "standard deviation, there is no trigger-point for action. And so, [surveillance as monitoring] really is a complete waste of time" (C6). Simply put, monitoring with action plans is the basis for true monitoring (C6, C8). Moreover, C6 provided an example where monitoring of a threatened bird species in relation to a wind farm operation had no consequence. Mortality of bobolinks (*Dolichonyx oryzivorus*) was found to be directly associated with the wind farm. However, when this was reported to government regulators, C6 described that the regulators replied "…ok, keep us informed…and nothing happens" (C6).

C5, C7, and C9 offered suggestions to encourage more effective monitoring. For them, pressure for adequate monitoring must come from public demand (e.g., evaluate public attitude toward the project) and be emphasized by project designers and consultants over a long period of time. Without highlighting any specifics, some participants emphasized the need for long term visions, whereas others suggested firm numbers. O8 stressed the importance of long term initiatives as a means to fix "weak" mitigation, which is "inherent across Canada no matter what program you're looking at, what mitigation you're looking at. The foundations for long term data are very poor". Specifically, G19 suggested that reviews and reports be monitored on a 3-year cycle, and C9 recommended a 5-year review schedule.

iii) Questionable knowledge basis

The quality of information that is used to design mitigation plans and programs was a concern in several participant interviews. Many experts were dissatisfied and referred to cases where information was unreliable, outdated, missing, untested, discontinuous, or disconnected. When discussing EA documents, C14 wondered "where did that person get that from?" and found many tools or resources doubtful and inappropriate compared to what may be available. C14 also wondered about obsolete information. For example, C14 was a self-declared specialist of wolverine (*Gulo gulo*) and fisher (*Martes pennanti*) issues (among other species), and was well aware that these two species are not well studied. Yet, C14 had seen several EAs refer to archaic information regarding the species' ecologies, and was worried about ramifications of using outdated science. Further, C14 was concerned about the possibility that junior professionals might rely on this outdated information, without even realizing it may be obsolete. C14 thought junior professionals may be using the information simply because it is presented in EAs and related documents and published by government sources that they trusted. This trend may not just apply to junior professionals but may be a reflection of the larger picture. In the past (and perhaps still today) EAs were not considered to contain valid portrayals of ecological trends, as put bluntly by C10: "….for many years, consultants were a joke in the scientific community". It should be noted also that perhaps a manipulation of information is occurring in EAs; C14 was disheartened when an EA used a grizzly bear (*Ursus arctos horribilis)* habitat suitability model developed by C14 without stipulating the limitations of the work "which were considerable and that I had taken great care to highlight in my reporting".

Similarly, due to a lack of continuity and dialogue among those developing mitigation plans, C15 came to understand that many authors of mitigation plans "reinvent things a little bit". C15 attributed this trend to the level of experience and background of such authors, where those with higher levels were able to better sift through the literature (and other available resources) and gather relevant material. C18 demonstrated this idea one step further describing proponents that sell and transfer their project, or the funds are depleted, and new managers and employees take over that were never involved in the original EAs. A turnaround of personnel can invite an array of problems, which may affect original commitments and expectations: "if they get new people, they will interpret it a different way and that is where you start arguments" (C18). Along the lines of information gathering for mitigation, O12 believed there was enough science available for proper decision-making and "more science" was not an absolute necessity. O12 recognized that while science is an expanding field that tries to fill in the gaps of knowledge, there is enough available that is "robust" and appropriate to mitigate properly: "we've got enough science to do the right thing."

Considering missing information, C3 described a case where information on an endangered amphibian presented to the biologist responsible for that portion of the EA was ignored in the resulting mitigation plan. Thus the validity of the mitigation was highly questionable and not "rigorously, scientifically defensible" in C3's eyes. Similarly, many mitigation programs are questionable since they have yet to be tried and proven. O9 and C10 explained that proponents are quick to indicate "yes, yes, yes we'll do that", yet mitigation opportunities are “never” completed. A vicious cycle appeared with commitments being made to mitigation techniques that are unconfirmed in being able to offset negative impacts, and thus the impacts are likely improperly predicted (O9). “If you can’t monitor the mitigation, the impact or the mitigation, then how do you even move forward? It’s just not going to happen” (O9). C10’s frustrations were the same: “why are we doing these environmental assessments and making these recommendations for mitigation when we have no idea if they’re ever carried out and have no idea if they’re effective”. C16 offered a solution to this “oversight”, which is to bring in more active interest groups. C16 found that many protests occur prior to projects getting established, and once certifications and permits are issued, the environmental voices “lose interest”. C16 would like to see groups visit a project site with a journalist alongside, and begin investigations into environmental damages (e.g. “turbidity is a good one because you can take photographs of it”). C16 believed such strides could shake up proponents into thinking twice about ignoring their mitigation obligations: “I think the agencies responsible for oversight occasionally need to be embarrassed to act”.

The origin of standards and best practices, and knowledge in mitigation was found to be awkward and clumsy. Sometimes EAs are just performed as a paperwork exercise rather than having some sort of intrinsic ecological importance (C11). C11 mentioned that components of EAs may be chosen based on political or economic drivers, or “just because”, and these become standards of the industry. For example, C11 illustrated that bat (Order *Chiroptera*) issues are popular in wind energy development projects. However, regardless of the different details of wind projects, the same baseline study is performed, the same “uniform results” of bat diversity and abundance, and the same type of analysis is executed “no matter how close or far we are from the bat hibernacula or habitat”. For C11, these types of EAs become standard to the point of being expected by the respective department of natural resources, which has been occurring for numerous years. C11 was weary and anxious: “we’ve been doing all this, but really what does it mean?”

iv) Gaps in policy

Commonly thought of as “better than nothing” (O5), most experts (33/48) believed that mitigation in the EA process was overall beneficial; however, doubts surfaced about the general process and policy performance. Project by project EAs and accompanying mitigation were one of the prevailing grievances among experts. Some participants refused to delve further into the topic and maintained that generalizations across all EAs and mitigations were too difficult (O3). On the other hand, C11 protested that there was no forum to look at EAs “holistically”. C11 noted that current mitigation is designed after looking at specific baseline studies, at a specific temporal and spatial scope, for one particular project. Furthermore, there is no present feedback loop where one EA can be used to inform the other (C6). C6 believed a strong feedback system that links monitoring results to EAs, regardless of sector, is a worthwhile endeavor considering much can be learned from each one. “In my experience, the EA process is one of the few places in impact assessment where research actually takes place, especially under the CEAA” (C6).

Similarly, C14 explained that there is no uniform framework for wildlife mitigation that those working with EAs can rely upon. C14 identified necessary items for a species-specific framework such as “interdisciplinary problem analysis” and decision-making processes, with inclusion of political and socioeconomic considerations. For example, a Grizzly Bear Conservation Strategy from the mid-1990s exists for the province of British Columbia that is popularly referenced (see BC 1995). But C14 emphasized the current need for unscrambling knowledge and opinion concerning the requirements for maintaining a healthy grizzly bear population in the EA process and other projects, “everything we think is needed to mitigate or compensate for negative effects”. Tradeoffs may be necessary, but they need to be executed with a full understanding of the holistic implications, risks, and uncertainties and legally bound through ethics, regulations, and policies (C14, C11).

Internal guidelines among companies have been developed to account for the project-by-project process, but this may contribute just as much to the overall problem. C6 recognized that internal practices were a good starting point, but consistency across the EA process was crucial to fully address all that is done to the natural environment. For example, O10 described a situation where a particular company was required to submit timely reports on its mine operation and compare effects from the original EA performed in 1995 to those effects evaluated at the time of reporting. Due to internal processing, a significant portion of the report was focused on the effects of the mine on birds, however birds were not an issue and certainly less important that the current effects on wolverine and grizzly bear. O10 stipulated that the EA process should reflect shifting needs in wildlife management and mitigation as projects develop past their original EAs.

Although internal guidelines may exist for professionals to follow, a concern about reporting mitigation choices and decision-making was common among several participants. When asked if proponents or regulators have ever requested to see the development of mitigation plans, C11 provided the example: “I haven’t had anyone specifically say can you document a weighted matrix”. O11 mentioned that “often, we don’t really have the correct tools to actually be able to weigh up the pros and cons, but the decisions get made anyway”. C12 responded with “I think that’s where the line between research and management gets blurred”. These participants demonstrated that there is little importance placed on how mitigation is arrived at versus whether a project will get approved. C12 stipulated that the onus is on the researcher to be rigorous in methodology and to portray an accurate description and analysis, regardless of inquiry. Notably, C15 needed to recall and defend the work behind an EA when the Consultant was questioned by defense lawyers. The professional credibility of C15 was on the line, which may be a strong motivator for all wildlife mitigation experts to maintain a documented chain of evidence behind every mitigation decision.

v) Back-to-basics: a vision for better mitigation

Participants did not need much prompting (e.g., a loss of optimism and morale was noted by C14) to expand on what they considered should be the most important, fundamental, and system-wide aspects of mitigation. As described above, effective monitoring was a popular concept that was identified by various experts, and which was tied directly to a form of adaptive management. Adaptive management in the original sense of Holling's (1978) work was not specifically mentioned by any of the participants. Instead, the term "adaptive management" was used to describe mitigation that was adjustable and dynamic in its ability to truly offset adverse environmental effects. Several participants described mitigation as needing to account for changes to the landscapes that were unidentified or misjudged during the EA process. "It also has to allow for unknowns, like all of a sudden you identify a rare orchid that was missed during the [EA] process. Then you have to have some flexibility and make room for that" (C3). Flexibility was also recognized by G14 as a key part of being adaptive with mitigation since many "cookie-cutter" approaches are relied upon for similar industrial projects (e.g., solar). G14 believed that no two projects are exactly alike, and having the ability to adjust projects based on positive, negative, or neutral results of mitigation is important to account for differences in the temporal and spatial scopes of projects.

Similarly, G6 maintained that "fluidity" and "adaptability" are constantly needed, especially when the EA is undertaken far ahead of project implementation. G9 also mentioned the issue of time frames: "you enter a process and you have no idea when you're going to get out of it”. It appeared to G6 that approvals and permits are obtained at the conceptual level, rather than at the practical level: “they want to be able to check off in their box that the EA was completed”. Also, G6 noted that at times mitigation commitments in EAs are clearly defined with little to no actual room for malleability, which dampens the ability to account for outdated effects analysis. Nevertheless, accounting for obsolete EAs through adaptive mitigation may be a reasonable and feasible manner of being proactive towards reducing adverse environmental effects (G6).

One government participant was saddened by a peculiar scenario where projects were allowed to occur as an experimental scheme. G13 reflected that a number of effects were allowed to occur in order to learn from their consequences to help enlighten future projects. “….it’s just hard to accept the fact that we let a certain level of impact happen before we are able to actually fix the problem” (G13). G13 mentioned this trend was an opinion and not documented in government policy or other formal document.

Accountability was a future hope for several participants when discussing the overall advantages and detriments of mitigation in the EA process. C4 remarked that there tended to be more follow-up with government projects versus the private sector since more might be at stake for public servants. Government departments need to demonstrate accountability to their constituents and council members (C4). Even so, some participants referred specifically to the BC Government Auditor General’s report (BC 2011), which acknowledged a lack of responsibility towards various monitoring and mitigation obligations (C16, G1, G7). The Auditor General appeared to condemn the [provincial] EA process for not being able to adequately assess the efficacy of mitigation, thus falling short of the duty to uphold sustainable development (G7). G7 confirmed that tuning into adaptive management is an obligation of proponents as a method of being responsible for adverse effects: “look, we got to ramp up….it’s bigger than we hypothesized, or we didn't think of this associated impact. Now we have to tune that mitigation program so here we go, let's tune it together".

'Working together' is not a unique concept, and several participants alluded to this need in some manner. C17 mentioned that new mitigation development needs to be a part of a "discourse" with practitioners, and C5 illustrated that a complete project from the design to operation phases needs to involve all interested parties and stakeholders, "you do everything together if you can and that's the only way we're going to learn whether these mitigation measures work or not". Doing and working together begins early on for C2 and C5 who stated that discussions with regulators, proponents, and stakeholders need to begin as early as possible to avoid unnecessary dilemmas. "You can't develop these things in a vacuum", and working closely and balancing "back and forth" with proponents and regulators allows a mutual understanding of the project and its constraints (e.g. economic, cultural, social, and ecological) to develop (C5).

Collaborative efforts may begin with a faction of like-minded experts of the same group. C14 referred to the aspiration of having wildlife biologists draft and present species-specific management programs for EAs that would include all that is necessary for adequate mitigation. A discussion of uncertainty, risks, ramifications of options and alternatives are to be included in such management programs. C14 stressed that interdisciplinary decisions are needed to fully grasp consequences and implications of various options available. However, recognizing that a biologist's input may be ignored, lost, or forgotten in such decision-making scenarios, C14 cited the BC code of ethics that includes binding legalities for the biologist: "ensure that the employer/client is aware of potentially adverse consequences if the member's professional recommendations are not followed" (C14, BC 2012).

Collaboration with academic and independent researchers was another type of systematic improvement suggested by participants. Diverting funds from proponents towards research that involved multiple projects was identified as a way to evaluate environmental changes and propose actions (G19). “I think the process could certainly be improved by bringing in academics, to treat the question academically, rather than operationally, as we do now” (G19). G19 provided a simple illustrative example when thinking about how research partnerships related to wildlife use and movement along river valleys can help inform mitigation guidelines: “….is 100 meters enough? Is 200 meters enough? 250? Do fishers use the river valley, but when there’s only 100 meters, do they stop using the river valley? What is an appropriate set back to maintain that function?”

Specific to monitoring of mitigation, establishing an independent authoritative organization was identified as a complement to collaborative efforts. O9 was distrustful of industry and government to undertake any kind of monitoring program, and believed that unless an independent organization is involved, proper mitigation will not occur. C3 agreed and believed that an independent environmental monitor should be able to cease a project if the need arises: “they can actually shut things down if things get out of hand” and “have independent oversight on the implementation of the mitigation”. An independent organization needs to operate in a precise and transparent manner: “…rigorous and defensible program where you don’t start cutting corners” (C3). O10 provided an example of how a separate monitoring agency works for a large-scale mine operation. The agency manages to push the limits every year, and demands performance measures and adaptive management approaches to environmental problems caused by the mining company. O9 also mentioned that the most successful mitigation efforts were related to those projects that had public monitoring agencies. However, without large profits to fund such an efficient monitoring organization, O7 illustrated that other smaller projects are deferred to government resources.

4.4 Discussion

Interviews with wildlife mitigation experts from three occupation groups and the process of conducting qualitative research on experts' knowledge provided vital data that can be used to improve the efficacy and policy approaches of wildlife mitigation programs in Canada.

4.4.1 Interview and research process

The process of conducting research on wildlife mitigation revealed crucial information about the development and implementation of wildlife mitigation programs. During interviews with experts, I learned that the process of creating and implementing mitigation programs is much more complex than is alluded to in EAs submitted for review to regulators. Considering the thousands of EAs processed annually it may be safe to assume that there is a relatively data-rich EA 'industry' in Canada (e.g. Barnes (2005) reports annual numbers in the range of 6,000 screenings, tens of comprehensive reviews, and less than five panels). Regardless of the prevalence of EAs, the process of engaging experts from different occupation groups in this study exposed unexpected challenges. I was able to contact a wide range of experts associated with mitigation practices in EAs, but only 48 were willing to participate. The remaining that did not participate stated reasons of inexperience or little to no interest. The 48 experts that did participate represented 22% of the target population. In general, sample size and participation rates in qualitative research vary widely (Guest *et al.* 2006; Mason 2010), but there are no other similar wildlife mitigation experts' knowledge research studies to form a comparison. However, Gunn and Noble (2011) studied the relationship and integration between cumulative effects assessment and strategic environmental assessments, both crucial sectors of EAs. The authors conducted in-depth interviews with 23 academic or experienced EA practitioners. Thus, my study was on par to the sample sizes in other reviews of EA experts' knowledge research such as Gunn and Noble (2011).

Generally, a low sample size begs the question of whether the data are representative of the overall population. In this case, do the wildlife mitigation experts interviewed embody the voices of all experts working on mitigation problems in Canadian EAs? Or are these 48 experts representative of a sample that is biased towards having their say and influencing change of current mitigation practices? Patton (2002) suggested an examination of the characteristics of the sample population to deduce whether this sample is illustrative of the whole. In this study, interviewed experts had a high level of experience in the categories presented, though 100% experience in all categories would have been ideal. However, the variation in experience represents the overall EA industry since senior and junior professionals are both tasked with mitigation development at some stage of the process. Also, interviewed experts were not favored based on region or specific mitigation program type, and I was careful to follow suggestions and recommendations for other experts as well as to solicit individuals independently. This allowed me to avoid the bias of having a group of closely networked experts voicing their common thoughts from a specific area or program.

One group from which I did not solicit participation was the proponents or industry representatives themselves. Separating participants from this group would be extremely difficult since many proponents defer to consultants. Thus, the possibility of having two individuals (e.g. one from the consulting group, one from the industry group) discuss their knowledge based on very similar experiences and processes is relatively high. In future research, specific questions (e.g. which projects have you represented?) and other information could be collected to distinguish individuals from one another to avoid bias. This may allow for improved expert representation.

This study's objectives were multifaceted in that I wanted to use data from qualitative interviews to better assess the status of mitigation in the EA process, to unearth trends in mitigation approaches, and to identify mitigation opportunities in the Canadian EA process. Following qualitative methodology is suitable when research objectives involve gaining information from participants' knowledge and experiences and developing ways of addressing complex trends (Patton 2002). To that extent, interviews were performed to collect first-hand information about the reality and efficacy of wildlife mitigation from a practical perspective. In-depth interviews were well suited herein to engage participants in assessing the current situation of mitigation in EAs, evaluating their own approaches, and suggesting possible improvements in a manner that other research methods (e.g,. quantitative) could not obtain.

4.4.2 Assessment of wildlife mitigation in the EA process

Overall, wildlife mitigation experts described various definitions of 'mitigation', which were somewhat inconsistent with the CEAA (2012). The terminology in CEAA is short and limited to "elimination, reduction or control of the adverse environmental effects of a designated project". Though some experts specifically mentioned "elimination" and "reduction", only one referred to "control" (C14). Perhaps some experts diverged from the legislated definition to provide a clearer interpretation of what "control" might include, which could be "modify", "prevent", "avoid", "offset". Further, while some experts included "compensation" in the definition, others did not. The Act specifically states: "…through replacement, restoration, compensation or any other means" (CEAA 2012). Although there might be pragmatic arguments for using a different definition of mitigation for oneself, there are numerous reasons why experts should be cautious when diverging too much from the legislated definition. First, there are general limits to the ability to apply diverse definitions and understandings of mitigation (e.g., when wildlife do not respond as expected). A consistent definition allows general patterns to develop for what can be expected and what might be unrealistic. Secondly, when experts provide examples of mitigation programs, these examples may not match the intent of mitigation under CEAA (2012), and thus obtaining approvals and permits may be challenging. Lastly, a consistent definition opens the door for further research under one umbrella, which can share universal designs that focus on discontinuous models that need improvement. Further, differing interpretations of mitigation may have consequences for effect analyses in EAs since a large part of impact prediction relies on in-design mitigation plans. Diverse definitions are likely to lead to incompatible impact predictions.

Mitigation plans and programs are relied upon in EAs to offset adverse environmental effects (CEAA 2012). Yet, information volunteered from mitigation experts suggests that the presence of mitigation does not necessarily ensure adverse environmental effects are addressed in some way that renders them negligible. This trend was in part due to inadequate commitments to oversee mitigation, and in part due to the lack of effective monitoring. As much as mitigation experts may be removed from the project once approvals and permits are obtained, mitigation experts may actually know when programs are put in place through evaluations of which projects are underreporting (or not reporting at all) results. Consequently, mitigation implementation and monitoring may be measured and quantified. Assessing the number of inadequate, missing, or outdated mitigation plans and programs allows authoritative action, similar to the BC Auditor General's report (BC 2011) to initiate substantial change to the course of wildlife mitigation.

Some experts in this study suggested creating a viable guideline for monitoring mitigation practices, which includes documenting changes to original mitigation. Further, granting access to these documents to other experts could be useful to resolve diverging definitions of mitigation, and help alleviate the inaccuracies of EA documents.

Importantly, some mitigation practices have become increasingly subject to rigorous science-based methods. For example, previous climate change models were releasing mitigation plans that did not take into account all major parts of planetary biophysical dimensions (e.g., atmosphere, biosphere, oceanographic factors). These simple plans were derived from abatement cost curves that were used to compare mitigation strategies, and as such could not reliably provide comprehensive mitigation plans to adequately address the perils of climate change (Fischedick *et al* 2011). Recognizing this faulty approach is a component of the Intergovernmental Panel on Climate Change (IPCC)'s current efforts to develop scenario-based and scientific mitigation efforts for renewable energy initiatives that are based on complex biophysical models (to be released April 2014, Fishedick *et al* 2011). Using in-depth analyses with complex systems reflected, mitigation efforts based on demonstrated technological improvements in the renewable energy sector are presumed to enable a significant reduction in greenhouse gas emissions (if implemented) (Fischedick *et al* 2011; Barker *et al.* 2007). Similarly, many experts in this wildlife mitigation study illustrated that the knowledge base of mitigation is lacking in both capability and consistency; too many plans and programs are unproven, unqualified, and based on unreliable models. A shift towards more scientifically-rigorous mitigation may be a challenge, but one that should be welcomed with open arms, as occurred with climate change mitigation. Science-based (and documented!) mitigation would necessitate an investment of time, personnel, and financial support, which may generate resistance from proponents. However, the benefits over time are sure to outweigh these costs, given that science-based processes lead to a reliable body of knowledge and thus the development of best practices, standards, and guidelines.

General mitigation guidelines may be a consistent and dependable resource from which inexperienced and junior professionals can begin. Notably, specific adaptations to account for landscape differences, species needs, and project designs are inevitable. For example, guidelines have already been developed by the Ontario government for bats and wind energy projects (OMNR 2011a), and specific changes for diverse projects are allowed. Unfortunately, these guidelines do not include many science-based references or science-based metrics. The mortality threshold of 10 bats/turbine/year is not associated with a referenced scientific study, and it is difficult for the user of these guidelines to understand the origin of such an important number. Improvements should be encouraged to include Scientific sources and Traditional Ecological Knowledge (Usher 2000) in order to strengthen the overall mitigation program. Not surprisingly, the mitigation guidelines for bird and wind energy projects (OMNR 2011b) follow exactly the same language as the bat document, and can be improved in a similar manner with science-based reviews.

4.4.3 Wildlife mitigation policy opportunities

Wildlife mitigation experts' illustrations of mitigation practices (or lack thereof) highlighted the main problem of ineffective monitoring of mitigation. Experts' observations that ineffective mitigation was occurring was largely associated with the sense of wavering commitments. Although examples of EAs and projects were provided to support the idea that follow-through was not taking place (see also Gachechiladze-Bozhesku and Fisher 2012; Noble and Storey 2005; O'Faircheallaigh 2007), experts did not provide species-specific numbers to confirm that adverse effects were ongoing. Thus it appears that neither project nor expert can confirm or deny trends that may or may not be occurring. However, anecdotal information is a powerful tool, and the sense that ecological health is on the decline is not a new or surprising drift. Experts are well-suited to be concerned with the well-being of sites slated for project development, with or without documented proof, and erring on the side of caution may be justified. In fact, experts are aware that inappropriate mitigation practices may be rampant, which could have inadvertent effects on the target wildlife species or their habitats. Though going through all projects that have passed EAs to evaluate the results of (any) mitigation implementation may be impossible at this point, prioritizing those projects that were expected to have large adverse environmental effects should be at the forefront of regulators' core tasks. In this manner, learning from past and present projects, and documenting change in a timely manner, can be used to inform current and future mitigation development in EAs.

Experts reported the need for implemented mitigation programs to be flexible and dynamic in a way that allows for new data to inform mitigation practices. Stagnant mitigation can do little to "eliminate, reduce, or control" (CEAA 2012) adverse environmental effects since ecosystems are constantly in flux and changing states. Experts recognized that mitigation needs to remain as fluid and adaptable as its ecosystem settings or the overall efficacy could be affected. Connecting results of changes to species populations and their habitats with implemented mitigation practices may help identify the conditions under which mitigation is appropriate. Methods to evaluate the change in species populations and their habitats are already widely known, but methods to link these changes to industrial projects need further support by experts and researchers as such studies are lacking (e.g. BC 2011). In the meantime, the principles of adaptive management can help develop a system for using data to inform better mitigation. The adaptive management scheme mentioned by interviewed experts was a subtle form of Holling's

(1978) version, but adopting the actual system addresses their concerns of inactive mitigation. Adaptive management practices have already been established in monitoring programs for natural resources with demonstrated success (e.g. Elzinga *et al*. 1998; Gibbs *et al.* 1999). Further, adaptive management in monitoring has been recognized as having the ability to validate assumptions, scan for desired outcomes, and check for unexpected results (Marcot 1998). However, long-term commitments with appropriate funding is necessary to allow for learning and response, which should be sustained by proponents of the projects undergoing EAs.

The Canadian Environmental Assessment Agency (CEA Agency) has provided guidelines through a policy statement for incorporating adaptive management under its legislation (CEA Agency 2009). The CEA Agency (2009) illustrated an applied example of adaptive management for the Ekati Diamond Mine Project that it considered relatively successful, which was also referred to by an expert in this research (O10). Due to a meticulous data collection system as part of the monitoring program for dissolved oxygen levels in nearby Kodiak Lake, adverse effects to fish health were avoided through immediate management decisions to aerate the lake and divert sewage effluents (BHP 1998; CEA Agency 1999). O10 described other successful adaptive management schemes at Ekati for oil and grease spill management, water quality, and molybdenum concentration levels, and maintained faith in such systems to address unexpected environmental effects. Through adaptive management, mitigation has the potential to become a science-based, tested, accountable, and iterative (e.g., through feedback) manner of addressing adverse environmental effects. For example, Gawlik (2006) used a wetland restoration example to demonstrate how science in an adaptive scheme can be used improve the rates of successful restoration. Gawlik (2006) recommended performance and target measures specific to wildlife species in the area to test restoration project particulars. The author also discussed the challenges of selecting performance measures, which can be difficult if ecological knowledge about ecosystems and wildlife is lacking. Although not specific to EAs, Gawlik's (2006) study is one example of many studies (e.g. Kallis *et al.* 2009; Giebels *et al.* 2012; Nelson *et al.* 2008; Thorn 2000) that demonstrate how science through adaptive management can inform policy decisions, and thus improve overall quality of imprecise processes such as EAs. Further, since projects are continually proposed through both federal and provincial EA systems in Canada, adaptive management within mitigation could benefit wildlife and their habitats across the nation.

Collaboration among proponents, stakeholders, regulators, researchers in academic institutions, and consultants was described by interviewed wildlife mitigation experts as a method to invite interdisciplinary decisions. Given the range of knowledge and experience of these interested parties, best mitigation practices may be developed through forums that encourage cooperation. Albeit complex and challenging, decision-making models with interdisciplinary perspectives are not impossible and are known to be operational and valuable in the environmental context in other areas (e.g. Convertino *et al.* 2013; Hardisty *et al.* 2012; Reed 2008). Proponents of projects, particularly from companies that operate in various parts of Canada, will encounter different regulatory requirements based on the individual regulator(s) receiving the EA. As a result, best practices for mitigation in EAs need to span provincial borders, otherwise it's "a waste of time", as bluntly put by one participant in this study. Albeit with its own set of challenges and problems, collaborative efforts have initiated efficiency and consistency in other complex natural resource management programs such as with Eastern Scotian Shelf Integrated Management (ESSIM) (Rutherford *et al.* 2005), which could serve as a starting model. ESSIM is a functional and dynamic initiative that involves a plethora of stakeholders from federal and provincial departments, First Nations and aboriginal groups, non-government sectors, industrial partners, community members, academic researchers, and many more interested and involved parties. ESSIM oversees the use of living and non-living resources in an offshore area that would have conflicting and potentially detrimental resource users if ESSIM were not a recognized collaborative structure (Foster *et al.* 2005; Rutherford *et al.* 2005). Further, other collaborative efforts could be launched on differing topics related to improving mitigation practices. For example, by addressing experts' main concerns of ineffective mitigation, academic researchers may investigate the metrics of ineffectiveness and propose new bars for acceptance or denial of approvals and permits. This type of partnership may increase the likelihood that future professionals developing mitigation plans and programs would adopt acceptable and adaptable practices.

Many experts described their desire for an independent monitoring agency to keep mitigation law-abiding, and improve accountability. Already established for the Ekati Diamond Mine, the Independent Environmental Monitoring Agency (monitoringagency.net) is largely responsible for ensuring BHP's mining operations remain on target for annual reports and mitigation and monitoring commitments. Thus, such a hope for a practical and functional independent agency need not be wishful thinking and could be established on a national basis (e.g., Gray and Jensen 1993). As illustrated by interviewed experts, an agency would remain responsible for ensuring that project-specific mitigation is achieved as intended in respective EAs, and results contribute to satisfying the CEAA stipulations for mitigation. When this is not occurring, the agency would be tasked with reviewing the damages to wildlife and their habitats, preferably within a period of time that would allow for remedial action. The agency would then select appropriate actions for ensuring proponents return to tending to their mitigation commitments, or adjust them as needed in the case that original mitigation was improperly designed. While the monitoring agency for Ekati Diamond Mine is an organization whose sole responsibility is the Mine, a national independent monitoring agency is needed to cover large and small projects and to hold them all continually accountable to their mitigation pledges.

4.5 Conclusion

Wildlife mitigation experts' interviews provided opinion and outlook on current mitigation practices and isolated opportunities to improve future mitigation. Knowledge from participants was motivated by the recognition of a lack of systematic evaluation of the successes and failures of mitigation practices. Few discrepancies were present among the experts' interviews on this topic, which identified a strong need for effective mitigation monitoring. I recognize that improvements to reporting requirements from project proponents may resolve the need for mitigation data. However, addressing the issue for effective monitoring identified here through the establishment of an independent monitoring agency at the federal level would also provide the foundations for mitigation development for future projects. Other recommended policy and management changes following this study include: 1) development of operational guidelines for mitigation on a specific wildlife (and habitat) basis, including protocols for documenting changes as a result of implemented mitigation, 2) adoption of adaptive management approaches to contend with results of monitoring mitigation programs, and 3) establishment of collaborative efforts and solid partnerships to encourage interdisciplinary decisions. These suggestions are not impossible to implement under the current structure of the EA process, especially if such initiatives are undertaken with the inclusion of wildlife mitigation experts from various occupations.

This research was performed with the overall objective of improving wildlife mitigation practices in the Canadian EA process. Meeting this objective, however, needs further investment to evaluate mitigation practices with respect to their ability to eliminate, reduce, or control adverse environmental effects. Ongoing research into ecological changes as a result of industrial projects is needed to support and subsequently alter the trends stressed by interviewed wildlife mitigation experts. Thus, this study forms the basis from which future research into mitigation practices could address conservation concerns and improve the likelihood that industrial development in Canada is environmentally sustainable.

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Chapter 4 Appendix A: Codes used in interview data

Table 4. A. 1: Codes and their categories that emerged from interview data used in Chapter 4.

Question	Code category	Code
Question 1: Mitigation definition	Dealing with effect	Control effect
		Modify effect
		Counteract effect
		Prevent effect
		Residual effect
		Cannot eliminate effect
		Offset effect
		Eliminate effect
		Alleviate effect
		Avoid effect
		Minimize effect
		Reduce effect
	Contradictions	No net loss
		No net loss is impossible
		Cannot eliminate effect
		Eliminate effect
		Impacts on ecosystems and their services
		Impacts on species
		Compensation not included
		Compensation is not included
	Current situation	Subjective
		Ecological heartbeat
		Seems simple but its not
		Others don't know
		Remedial measures
		Unavoidable impacts
		Buffer
		VEC
		CEAA definition
		Improve status
		Reality is pessimistic
		Rubber stamping
		Action
		Federal versus provincial
		Occurs at different phases – part of design process
		Occurs at different phases – step-wise process
	Mitigation should be –	Flexible
		Holistic
		Identifies the right thing to do
		Assigns responsibility
		Ensures financial resources
		Toolbox
		Advance planning

Question	Code category	Code
		Ecological heartbeat
		Last resort
		Needs consistency
		Would like adaptive
		Finding alternatives
		Strategy
	Examples of ways to mitigate	Specific projects – Site C
		Specific projects – Alberta advantage
		Specific projects - McClelland Lake, Alberta
		Specific projects – Jumbo Creeks Ski Area
		Specific projects – Prosperity Mine
		Environmental Enhancement Fund
		Fisheries Act
		Enhancement
		Restoration
Question 2: Decision to use mitigation. Choice of process.	Needs	Need participatory process
		Need database
		Achieve no net impact
		Goal – get back to as good or better
		Goal – negate residual effect
		Climate change
		Needs experts to come together
		Best mitigation is no project at all
		Cumulative effects
		Accountability
	Methods	Common sense
		Crystal balling
		Don't know
		Follow-up program
		General to specific
		Logic framework
		No net loss
		Pie in the sky
		Rigorous and defensible science-based
		Risk assessment
		Site specific management of habitat
		Table of commitments or concordance
		Metrics
		Adaptive management
		Look at residual effects
		Rank options
		Monitoring
		Balance between cost and response
		Project specific
		Ecosystem analysis
		Literature search
		Research
		Effects analysis

Question	Code category	Code
		Matrix
		Meeting minimum standards or best practices
		Expert opinion
	Problems	Rare to eliminate effects
		Unreliable tools and resources being used by others
		Diversity of opinion
		No EIA turned down
		Information – ignored
		Information – outdated
		Not required to show how choices were made
		Disconnect between experts info and EAs
	Decision to use	Decision to use – costs
		Decision to use – monitoring
		Decision to use – practicality
		Getting projects approved
	Outlier or divergent view	Satisfied with best available science
		No push back
	Examples	Prosperity Mine
Question 3: Upkeep of mitigation	Needs	Need more experienced people
		Need feedback loop
		Need broader scope program
		Need academic involvement
		Do the right thing
		Need tools
		Need dynamic wildlife effects and mitigation document
		Accountability
		Need interdisciplinary collaboration
		Need independent organization
	Problems	Not kept up to date
		Problems interpreting results
		Reinventing the wheel
		Difficult to trace
		Usher to get through legalities
		Not enough monitoring
		Push back
		Discontinuity
		Weak policy
		Effectiveness
		Spatial and temporal issues
		Cost, funds and resources
	Methods and means	Residual effects
		Remedial
		Table of Commitments
		Targets
		Compensation Fund
		Anecdotal information

Question	Code category	Code
		Best practices
		Review of results
		Reporting
		Ground truthing, site visits
		Research
		Adaptive management
		Follow up and monitoring
	Auditing	BC Auditor General report
	Examples	Fisheries Act
Question 4: Mitigation program objectives and goals	Needs	Need separate EA mitigation and compensation policy
		Need alternatives properly assessed
		Need independent organization
		Interdisciplinary results
		Meaningful results
		Need to harmonize federal and provincial processes
		Need to separate knowledge and opinion
		Scientific process
		Need collaboration of experts
		Long term goals
	Outlier	Thankful for process
	Reality	Immediate issues to address – questionable value
		Immediate issues to address – unqualified professionals
		Immediate issues to address – loss of optimism or morale
		Immediate issues to address – unacceptable impacts
		Immediate issues to address – unmitigatable impacts
		Immediate issues to address – public angst
		Immediate issues to address – masking real effects or reality check
		Missing mitigation programs
		Paperwork exercise
		Untested mitigation
		Loop holes
		Outdated mitigation
		Relationships influence EAs
		Missing or outdated data
		Costs
		CEAA 2012
		Project specific
		Gaps in policy, standards of practice
		Inadequate monitoring and follow up
		Getting projects approved
		Yes beneficial and better than nothing

Question	Code category	Code
	What mitigation should be about	Purpose of EA process
		Code of ethics
		Five pillars – sustainable or unsustainable
		Accountability
		Improvements in process
		Cumulative effects assessment
		Adaptive management
		Effectiveness
	Examples	Prosperity Mine

Chapter 5.0: Conclusion

5.1 Dissertation review: key findings

In this dissertation, my main objective was to investigate the extent that mitigation practices and plans can be strengthened to address disturbance to wildlife and wildlife habitat. To unearth the possibilities through which mitigation can be strengthened, I used two main questions throughout my research: 1) how do perceptions of use and success influence choice of mitigation program in the Canadian EA process, and 2) what policy changes can address major systemic pitfalls identified by experts so that environmental sustainability can be realistically achieved. I describe below how my chapters tackled these two underlying queries.

5.1.1 Judgment of mitigation

Gauging the current status of mitigation in the Canadian EA context is a key issue that I explored in this dissertation. I used two main methods of inquiry presented in two separate chapters to evaluate different aspects of the same concept. In Chapter 2, I used quantitative techniques to understand how the use of various mitigation programs can contrast with perception of success. In that chapter, experts were analyzed by occupation group. In Chapter 3, I used a qualitative method to evaluate the use of telemetry as an informational tool in mitigation development. Experts' knowledge data were not used for this chapter, since I relied on an analytical method to dissect the utility of telemetry in mitigation. Both chapters together provided crucial insights. Chapter 2 determined that mitigation programs were rarely, if at all, perceived successful by mitigation experts. Thus, any informational tool applied in a ground-truthing context (e.g., wildlife dispersal in relation to habitat modifications) may improve the success rate of implemented mitigation. Chapter 3 determined that telemetry may prove to be a reliable informational tool that could be used in the foundations of mitigation development. Conversely, Chapter 3 also demonstrated that telemetry studies should only be used in cases when support is guaranteed in terms of funds, networks, analytical expertise, and adaptability. Implementation of mitigation programs should be flexible enough to adjust for unexpected changes, and thus telemetry needs to inform mitigation success (or failure).

The use of mitigation programs was tested in situational contexts in Chapter 2. The programs used to alleviate adverse environmental effects were generally consistent. These programs were zoning and mapping, conservation and protection, and education and outreach. These three programs require a thorough understanding of ecological trends and life histories of the wildlife species in question. In this regard, telemetry studies are likely to be at the forefront of published literature, particularly for large mammals. Telemetry studies are also likely to be undertaken as part of environmental baseline studies in situations where published literature is lacking, provided budgets are available. As telemetry is an appropriate tool discussed in Chapter 3, the evidence from experts' knowledge in Chapter 2 supports this trend. Further, telemetry studies are generally subject to some government scientific protocols (e.g. AB 2012, MELPRIB 1998) which can ameliorate the profile of mitigation knowledge (identified as a need in Chapter 4).

Chapter 2 demonstrated that the least favored mitigation program across all contexts and occupation groups was translocation/relocation plans. Translocation/relocation efforts were not considered effective mitigation strategies since most experts viewed them as unsuccessful in alleviating adverse environmental effects. The act of moving an animal out of its usual range due to industrial development and activities was considered a last-resort effort. Most experts did not consider it appropriate because many wildlife individuals are known to return, or because many individuals are unable to establish themselves in their new habitats. It is likely through telemetry studies that this information might be acquired. Such animal movement information (e.g. disturbance) in direct relation to industrial development and activities is most useful in a cause and effect context. To that end, Chapter 4 brought forth the notion of adaptive management. Telemetry applications in a cause and effect context of a mitigation program might solve some of issues brought forth by experts. For example, the success or failure of a mitigation program may be determined through telemetry studies. Adaptation and further monitoring of the mitigation program would follow suit to improve the efficacy of the mitigation.

Chapter 2 also demonstrated that when experts' knowledge data are analyzed according to their occupation groups, interesting trends emerge. Environmental consultants, on average, applied mitigation programs more frequently than government or academic / environmental non-government (ENGO) personnel. Government personnel were found to be in the mid-ranges of use, and academic/ENGO personnel were less willing to apply mitigation programs. Yet, criticisms of process and mitigation emerged in Chapter 4, with no one occupation group being more or less disparaging than the other. Individuals expressed similar discontent with mitigation mostly due to ineffective follow-up and monitoring, which may also have ramifications for the adoption of adaptive management approaches. Experts conveyed that incomplete monitoring of mitigation was to blame for a lack of implemented mitigation. Without the knowledge base, or the commitment to develop criteria for worthy programs, experts were frustrated with current approaches to recommending appropriate mitigation.

In general, Chapter 2 showed that higher rates of use of mitigation programs corresponded to higher perceived success scores for all occupations. All occupation groups were consistently less willing to take risks with what each perceived to be unsuccessful mitigation programs. Experts might agree that running the risk of causing more adverse environmental effects by implementing mitigation with unknown results is not an appropriate approach. However, taking risks might be a manner through which lessons can be learned through sharing about the resilience of ecosystems and targeted wildlife species. An adaptive management scenario as suggested in Chapter 4 may be the only supported system through which experts may undertake an experimental approach to unraveling criteria for adequate and appropriate mitigation (Riley *et al.* 2002; Wilhere 2002).

In short, Chapters 2 through 4 revealed that mitigation for wildlife and wildlife habitat is a complex and multifaceted concept. These chapters showed that many experts believed mitigation has yet to be fully realized in its ability to offset adverse environmental effects.

5.1.2 Environmental sustainability through mitigation

The ultimate goal of the EA process is to allocate approvals for projects without considerable harm to the surrounding environment. Yet, experts working in the field of EAs that I interviewed for this dissertation were largely dissatisfied with the high approvals rate and process. Experts in different occupations noted that the quantity of approvals does not reflect any kind of quality of EAs. It seems as though the quality of environmental effects assessment suffers while numerous EAs are submitted for industrial development.

Many EAs include explicit mitigation programs (or sometimes they are embedded in project design). Ideally, mitigation programs exist so that industrial projects are acceptable on the basis of sustainability. At this juncture is the element of quality. Chapter 2 revealed that experts had little confidence in the mitigation programs commonly used in EAs, which points to the lack of quality in EAs. Ironically, I interviewed experts who were actually involved in selecting mitigation programs, and it is surprising how little certainty they had in the different options.

Perceived success of mitigation programs did correlate with use of programs, which was a positive relationship that I hoped to see. Yet, overall success of mitigation programs was not a pattern perceived by many experts. Of the different occupation groups that I interviewed, consultants had the strongest relationship and higher frequency of use of programs, which was likely related to the nature of the consulting industry. These trends were expected, given that consultants operate under a level of stress and pressure with billable hours to ensure proponents' projects progress through the EA approvals process.

Though Chapter 2 determined that experts have little faith in mitigation programs, Chapter 4 brought out elements that could be used to improve the quality of EAs. Specific to mitigation practices, elements such as collaborative decision-making, the establishment of an independent monitoring agency, and the inclusion of adaptive management practices were commonly identified by experts. Implementing such elements may lead to more confidence in mitigation programs since they would be supported by multiple stakeholders, tested by the rigors of science, and subject to accountability. A higher level of trust in mitigation may lead to a better EA process, thus reducing the overall adverse environmental effects of industrial projects – the ultimate goal of environmental sustainability through EAs.

5.2 Key contributions to the literature

My dissertation contributes theoretically and empirically to the existing body of literature on wildlife mitigation in the EA process. Here I discuss how my dissertation contributes to these two main facets of research.

5.2.1 Theoretical contributions

A few academic studies investigated the characteristics of wildlife mitigation (e.g. D'Angelo *et al.* 2006; Gagnon *et al.* 2007; McCoy and Mushinsky 2002; McCollister and van Manen 2010; Searcy and Schaffer 2008). However, my dissertation is the first (as far as I am aware at the time of writing) to develop theories around the relationship between the use and success of wildlife mitigation programs as perceived by experts (Chapter 2), and policy guidelines (Chapter 4). Some authors have shed light on the relationship between wildlife and wildlife habitat mitigation and the EA process (e.g. Drayson and Thompson 2013; Noble 2011), but my dissertation takes a unique approach in narrowing in on perceived success by experts and needed improvements for future use. To my knowledge, no other study connects experts' opinions from different occupations to underlying patterns. These patterns are important for understanding differences between occupation groups. For example, knowing the stance and pattern of thought through open sharing from each occupation group will enable collaborative work to be more valuable and effective (Hattori and Lapidus 2004). Or in some cases (e.g., thoughts behind translocation in Chapter 2), knowing that each group is similar in thought may allow research efforts to focus on these trends to work towards improving them.

Though there are a few exceptions (e.g., summary of telemetry technology, Rodgers 2001), studies involving telemetry tend to focus on the application of this tool (e.g. Cagnacci and Urbano 2008; Oli *et al.* 2002; Stewart *et al.* 2012; among many others). There is little described about this role in the EA process, though many companies and researchers rely on telemetry in environmental baseline studies to inform parts of EAs. To align these studies regarding how, why, and when to use telemetry, I offered a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis in Chapter 3. Through the SWOT, I suggested that telemetry is context-dependent rather than fixed and universal. Certain conditions (e.g. support, budgets) need to be present to ensure the utility of telemetry is maximized as an informational tool. Initially, I expected these conditions to be clear and unmistakable. However, after talking to experts in the interviewed segment of my dissertation, it became clear to me that telemetry is used under different conditions. Some experts even mentioned cases when funding was lost part way through a study, logged data was a challenge to use due to incompatible software, and telemetry results were not used at all due to conflicts with project design. Although I did not write about this portion of the interviews since it was not a structured part of the research, I did learn that writing about the minimum support components for a telemetry study is a worthwhile endeavor. The experts who talked further about the utility of telemetry noted that guidelines would be welcome and are needed for operating this expensive informational tool. Hence, Chapter 3 contributes to the ethos of telemetry in a way that places emphasis on securing appropriate conditions first for telemetry studies to be fully achieved.

5.2.2 Empirical contributions

I embarked on this research to bring attention to the voices in the field of EAs and wildlife mitigation since there are few studies (e.g. Swor and Canter 2011) that investigate this body (or similar) of experts' knowledge. My dissertation moves forward the understanding of how experts' occupational background might influence the perception of success of mitigation. My dissertation also examined how the use and perceived success of different mitigation programs were correlated. I demonstrated that experts' perception of success of a mitigation program is likely to influence their willingness to use specific programs in different contexts. My dissertation also provides empirical evidence that experts' knowledge about wildlife mitigation may change depending on their occupation. Bringing attention to these two ideas is important given the differences between and within occupation groups that Chapters 2 and 4 described. Being aware of such differences in approaches to mitigation is crucial to developing strong collaborative efforts, and may lead the way for interdisciplinary decisions (Chapter 4) (provided stereotypes are not developed). Further, if all occupation groups are aware of the multiple approaches to mitigation by each other, individuals may feel more comfortable straying from the norm towards embracing alternative, practical solutions (e.g. adaptive management as in Chapters 3 and 4).

The use of a SWOT analysis in a natural resource management context is an emerging approach to analysis of data that are empirically collected. Though more often found in business applications, other studies in natural resource management apply the SWOT approach (e.g. Nikolaou and Evangelinos 2010; Paliwal 2006). In Chapter 3, I provided detailed matrices with itemized justifications for each element analyzed. This level of detail is necessary as a way to provide background information and reasoning for each element in each category. A SWOT can be a subjective analytical tool, dependent on the perspectives of the user (Nikolaou and Evangelinos 2010). To work around this issue, I described each element and provided justifications following the examples of scientific studies. Including peer-reviewed evidence is a robust and acceptable method to analysis that I followed to add empirical weight to my conclusions. Although not a common approach, I recommend other users of SWOT analyses provide this type of scientific rationalization to add validation to their studies. This step is particularly important if the context consists of a natural resource, since many science-based studies are likely to have already developed detailed information for a natural resource.

5.3 Suggestions for future research

In Chapter 2, I argued that occupation groups have a limited influence on the selection of mitigation programs in different contexts. I also found that attributing "success" to any particular mitigation program was a challenge for almost all experts interviewed. In a future project, I hope to conduct a more systematic relationship between success and use of mitigation program by focusing on each occupation group where experts conduct their own mitigation work (ground-truthing scenarios). Key questions may include: what is 'success', and where are the 'successful' mitigation programs? To whom and for what are these considered 'successful'?

In Chapter 3, I argued that telemetry as an informational tool in the EA process should be used in specific contexts. With the right amount of support, telemetry can be a powerful use of technology to inform mitigation practices. I wonder about other tools that can be used similarly, and databases that can be developed to prevent 'reinventing the wheel'. For example, cumulative effects in EAs is a difficult concept to work through and many studies have tackled different elements of it (see Connelly 2011 for a summary). Telemetry results from wildlife in EA projected and post-EA disturbed areas are generally not shared, especially when proponents invest a considerable amount of time and money for their own project benefit. In the future, the benefits and ways of sharing results to inform cumulative effects assessment can be assessed through a SWOT analysis. Ideally, multiple perspectives would be included in this type of study. A key question may include: to what extent can a shared database of informational results be used to inform cumulative effects assessments?

In Chapter 4, I argued that experts' frustrations around the quality of wildlife mitigation in Canada can be addressed through improved policy guidelines and other operational additions (e.g. an independent monitoring agency). Specifically, I suggested that adaptive management is one way to contend with results of monitoring mitigation programs. Future ground-truthing studies that demonstrate how adaptive management can be used as part of an effective monitoring (and action) program would strengthen the utility of incorporating this management scheme. Following the examples and thoughts of McFadden *et al.* (2011) and Westgate *et al.* (2013), adaptive management studies may be put in place, which would spear-head this approach as a crucial component in the EA process. Key research questions may include: how does an adaptive management approach to wildlife mitigation continually guarantee a response to adverse environmental effects from industrial projects? How effective is adaptive management is this context?

5.4 Concluding remarks

Adverse environmental effects from industrial projects are inescapable, and the number of industrial projects on Canadian lands is not dwindling. Currently, there is a societal responsibility to handle adverse environmental effects in the best means possible. However, this dissertation showed that experts in the field of EAs are not satisfied with the progress that has been made towards mitigating adverse environmental effects upon wildlife. Through qualitative and quantitative analyses, I found that the reasons for this lack of progress are numerous. The reasons vary from improper and misused mitigation programs in different contexts, to ineffective monitoring, and uncertainty with respect to knowledge of ecological changes in direct relation to industrial projects. Thus, I questioned how to make sense of wildlife mitigation in the Canadian context.

This dissertation provided suggestions for improving the current status of wildlife mitigation derived through the EA process. Whether any of these suggestions will reach the necessary political forum and drive the will to change remains to be seen. However, the adverse effects on wildlife over time must be recognized (and hopefully not be too late), and they may speak for themselves since adverse changes are no longer acceptable. Recognizably, change is slow to happen in the arenas where environmental sustainability is discussed. Nevertheless, as long as environmental sustainability is the manifesto there may be a real drive to change policy and guidelines in Canada for the benefit of wildlife and their habitats. As more expert voices are heard on this topic, as in this dissertation, more possibilities for progress may be realized.

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