Evaluating an Ecosystem-based Management Approach to Conserve Biodiversity in Boreal British Columbia

By

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COMMITTEE APPROVAL

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Abstract

Biodiversity in boreal British Columbia is threatened. Protecting biodiversity and integrating the conservation of at-risk species, sensitive ecological communities, and cultural diversity in this region is an ongoing challenge. Following a systematic structure based on ecological principles may help integrate social-ecological systems with multiple values, needs, and interests across diverse cultural and ecological landscapes. My research assessed whether an ecosystem management approach can be used as a framework for achieving biodiversity conservation and supporting planning processes in northeast British Columbia. I examined fundamental principles, characteristics, and components of various ecosystem-based methods and explored social barriers and organizational challenges when attempting to implement such an approach. My qualitative research method consisted of detailed document analysis and in-depth semi-structured interviews. From this, I concluded an ecosystem-based management approach may help conserve biodiversity and recommend a potential framework to guide resource planning and land use decision-making in the boreal forest ecosystem over time.

Keywords: Biodiversity conservation, ecosystem-based management, ecological framework, boreal forest, British Columbia, Indigenous socio-cultural values.

Table of Contents

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Abbreviations Listing

BC CDC – British Columbia Conservation Data Center

BC OGC – British Columbia Oil and Gas Commission

BEC – Biogeoclimatic Ecosystem Classification

BGC – Biogeoclimatic

BC – British Columbia

CBD - Convention on Biological Diversity

CEF – Cumulative Effects Framework

CIT – Coastal Information Team

COSEWIC - Committee on the Status of Endangered Wildlife in Canada

EBM – Ecosystem-based Management

FLNRORD – British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development

FPB – Forest Practices Board

FRPA – Forest Range and Practices Act

FSJ – Fort St. John

GAR – British Columbia Government Actions Regulations

GOC – Government of Canada

IUCN - International Union for Conservation of Nature and Natural Resources

LRMP – Land and Resource Management Planning

MKMA – Muskwa Ketchika Management Area

NDU – Natural Disturbance Unit

NRV – Natural Range of Variation

OGAA - Oil and Gas Activities Act

RRU – Royal Roads University

RSEA – Regional Strategic Environmental Assessment

SARA – Species and Risk Act

SFMP – Sustainable Forest Management Plan

TSA – Timber Supply Area

UNDRIP – United Nations Declaration on Indigenous Peoples

UWR – Ungulate Winter Range

WHA – Wildlife Habitat Area

Introduction

The boreal region of Canada is biologically and ecologically diverse providing a variety of ecosystem services and containing a vast array of species and ecosystems that are unique within the province. Many ecologically important and sensitive elements exist within this vast landscape (Andrew et al., 2014; Brandt et al., 2013; Carlson & Browne, 2015). From an ecosystem standpoint, this includes extensive wetland complexes, abundant riparian channels along intricate water networks, important old forest and late-seral mixed wood forest communities, and other fragile areas such as subalpine and alpine ecosystems and native grasslands. The boreal region also stores a substantial amount of carbon in the soils, forests, and wetlands, and these ecosystems are also large sinks for atmospheric carbon (Brandt et al., 2013; Roulet, 2000). From a habitat standpoint, the boreal region also contains important core and seasonal range territory and connectivity corridors for both large and small mammals as well as habitat for aquatic species, and feeding, mating, and refuge areas essential for many ecologically important migratory birds (Blancher, 2003; Brandt, 2003).

Biodiversity Loss

The Secretariat of the Convention on Biological Diversity (CBD) in 2011 indicated that biodiversity loss at the global scale was continuing, at rates far greater than previously estimated (CBD, 2011). The Millennium Ecosystem Assessment (2005), as well as Cardinale et al. (2012), and more recently Duarte, Ribeiro, and Paglia (2016) reported extensive decline in ecosystem services around the globe. As outlined by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2019) and further reported by Díaz et al. (2019),

"terrestrial ecosystems worldwide are at risk and in decline [and] human impacts have resulted in a direct loss of 20% of terrestrial ecosystems internationally since pre-history" (Díaz et al., 2019, p.3). The Government of Canada developed the 2019-2022 Federal Sustainable Development Strategy that aligns this country's goals with the UN Sustainable Development Goals (SDGs), including the need to "take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and by 2020, protect and prevent the extinction of threatened species" (Government of Canada, 2019, p. 118).

In a 2015 review of biodiversity conservation measures in Canada (in relation to the Secretariat on the Convention on Biological Diversity (CBD) Aichi Targets), MacKinnon et al. (2015) reported that the global decline of biodiversity is a serious environmental threat facing humanity, that several ecological thresholds and important species boundaries are currently exceeded, and that independent audits are revealing that there is an ever increasing gap between biodiversity commitments and results in biodiversity protection (Mackinnon et al., 2015, p. 3577). In northeast British Columbia (BC), Lee and Hanneman concluded that the Peace Region "has experienced rapidly escalating changes due to a convergence of industrial interests on the same land base" (Lee & Hanneman, 2013, p. 82).

In a recent 2020 publication regarding how to improve wildlife stewardship and habitat conservation in BC, the province reported that "wildlife and their habitat face unprecedented and accelerating challenges due to climate change, increasing human activity, and competing pressures on the land base" (Province of British Columbia, 2020a, p.4). More specifically, in boreal BC, the sustainability of ecosystem functions and associated services are potentially

threatened as a result of expanding and intensifying natural resource activities (e.g., agriculture, forestry, mining, oil and gas, renewable energy, and associated built infrastructure) and climate change and climatic variability (Creed et al., 2019, p. 407-408). For example, the province estimates that the decline of boreal caribou in BC may be attributed to habitat loss, habitat fragmentation and alteration, and increased predation resulting from forestry and petroleum and natural gas activities on the landscape (Province of British Columbia, 2020b).

At this time there is wide agreement among more than 1,500 scientists globally about the need to develop scientifically based and comprehensive approaches to manage the system as a whole and the full diversity of species and ecosystem functions, rather than for single species purposes, or politically motivated targets (Noss et al., 2012; Wells et al., 2018). Prominent early researchers in ecosystem management, Franklin (1993) and Weddell (2002), claim the overall goal of any ecological management system should be to manage healthy ecosystems across the entire landscape rather than simply in single purpose needs, isolated to a few protected areas, or carried out for the management and protection of a single species. Cardinale et al. (2012) states the importance of a systematic ecological approach, saying that “without an understanding of the fundamental ecological processes that link biodiversity, ecosystem functions and services, attempts to forecast the societal consequences of diversity loss, and to meet policy objectives, are likely to fail” (p.66). Further, within the boreal, Price et al. (2013) asserts that considerable ingenuity from scientists and land managers will be needed to develop sustainable practices to address the challenges of posed by climate change (Price et al., 2013, p.322).

Evolution of Ecosystem and Biodiversity Management Related to Boreal BC

In this section I provide a brief overview of ecosystem management, biodiversity conservation, and current legislation within the province of BC, identify knowledge gaps and provide context for this research.

Ecosystem Management

Modern ecosystem management concepts are not new. Simberloff (1998) claims that ecosystem management has "exploded on the resource management scene following a technical session of the American Association for the Advancement of Science Annual Meeting in 1991" (p.251). For many years, scientists, academics, and environmental advocates have presented the virtues of ecological-based systems (e.g., Dale et al., 2012; Dale, 2018; Franklin, 1993; Franklin et al., 2000; Gabriela et al., 2016; Galindo-Leal & Bunnell, 1995; Gram et al, 2001; Grumbine, 1994; Holt et al., 2003; Holt & Hatfield, 2007; Meffe et al, 2002; Noss, 1990 & 1999; Pickett et al., 1992, Pojar et al., 1987; Slocombe & Hanna 2007; and Weddell, 2002).

Like many other developed jurisdictions, since the latter part of the 20th century the province of BC moved from solely the exploitation of resources and managing for the sustainable yield of a single resource to incorporating environmental policy and environmental standards into resource management. This move has been gradual as knowledge, technology, and public opinion and pressure have advanced and the recognition of Indigenous Rights and Title have evolved over time. For example, in the forest sector, this includes introducing silviculture practices and associated legislation and integrated land management planning in the 1980s, initiating forest practices standards and policy in the 1990s, developing long-term sustainable

forest management planning in the 2000s. In other resource sectors, such as mining and oil and gas, this includes the maturation of the environmental assessment process both federally and provincially for resource development proposals.

Simultaneously, over the last 50 years a significant evolution of knowledge about ecology and ecosystems has occurred in BC. Forest ecosystem classification science and ecosystem theory from European forestry was introduced and began to take hold in the province in the 1960s (Krajina, 1969; Krajina et al., 1982). Also, the province began to map biophysical and soil landscapes in the 1970s. In the following decades, substantial forest ecosystem research, ecosystem identification, and related analysis, and reports relating to forest and ecosystem management were published. Furthermore, a province-wide Biogeoclimatic Ecosystem Classification (BEC) system evolved and matured in the province, as well as numerous resource inventory and mapping processes, protocols and province-wide standards were developed, including regional ecosystem site identification information and guidebooks.

Recent technological advances related to ecosystem management also affect how society views and manages the natural world. Technology has progressed extensively throughout the world since the turn of the 21st century. For example, since this time BC experienced exponential advances and availability in modern land analysis tools, geographic information systems (GIS), remote (satellite) imagery, and decision analysis and network decision tools. These advances allow for significant improvements to the identification, assessment, classification, and mapping of land, resources, and ecological information.

Within many western cultures, the general public's understanding of, and support for increased environmental protection have also evolved. As overall knowledge and concern becomes more commonplace in society, political ideologies and governments at various levels are also needing to react and respond accordingly. Dale (2018) states that "in Canada, the land use conflict between economic growth, equity, and ecological limits is front and center on the political agenda…" (p.92). However, as outlined by Kimmins (1992) almost 30 years ago, there is a growing need to move from a 'political [or analysis] phase' to an 'implementation phase' of conservation. Kimmins reasoned that "real change for the better comes in the form of new legislation, policy, regulations, economic incentives, institutional structures, and government-sponsored opportunities that are made possible by the successful execution of the political phase" (p.9).

In 2020, as outlined by the province's Old Growth Review Panel (2020), natural resource management policies within the province are in a state of flux with several interrelated government initiatives underway including the provincial old growth review, modernized land use planning, caribou conservation, and a review of the Forest and Range Practices Act (p.20-21). Furthermore, the role of Indigenous communities in land and resource management in the province is now being recognized. In particular, and of note in boreal BC, is the 2021 BC Supreme Court decision recognizing that the impact of resource development over many years has significantly impacted the ability of the Blueberry River First Nation (and other Treaty 8 First Nations) to meaningfully exercise their Treaty rights (Supreme Court of British Columbia, June 29, 2021).

Environmental Legislation in British Columbia

A review of the evolution of ecosystem management and biodiversity conservation is incomplete without also reviewing existing applicable environmental legislation in the province. There are several land use planning, regulatory and policy instruments used by federal, provincial, and local governments that are intended to provide a wide range of environmental protection, legally guide resource activities and extraction, or support the conservation of extirpated, endangered, or threatened species, ecosystems, and wildlife habitats. Although certainly not an exhaustive list, the most relevant federal and provincial legislation and regulatory strategies, orders, and guidelines related to terrestrial biodiversity and environmental protection in the province of BC are provided below in Table 1, along with a concise description of the intent, objective, or requirement of the policy, strategy, or framework.

Table 1

Environmental Protection and Conservation Legislation in British Columbia

Act/ Legislation/Guideline	**General Description or Requirement**
Acts	
Federal Species at Risk Act (SARA)	Provides protection on federal lands for various wildlife and plant species identified under Schedule 1 of the Act. As outlined by the Government of Canada (2022a), the purposes of the Species at Risk Act (SARA) are to: Prevent wildlife species in Canada from disappearing, to provide for the recovery of wildlife species that are extirpated (no longer exist in the wild in Canada), endangered, or threatened as a result of human activity, and to manage species of special concern to prevent them from becoming endangered or threatened (p.7).
Federal Sustainable Development Act	The purpose of the Act, which came into force in 2008, is to provide the legal framework for developing and

	implementing a Federal Sustainable Development Strategy that will make environmental decision-making more transparent and accountable to Parliament (Government of Canada, 2020b, p.2)
Federal Impact Assessment Act (IAA)	The purpose of the IAA is "to protect the components of the environment, and the health, social and economic conditions that are within the legislative authority of Parliament from adverse effects caused by a designated project" (Government of Canada, 2019, p.8). The Act includes: • Proactive strategic and regional assessments to evaluate big-picture issues (e.g., climate change, biodiversity, species at risk) and cumulative effects. • Indigenous engagement and partnerships • Strengthened monitoring, follow-up, and enforcement (p.8).
BC Environmental Management Act	This Act includes provisions regarding pollution prevention, waste management, spill preparedness, response, and recovery, contaminated sites and reclamation and remediation (Province of British Columbia, 2020a)
BC Forest and Range Practices Act (FRPA)	The FRPA and regulations govern the activities of forest and range licensees in BC. The statute sets the requirements for forest land users related to wildlife areas and habitat features, as well as planning, road building, harvesting, and old growth management areas. (Province of British Columbia, 2021a)
BC Oil and Gas Activities Act	This Act provides specific recommended requirements and practices for the protection of the environment related to oil and gas development in BC (Province of British Columbia, 2022b)
BC Wildlife Act	This Act pertains to all wildlife species, wildlife habitat, and their management, including requirements for handling and surveys of wildlife (Province of British Columbia, 2022c)
BC Park Act	The Park Act protects crown land and natural resources from industrial extraction and other resource use (Province of British Columbia, 2022d).
Protected Areas of BC Act	This Act affords various levels of protection to crown lands through ecological reserves, parks, and conservancies (Province of British Columbia, 2022e)
Supporting Strategies, Orders, and Frameworks	

Federal Committee on the Status of Endangered Wildlife in Canada (COSEWIC)	The independent advisory panel evaluates and classifies wildlife and plant species following the SARA framework. The committee determines the national status of Canadian species, subspecies, and populations suspected of being at risk and advises the Minister of Environment and Climate Change Canada regarding potential required protection. (COSEWIC, 2022)
Federal Species Recovery Strategy	A species recovery strategy is a planning document that identifies what needs to be done to potentially avert or reverse the decline of a species. Federal strategies are developed for a species designated as extirpated, endangered, or threatened, identifies critical habitat for a species list in Schedule 1 of SARA (Government of Canada, 2022a)
BC Government Actions Regulations (GAR)	Orders made under GAR are a key component of land designations, management and protection for environmental values, and the implementation of stewardship measures under FRPA (Province of British Columbia, 2022f)
BC Conservation Framework	The non-legal framework is an approach developed by the province in 2009 in an attempt to maintain biodiversity in BC. The framework goals are to: • contribute to global efforts for species and ecosystem conservation • Prevent species and ecosystems from becoming at risk • Maintain diversity of native species and ecosystems (Province of British Columbia, 2009)
BC Cumulative Effects Framework (CEF)	A framework containing policy, procedures, and decision-support tools to improve the consideration of cumulative effects in natural resource decision-making in B.C. It provides a strategic approach to assessing cumulative effects, values, and management responses (Province of British Columbia, 2021b)
BC Conservation Data Centre (BC CDC)	The BC CDC is a non-legal entity that assists in the conservation of the province's biodiversity by identifying, tracking, and assigning conservation status to wildlife and plant species and ecosystems based on their global, national, and provincial conservation status (BC CDC, 2020).

The above legislation and supporting strategies, orders, and frameworks are created to support both environmental protection and biodiversity conservation. In some cases, overarching protection of broad environmental requirements are provided or species-specific protection rules or guidance are clear. On the other hand, many of the existing policies and guidance pieces are applicable to a narrow management activity or only have a legal bearing within a single resource sector or natural resource Ministry.

Biodiversity Management

The province attempted to address biodiversity conservation in the 1990s and 2000s. Overall these initiatives, although well intended, were mainly developed for single natural resource sectors and excluded input from area First Nations. Furthermore, these initiatives were not widely supported within industry, were watered down, or were not implemented as originally envisioned. Policy-wise, substantial preliminary guidance related to biodiversity management in the forest sector came about with the development of the 1995 Forest Practices Code and the associated Biodiversity Guidebook (Province of British Columbia, 1995). The guidebook attempted to address and protect biodiversity at both the landscape (coarse-filter) and site-specific (fine-filter) level.

Within boreal BC, the province, along with industry and area municipalities developed the 1997 Fort St John (FSJ) Land and Resource Management Planning (LRMP) process. At that time, the LRMP stated that biodiversity threats in the region include the loss of species, loss of habitat (i.e., anthropogenic disturbance through land clearing and land use change), and the loss of function (fragmentation and degradation). As well, the LRMP identified that nationally and

internationally recognized wildlife resources exist within the FSJ Timber Supply Area (TSA), especially in the wilderness areas in within the Muskwa-Ketchika Management Area (MKMA) (Fort St. John Working Group, 1997, p.171). At that time, the LRMP identified the maintenance of biodiversity in the area required:

- protection and connectivity of large areas
- habitat variety and connectivity at the landscape level, and
- management practices at the stand level (p.18-19)

The 1997 LRMP established landscape-level biodiversity guidelines for each Resource Management Zone to provide strategic direction for land use planning decisions. The LRMP's 1997 general management direction relating to biodiversity was to:

- Identify and map rare ecosystems, plant communities, sensitive areas and habitat types.
- Maintain large patches of unfragmented mature and older seral stage forests (where appropriate).
- Ensure connectivity between important habitat types using naturally occurring corridors (e.g., riparian types) (p. 18-19).

The period that followed saw the development of Graham River Integrated Resource Management Plan, which was to include management strategies and operational plans such as sequential clustering of development, connectivity corridors, access management, and adaptive management (Fort St. John Pilot Project, 2018, p.57).

Following guidance from the 1997 FSJ LRMP, the FSJ Pilot Project was also initiated. This exclusive Project is unique to the region and has its own regulation under the Forest and

Range Practices Act (FRPA) focusing on results rather than process. The intention of the Project is to protect a range of forest resources originally intended under the Forest Practices Code (Fort St. John Pilot Project, 2018, p .20). From this Project the Sustainable Forest Management Plan (SFMP) was developed for the FSJ TSA, culminating in SFMP No. 3, which was signed off by the forest industry and the provincial government in 2018 (Fort St. John Pilot Project, 2018). The SFMP was created to provide direction for forest management in a way that recognizes the principles of sustainable management and incorporates other ecological and cultural values while maintaining and enhancing the long-term health of forest ecosystems (Fort St. John Pilot Project, 2018). The current approved 2018 SFMP includes the following key biodiversity strategy components:

- Coarse-filter ecosystem type representation examines the proportion of each ecosystem 'type' that is expected to remain non-harvested.
- Landscape level forest structural assessment at various temporal and spatial scales to assess habitat and biological richness.
- Monitoring the presence and trends of species in response to changes in habitat structure and pattern (Fort St. John Pilot Project, 2018, p. 47).

In the early 2000s, the BC government completed various provincial-level evaluations of biodiversity, including studying biodiversity elements and biodiversity threats and priorities related to understanding key flora and fauna and ecosystems that require protection across the province (e.g., Holt et al., 2003; Holt & Hatfield, 2007).

With respect to ecosystem management, in BC today, there is wide acceptance of the technical process of ecosystem identification, classification, and analysis as well as integration of ecological information into legislation, standards, and policy development relating to various resource operations. However, even though ecosystem and biodiversity science, technology, and opinions have progressed considerably, currently, ecosystem management is often only applied for single-use applications, used as a mitigation tool or applied in special circumstances (e.g., a project-specific environmental assessment, a harvest prescription for forest operations, or for habitat protection planning for identified species-at-risk), or is constrained by existing legislation. Van Damme et al. (2014) contends that there is a need to strike a balance between timber supply (quota) and biodiversity protection in the boreal, citing that "it is unlikely that biodiversity protection can be fully achieved if conservation can only be carried out so long as it does not unduly impact timber supply from the area forests" (p.11). Furthermore, the recently completed provincial Old Forest Review Panel (2020) stated: "the policy direction has been to limit the impact of biodiversity conservation on timber supply to approximately 4% across the province… [noting that this approach compromises old growth targets and] … weakens the original intent [of old forest retention]" (p. 32).

Knowledge Gaps: Why Consider an Ecosystem-based Management Framework

In an evaluation of the status of EBM in Canada Van Damme et al. (2014) reported that "BC does not explicitly set out its boreal forest management requirements under a comprehensive ecosystem-based management (EBM) framework" (p.23). The current fragmented legislation and approach to (biodiversity and ecosystem) management poses a

substantial obstacle to improved sustainability planning (Dale, et al., 2012). Dale et al. (2012) further emphasize that 'fragmentation' is the "planning equivalent of silos and solitudes…and the opposite of integration and remains a substantial obstacle to improving approaches to sustainable planning based on ecological, regional, and system-based thinking" (p.33). Duarte (2016) emphasized "the urgent need to incorporate services into the decision-making process in order to ensure human well-being, presently and in the future" (p.2). Although, different methods and techniques used to protect and manage biodiversity at the species, ecosystem and landscape level are as diverse as the various landscapes and species themselves, as Dale et al. (2012) point out, any land management framework should be both strategic and comprehensive. With this in mind, such a framework is intended to provide guidance and management of the whole system at various temporal and spatial scales. Along this line of strategic thinking, the province's Old Growth Review Panel (2020) recommended declaring the conservation and management of ecosystem health and biodiversity of British Columbia's forests as an overarching priority and enact legislation that legally establishes this priority for all sectors (p.15).

Regarding First Nations, there is a historical treaty, international recognition, a provincial declaration, and a recent court judgement, as well as a multitude of existing plans and regionally important initiatives affecting land and resource management and decision making within First Nations territories in northeast BC. Most notably, Treaty 8 was signed on June 21, 1899, between the Government of Canada and area First Nations (Government of Canada, 2013). In modern times, in 2014, the Province of BC and area First Nations entered into Provincial–Indigenous government-to-government processes such as the northeast Regional Strategic

Environmental Assessment (RSEA) conducted under the provincial Environmental Stewardship Initiative (ESI) (Province of British Columbia, 2019a). The RSEA process is intended to focus on ecosystem research, knowledge exchange, assessment, restoration, and stewardship education and training while providing meaningful steps towards reconciliation relating to the United Nations Declaration on Indigenous Peoples (UNDRIP) (Province of British Columbia, 2019a). In 2019, the province also officially endorsed UNDRIP (Bellrichard, October 24, 2019; Little, November 26, 2019). Further in 2019, the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) began working with interested Treaty 8 First Nations with the objective to prepare for an update to the FSJ LRMP (Province of British Columbia, 2019c). The LRMP is intended to set objectives and strategies that govern how land and resources are managed, including identifying resource management zones and protected areas (Province of British Columbia, 2019c). Within this process, the province and First Nation governments began exploring modern ways to manage this vast landscape. The challenge is to integrate the many needs and values within the region, resource development, protecting biodiversity, and recognizing First Nation sociocultural values as per Treaty 8 Rights and Title. At this time, the province of BC expressed interest in exploring ecosystem management frameworks to determine how they may apply in the region in a boreal context (R. Cage, personal communication, November 21, 2019).

In addition to these agreements, declarations, and processes there are many concurrent and overlapping policies, plans, and initiatives affecting biodiversity conservation in the region. Some examples would include the FSJ SFMP (Fort St. John Pilot Project, 2018), much

provincial-level environmental legislation, existing cumulative effects policy, provincial old growth policy updates and wildlife habitat orders (e.g., boreal caribou), regional FRPA evaluation and monitoring programs, and the FSJ TSA annual allowable cut determination (FLNRORD, 2018).

On June 29, 2021, the BC Supreme Court ruled in favour of the Blueberry River First Nations (versus the Province of British Columbia) stating that the province allowed "industrial development in Blueberry's territory at an extensive scale without assessing the cumulative impacts of this development and ensuring that Blueberry would be able to continue meaningfully exercising its treaty rights in its territory" (Supreme Court of British Columbia, 2021, Overview section, para. 3). There are a number of in-progress outcomes resulting from this judgement related to land and resource management in northeast BC (Province of British Columbia, 2021).

With all this happening, implementing an over-arching strategic and comprehensive land use framework may prove beneficial to addressing complex social, environmental, and resource management values, beliefs, goals, and objectives in boreal BC. An EBM framework may be such an approach. According to many researchers, true EBM includes a few essential tenets, such as managing the entire ecological system, focusing on ecological integrity (health), addressing governance and sustainability, and integrating human well-being (Andison, 2020; Arkema et al., 2006; Coast Information Team (CIT), 2004; Foley et al., 2010; Gilani, et al., 2018; Grumbine, 1994; Slocombe, 1998).

In boreal BC, an EBM approach may potentially help to map, organize, and manage spatial and temporal ecological information and be used to assess the status and condition of land

use, ecosystems, and threatened wildlife species (e.g., bison, boreal caribou) over time. For example, evaluate wildlife habitat availability and suitability, and direct restoration plans and reclamation priorities, assist to predict land use capability and land productivity, support cumulative effects assessments, and provide a rigourous structure for long-term biodiversity monitoring. An ecological framework may also provide a valuable opportunity to bridge Indigenous traditional knowledge, incorporate cultural diversity, and community-based concepts with western technical science and modern biophysical approaches to environmental management. This method and structure may offer an opportunity and path forward to build (or re-build) trust between governments and communities, increase confidence in long-term management strategies, and improve support for jointly determined land use decisions by various governments, interested parties, communities, and affected stakeholders.

Research Objective and Question

The objective of my research is to investigate EBM as a potential framework to protect biodiversity and improve land use planning and resource decision-making in northeast BC.

Research Question

My main research question is: How can an EBM approach and structure potentially contribute to conserving biodiversity in boreal BC? My research sub-questions are:

- Can an ecosystem management approach provide an effective framework for the protection of biodiversity in Boreal British Columbia?

- What are the principles, criteria, and key characteristics of EBM applicable to a boreal-based EBM? What are the barriers and challenges to implementing a potential EBM framework in the region? and
- What may be a suitable EBM framework and recommended components for boreal BC that could potentially help improve land use planning and guide resource management decision-making in the region?

Study Area

My research concentrated on EBM in a boreal context and is applicable to the boreal region throughout northeast BC. However, for scope, more specifically, my research covers the region of the boreal located within the FSJ TSA (Figure 1). This area covers approximately 4.7 million hectares in northeast BC and lies within the Boreal Plains Ecoprovince and Natural Disturbance Unit (Delong, 2011; Demarchi, 2011).

Geographically my study area lies within a portion of the Treaty 8 Territory and generally falls within the broader traditional territories of a number of First Nations: Blueberry River First Nations, Doig River First Nation, Halfway River First Nation, Prophet River First Nation, Horse Lake First Nation, Fort Nelson First Nation, Dene Tha' First Nation, Saulteau First Nations, Tsay Keh Dene Nation, and West Moberly First Nations. The First Nation communities of Blueberry River, Doig, and Halfway River as well as the community of Taylor and the municipality of Fort St. John are located in my study area.

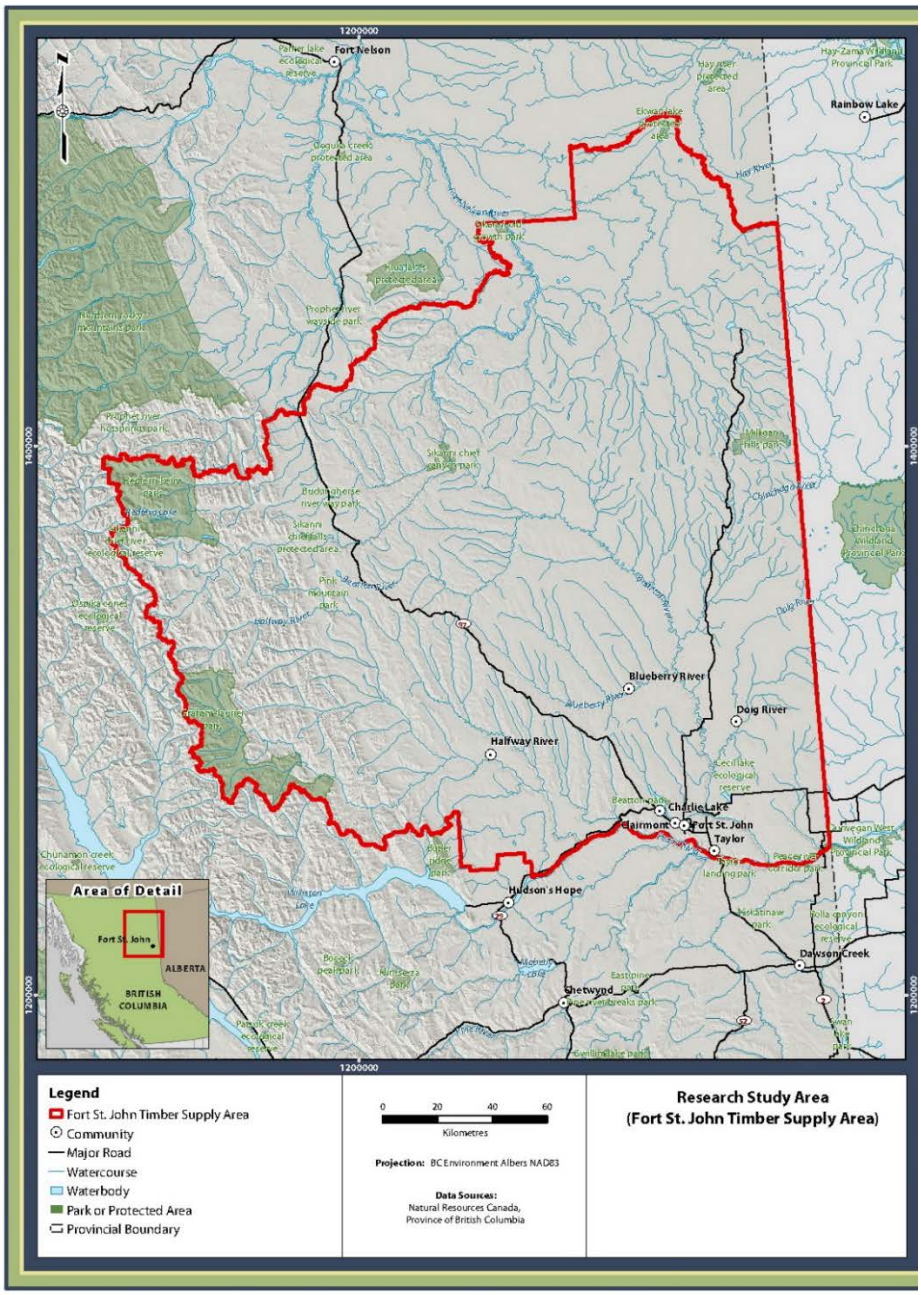

Figure 1. Research Study Area Adapted from Atticus, 2021

Current Condition

Over the last half century, extensive agriculture, timber harvesting, and oil and gas resource development has occurred in this resource rich area of the province (Creed et al., 2019; Lee & Hanneman, 2013; Nitschke, 2008). Lee and Hanneman concluded that the Peace Region "has experienced rapidly escalating changes due to a convergence of industrial interests on the same land base" (Lee & Hanneman, 2013, p. 82). Furthermore, in their 2021 investigation, Atticus (2021) reported that "approximately one-third of the study area is anthropogenically disturbed or altered (by agriculture land conversion, oil and gas exploration and infrastructure, and timber harvesting operations and roads)" (p.33). In 2021 the RSEA process undertook a joint methods pilot project in northeast BC which developed and tested methods to evaluate potential cumulative effects resulting from various resource development scenarios. The RSEA Methods Pilot Methods and Analysis Report (Ecora, 2021) concluded that:

> Industrial practices have left the pilot area in a poor current condition for a wide range of indicators when compared their associated thresholds. There are currently approximately 280,000 km of linear disturbances (pipelines, roads, and seismic lines), plus ~436,000 ha of area disturbances dominated by agricultural land, harvesting and well pads (p. ii).

Development has occurred following a diverse array of tenure structures and regulatory settings with each sector managed by different government departments (e.g., FLNRORD, the Ministry of Energy Mines and Petroleum Resources, the BC Oil and Gas Commission, and the Ministry of Agriculture). This substantial anthropogenic disturbance throughout the boreal landscape combined with naturally occurring wildfire events and pest outbreaks (e.g., mountain

pine beetle infestation) is putting substantial pressure on the region's biodiversity (Creed et al., 2019; Province of British Columbia, 2019c; Lee & Hanneman, 2013; Nitschke, 2008).

Figure 2 below, from Creed et al. (2019) shows an average anthropogenic disturbance index across the Canadian boreal from 2008 to 2010 using Environment and Climate Change Canada data. This diagram shows the high level of disturbance in northeast BC compared to other portions of the country.

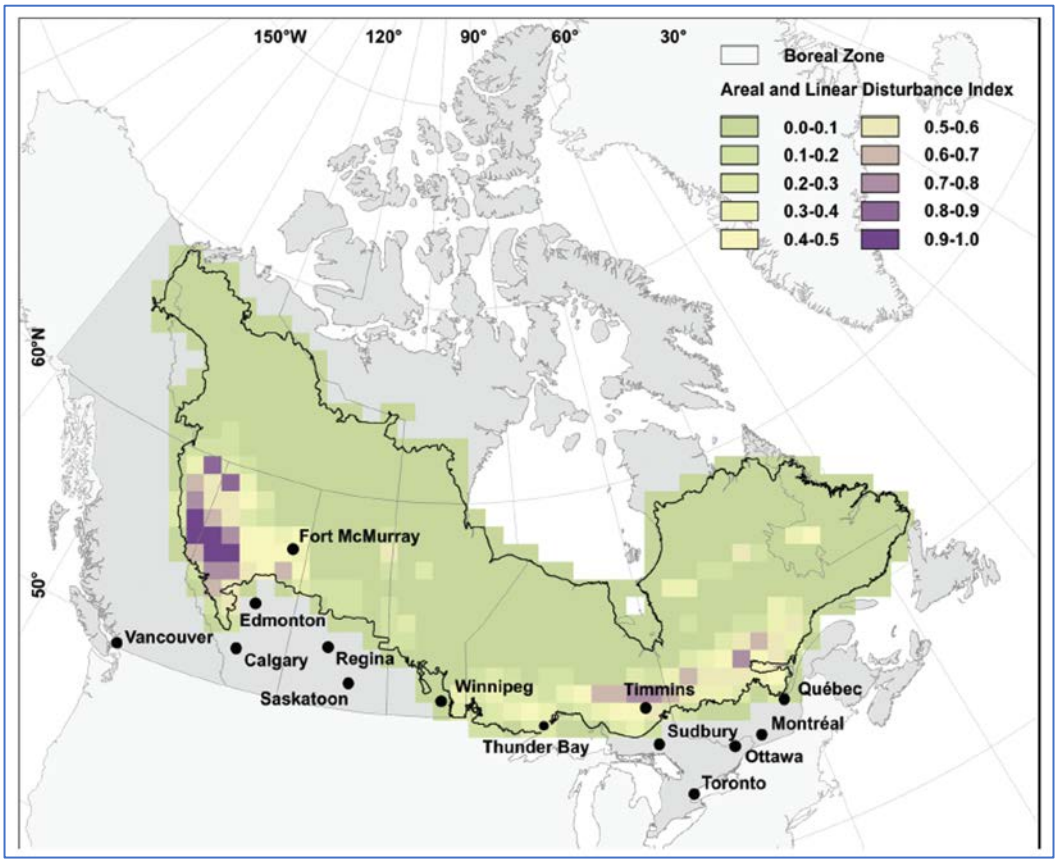

Figure 2. Anthropogenic Disturbance in the Canadian Boreal from Creed et al., 2019

Methodology

My research consisted of a review of scholarly findings in the peer reviewed literature, analysis of documents such as government and other technical publications and reports, and data collection and analysis of in-depth semi-structured interviews. I followed a qualitative approach as per Cox (2015), Creswell (2009), and Bensted-Smith and Kirkman (2010). This type of approach is similar to that implemented by Bensted-Smith and Kirkman (2010), Christie et al. (2009), and Pitcher et al. (2009) to generate key interpretations and EBM concepts. Further, as Creswell (2009) states, a qualitative approach provides "a means for exploring and understanding the meaning individuals or groups ascribe to a social or human problem" (p. 4). Throughout the process I kept my research question and scope top of mind, and worked to ensure that my research is valid, reliable, and trustworthy by maintaining good protocols, documentation, and chain of evidence as per Aberdeen (2013). Moreover, to ensure that my research is credible, transferable, dependable, and confirmable I followed Guba's (1981) qualitative research criteria (Guba, 1981).

Literature Review

The literature review included a thorough investigation of various existing EBM approaches, applicable frameworks, definitions, and fundamental principles and components that could potentially be applied to conserving biodiversity in boreal BC. This included a comprehensive and wide-ranging search using Royal Road University (RRU) library services, Google Scholar, and other environmental databases. Applicable peer-reviewed literature was reviewed, and document analysis was conducted of relevant professional technical reports,

publications relating to ecosystem management from federal and provincial governments, and related biodiversity conservation and ecological frameworks explored in other jurisdictions. While the research focused on land-based resource management in BC, international EBM approaches and other biological disciplines (e.g., marine) were considered as they could also provide valuable insight and lessons applicable to northeast BC. Key concepts and keywords included: ecosystem management, ecosystem-based management, ecological frameworks, systems, biodiversity conservation, species protection, boreal (BC, ecology), First Nation traditional land use and Indigenous knowledge, ecological risk analysis, ecological resilience, and natural disturbance theory.

In addition to EBM approaches, the literature review also explored key terms and definitions (i.e., ecosystem, biodiversity, ecosystem management, and ecosystem-based management), and related and relevant ecological concepts that are foundational to EBM.

Furthermore, for context, the literature review included a review of important and relevant biodiversity components and threats within the study area. To this end, the review included a brief description of species and ecosystems at risk and environmentally sensitive ecosystems within the region. In addition, given the history, complexity, and importance of natural resource extraction in the region, an overview of past, current, and future resource use was developed to provide important context while looking to understand potential natural resource trends and demands.

Document Analysis

The focus of the document review was to investigate EBM approaches and applicable frameworks and identify and summarize several potential characteristics and components (of ecosystem management approaches and EBM frameworks), that may be applicable to biodiversity conservation and land and resource management planning in boreal BC. More than 350 papers and documents were initially scanned (e.g., abstracts or table of contents reviewed) for relevance to my research. From this initial review approximately 100 papers and documents were extensively reviewed which led to the development of a matrix used to compare, contrast and summarize important EBM components. This key component matrix included scope (geographical context and spatial boundaries), framework goals, key principles, and important implementation elements and fundamental criteria as it may apply to a boreal-specific EBM. The analysis also evaluated and summarized barriers and challenges as well as lessons learned various ecological frameworks and ecosystem management frameworks globally, nationally, and provincially.

Data Collection: Interviews

Information acquired and summarized from the literature review and document analysis phase informed the collection of new data obtained through interviews. The objective of the interviews was to investigate knowledge, attitudes, willingness, and expectations of people who are involved in ecosystem management, land and resource planning, and community or environmental management processes in the region. The interview process was intended to cover a range of areas and topics related to biodiversity conservation, ecosystem management, biodiversity impacts, First Nation sociocultural values, and explore understanding and

perceptions of EBM as a potential approach or framework. Prior to the interview phase of my research the RRU Ethical Review for Research Involving Humans was completed and approved.

The target interviewees were identified and solicited based on personal knowledge as well as searching various web pages. Participants consisted of regional ecological and subject matter experts including professional biologists, provincial program managers, First Nations community members, municipal managers, and land and resource planning specialists. Interview requests were sent by way of an introductory email in June 2021 to 25 individuals. Where applicable, the interview requests respected First Nation specific communication and confidentiality protocols. Therefore, prior to conducting any interviews appropriate approvals were first sought from applicable First Nation government representatives. In some cases (e.g., when I did not receive any return communication) I followed up with a second email and/or a phone call offering to explain my research and proposed process and protocols.

A comprehensive Research Request and Participation Guide was developed and sent to organizations and/or individuals at the time of the interview request. This guide included contact information for myself and my Thesis Supervisor, my project research objective and research questions, as well as information about the interview process, data analysis, use of information, and confidentiality. The guide also outlined my willingness to sign a confidentiality agreement before proceeding, if necessary.

The participant guide included 16 carefully crafted interview questions that were developed as a result of the document analysis findings. All of the interview questions were asked of each participant and presented in an unbiased and neutral manner. The intention was to

implement a semi-structured process that allowed for consistency of inquiry and appropriate response comparisons but without limiting the genuineness and applicability of the answers provided by the participants.

Refer to Appendix A for the Research Participation Request and Guide (and the interview questions) provided to each prospective interviewee.

The interviews were conducted in private by telephone or using a virtual medium (i.e., Zoom). At the beginning of each interview I reiterated the key protocols I was following to ensure confidentiality and anonymity of their responses. I informed each individual that I was not digitally recording the interview, but that I will keep interview transcript notes to document key responses and opinions expressed to each of the research questions. Each participant was asked questions in a clear, concise, and unambiguous fashion, but the delivery style was also somewhat flexible to allow for different worldviews and maximum comfort of the interviewees. All of the above questions were presented to each participant; however, given the sociocultural nature of land and resource planning processes, the intention was to also allow a portion of the interview to be as open and collaborative as possible to gain as much insight into participant values, perceptions, and regional planning issues.

Interview Participants

Fourteen people accepted my invitation to be interviewed. I completed semi-structured interviews with each of these individuals between August and October 2021. As shown in Table 2, the interviewees were from a wide range of professional roles, positions, and affiliations. Many of the participants had extensive knowledge and direct experience with either forest

management, ecosystem management, community planning, or strategic land and resource planning. Participants included various forest and land managers, ecologists, and scientists, all of whom are specialists with extensive knowledge and experience relating to biodiversity, conservation, cumulative effects, and ecosystem management in northeast BC. Half of the participants have active land management roles with the provincial government (including one participant that is a senior Manager of Natural Resource Policy and Aboriginal Title), two participants have positions within local municipal governments, and three participants are Directors or Land and Environment Managers representing different area First Nations.

Table 2

Role or Profession of Interview Participants

Participant #	**Role or Profession of Interviewee**
1	Manager, Aquatic and Terrestrial Habitat
2	Cumulative Effects Assessment Specialist
3	First Nation Land and Environment Manager
4	Research Silviculturalist
5	First Nation Director of Treaty Rights and Environmental Protection-Lands
6	Regional Research Ecologist
7	Municipal Director of Planning and Engineering
8	First Nation Land and Environment Manager
9	Manager Provincial Strategic Initiatives
10	Municipal Executive Director
11	Manager Natural Resource Policy and Aboriginal Title
12	Research Ecologist/Scientist
13	District Forest Manager
14	Land and Resource Specialist

The majority of the participants are located in northeast BC, and more than three-quarters are living in communities in the northeast and other northern communities of the province. The people living outside the region are in Victoria, BC, and have provincial-level responsibilities.

Interview Data Analysis

After the completion of the interview process the transcribed notes from each interview were reviewed. For comparative purposes, a separate comprehensive working document was prepared for each individual question that provided key information/responses from each of the interviewees specific to each question. The detailed notes were entered into Nvivo (Version 1.5.2) from QSR International which was used to complete qualitative analysis of the interview data on a question-by-question basis. The qualitative analysis included examining dominant themes and shared beliefs overall and for each question individually through coding analysis and word/phrase examination using the Nvivo software. The interview data was summarized for each question in paragraph form or depicted as word clouds (i.e., definitions and key concepts) which captured the essence of the combined responses from all participants. In some cases, I found it best to summarize the interview data as comprehensive lists to capture the unique information, wide range of perspectives, and quality ideas provided by the participants. This objective process allowed me to compare and contrast responses in an unbiased and comprehensive manner.

The summarized interview data was used along with the findings from the document analysis to evaluate and determine the key components necessary to include in an ecosystem management framework for the protection of biodiversity for northeast BC.

Research Limitations and Delimitations

Limitations

I recognize there are other ways to conduct research and investigate EBM. For example, another method could include examining EBM case studies of various jurisdictions using an ecosystem-based approach. However, during a preliminary review of literature, although ecosystem-based management was found to be implemented in some other disciplines (e.g., international marine environments) and biomes (e.g., outer coastal region of BC), I did not discover enough practical examples that appear to be relevant enough to terrestrial biodiversity conservation within a boreal BC context. Both Aberdeen (2013) and O'Leary (2014) caution about using case-studies that may be too dissimilar or not be as relevant to the objective of my research. As outlined by Aberdeen (2013), some key limitations may include the difficulty of integrating information across dissimilar cases, examining the relationship of different variables used, replicating single-case information, confirming applicability and conclusions, and difficulty applying conventional standards of reliability and validity given the subjective nature of the investigation. Similarly, O'Leary (2014) cautioned that case study approaches need to consider potential flaws such as data currency and relevancy to the intended research objectives.

Further, my literature review did not result in sufficient information that evaluated implementation results of existing EBM. That said, an alternative, and interesting, research approach to the one I took could be to set up a more in-depth review of the literature and conduct interviews of parties specifically involved in the EBM attempted in the Great Bear Rainforest since 2006 between coastal First Nations and the BC government (Bunsha, 2012; CIT, 2004;

Price et al., 2009). This approach would also examine the success of this initiative from various perspectives; then specifically compare and contrast similarities, key differences, and lessons learned to a proposed boreal BC based approach.

Delimitations

My research includes a few notable delimitations. While I do cast a wide net to investigate overall EBM principles and components, I chose to focus on EBM approaches that are most applicable to boreal BC rather than attempting to develop a broader provincial level framework. I also elected to geographically focus on the boreal region located within the FSJ TSA. I further recognize that my chosen study area is based predominantly on an administrative boundary rather than natural or ecological boundaries. The FSJ TSA was chosen specifically because many historical plans and current planning initiatives are based on this current boundary. Furthermore, virtually all the EBM concepts, components, and findings may be equally applicable to any future natural or administrative spatial boundaries (or combination thereof) that may be determined by provincial and First Nation governments, planning tables, communities, and interested parties.

In order to control scope, I also had to make a few additional decisions regarding approach. First, given that my objective focuses on whether EBM can conserve biodiversity, my approach did not include an indepth investigation or summary of individual Nation-specific sociocultural interests, values and beliefs at this time. That said, my research does include overall First Nation ideals, perspectives, and integration as much as possible. As outlined by several researchers before me (Gilani et al., 2018; Lertzman, 2010; Moore & Tjornbo, 2012), I recognize

that although many existing EBM approaches are technical or science-based, the integration of First Nation sociocultural worldview and values, and incorporating the social and human element is absolutely paramount for successful biodiversity conservation outcomes.

Second, currently an in-depth analysis of economic factors relating to EBM is outside the scope of my research. Economic viability of any potential EBM, and the related land use decisions and trade-offs, is crucial to successful implementation by all parties involved. I expect this sort of analysis will also be a key feature when considering EBM implementation in the region.

Third, I did not conduct a rigourous investigation of projected impacts of climate change to ecosystems and species within the boreal region. However, climate change theory and related aspects were reviewed, and the importance presented in general as it relates to the development of an EBM framework for boreal BC.

Researcher Perspective

I am a Registered Professional Forester and a practicing consulting forest ecologist within the province of BC and have practiced western technical approaches to land management for almost three decades. I recently held various service contracts with the provincial government to provide technical advice and ecological analysis expertise in support of ongoing planning processes within northeast BC. As per Aberdeen (2013), I am aware of my preconceived notions and technical bias when conducting this research and mitigated this whenever possible by reviewing a wide range of documents, remaining open-minded, and following a strict research protocol and process rather than simply following a solution-based approach.

Literature Review

The literature review gathered information from a wide range of sources that are conceptually or geographically relevant, or both, and constructs a summary of key EBM concepts related to ecosystem management and biodiversity conservation. Initial search terms to obtain peer-reviewed papers included concepts and keywords relating to (but not limited to): ecosystem management, ecosystem management approach, ecosystem-based management, British Columbia, boreal forest management, biodiversity, conservation, system, natural disturbance, and ecological frameworks. More than 350 peer-reviewed papers and relevant and important local, regional, and provincially based grey literature were initially examined, categorized, and organized for additional review. The information from this review provided a comprehensive summary of terms and definitions fundamental to EBM and relevant ecological concepts. In addition, an environmental overview of the study area (including an overview of species and ecosystems at risk and environmentally sensitive ecosystems within the region) was developed from this literature review.

Fundamental Terms and Definitions

Ecosystem management and biodiversity science use many terms, and often have similar and overlapping terms and definitions in research, grey literature, and within legislation and agency programs. It is, as described by Slocombe (1998), essential to provide clarity on terms and concepts used to foster communication and EBM implementation success. Given this, although certainly not exhaustive, my research summarizes definitions of four fundamental terms

(i.e., ecosystem, biodiversity, ecosystem management, and ecosystem-based management), derived from a comprehensive review of available literature.

Ecosystem

Noss and Cooperrider (1994) describe an ecosystem as "a dynamic complex of plant, animal fungal and microorganism communities and their associated non-living environment interacting as an ecological unit" (p. 9). Meffe et al. (2002) further state that ecosystems are functional and not a spatial concept, and that they encompass both biotic and abiotic components (p. 70). The Province of BC defines an ecosystem on their current (2021) website (n.d.):

> An ecosystem is a collection of communities of both living and non-living things that are connected. The biotic elements in an ecosystem include living things such as plants and animals. The abiotic elements found in an ecosystem include non-living things like landforms or climate (Province of British Columbia, n.d., para. 2).

Biodiversity

Biodiversity means different things to different people, depending on one's perspective, technical knowledge, and background; yet, in general scientists agree on the fundamental description and key components of biodiversity. Biodiversity pioneers Meffe et al. (2002) and Noss (1990) believe that biodiversity is a fundamental objective of ecosystem management, and summarize that, "biodiversity includes the variety of life and its processes, and consist of composition (what is there), structure (how it is distributed in space and time), and function (what it does)." (p.69). Globally, in 1992 the CBD defined biodiversity as, "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other

aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (p.1). The CBD (from 2011) further states:

> Biological diversity underpins ecosystem functioning and the provision of ecosystem services essential for human well-being. It provides for food security, human health, the provision of clean air and water; it contributes to local livelihoods, and economic development, and is essential for the achievement of the Millennium Development Goals, including poverty reduction. In addition, it is a central component of many belief systems, worldviews and identities (p. 1).

Provincially, in 1995, the Biodiversity Guidebook defined biodiversity as: "the diversity of plants, animals and other living organisms in all their forms and levels of organization, and includes the diversity of genes, species and ecosystems, as well as the evolutionary and functional processes that link them" (Province of British Columbia, 1995, p.74). Currently, the Province simply defines biodiversity as "the variety of all living things" (Province of British Columbia, n.d.), and the Department of Geography from the University of British Columbia (which run E-Fauna BC and E-Flora BC on behalf of the province) also states that biodiversity, in its simplest terms, is "all living things on earth" (Klinkenberg, 2020). In a 2003 Assessment of Biodiversity Conservation in BC, Holt et al. (2003) defined biodiversity as "all living things on earth, from genetics through to landscapes, including ecological and evolutionary processes" (Holt et al., 2003, p.3).

Understanding and fully characterizing biodiversity is essential to understanding the goals, methods, and desired outcomes related to ecosystem and program management. When

comparing various definitions of biodiversity, ‘species richness’ is an important component on its own and, in an ecosystem management program, is the easiest to apply and monitor. However, richness is just one element in a complex system, and if used alone, is an oversimplification of biodiversity. All ‘three levels of biodiversity’ (genetic, species, and ecosystem diversity), as described by an early pioneer (Noss 1990), are powerful and meaningful and capture the complexity needed in an environmental management program. Developing ecosystem management approaches that manage, conserve, and protect genetic, species, and ecosystem diversity goes a long way in supporting ecological integrity, ecological health and providing resilient ecosystems. However, these individual classifications of diversity, although strong and important building blocks of biodiversity, need to also include biological and natural processes in an interconnected and multi-organized way (Noss, 1990, p. 355-356). As Noss (1990) puts it, “… [one must] consider composition, structure, and function [in order to] characterize the components that define biodiversity” (Noss, 1990, p.356). Further, a good management program should incorporate multiple temporal and spatial scales and stresses at different levels of organization and develop meaningful indicators to measure outcomes (Noss, 1990, p. 356). Meffe et al. (2002) agrees, and describes composition, structure, and function from genes to landscapes as the building blocks of biodiversity (p. 70).

As Cardinale et al. (2012) states, “biodiversity is the variety of life, including variation among genes, species and functional traits. It is often measured as: richness…a measure of the number of unique life forms; evenness… a measure of the equitability among life forms, and heterogeneity…the dissimilarity among life forms” (p.60).

All of the above definitions of biodiversity share some common key principles including: the variety of life, all living things, and organisms interacting in a complex system at multiple scales.

Ecosystem Management

Ecosystem management differs from conventional resource management. Conventional resource management, as described by Weddell (2002) is rooted in the utilization and exploitation of economically valuable species and the development of natural resources for human benefit, known as a utilitarian perspective (Weddell, 2002, p. 29). This view of the natural world was born from the "demographic and economic changes that evolved in the developed and developing world", such as the European colonization of "the New World" and the growth and consumption of resources particularly after World War II in the United States (p. 29-32, 164).

True ecosystem management is fundamentally about managing the entire system (as a whole) rather than narrowly focusing on certain components or maximizing the yield of an individual natural resource (Levin et al., 2009; Wenig, 2012). In a review of ecosystem management, Wenig (2012) quoted the United States legal scholar, Oliver Houck (1998), who described ecosystem management as a: "whole new species of thought… half science and half religion… [that] has arisen in research, articles, books, management plans and litigation, a new field of conservation biology … [which is] changing the language of the game" (Wenig, 2012, p.1). From this researcher's perspective, ecosystem management is not just a passing fad, and

has really taken hold over the last few decades, growing from freshwater and marine environments to terrestrial applications.

There are many different descriptions of ecosystem management in the literature. Some of the most notable definitions of ecosystem management in the literature that relate to boreal BC are provided by Christiansen et al. (1996), Lackey (1998), Grumbine (1994), International Union for Conservation of Nature and Natural Resources (IUCN), and Leech et al. (2009).

Bensted-Smith and Kirkman (2009), cite Christiansen et al. (1996) who define ecosystem management as management driven by explicit goals, executed by policies, protocols and practices and made adaptable by monitoring and research based on the ecological interactions and processes necessary to sustain ecosystem composition, structure, and function (Bensted-Smith & Kirkman, 2009, p.3). Lackey (1998) presents a definition of ecosystem management based on seven pillars as the application of ecological and social information, options, and constraints to achieve desired social benefits within a defined geographic area and over a specified period. Further, Lackey (1998), state that ecosystem management should determine a goal, implement a set of decisions to reach that goal, and determine the system's capacity to reach that goal (p. 21-22). While supporting the Central and North Coast LRMP, the Coast Information Team (2004) cited Grumbine's 1994 definition of ecosystem management: "Ecosystem management integrates scientific knowledge of ecological relationships within a complex socio-political and values framework toward the general goal of protecting native ecosystem integrity over the long term" (Grumbine, 1994, p. 28). Additionally, Leech et al. (2009) describe ecosystem management as an evolving approach to natural resource

management that requires significant adjustments to institutions, policies, and the current norms of doing business in natural resource management. It hinges on the human element: relationship building is critical in developing the interagency collaboration, stakeholder involvement, and public trust necessary to implement ecosystem management (p. 3-5). Lastly, the CBD adopted an ecosystem approach as their primary framework in 1995. The IUCN describes ecosystem management as "a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way" (IUCN, 2004, p.1).

In summary, the definitions of ecosystem management from these leading researchers share some key components such as:

- define the system as a whole
- have explicit goals
- understand and describe ecological relationships, interactions, and processes, and
- introduce human elements (e.g., administrative, collaboration, and interagency involvement).

Ecosystem-Based Management

Ecosystem-based management often means different things to different people, cultures, groups, organizations, disciplines, and researchers, and debate is ongoing about what such a framework should (and should not) include. Further, no two EBM approaches are quite the same, and as Price (2021) explains, there is not one EBM panacea for all situations. However, in general most EBM definitions today include a few essential tenets, such as managing the entire ecological system, focusing on ecological integrity (health), addressing governance and

sustainability, and integrating human well-being. EBM should be seen as an aspirational journey, not an end goal (Andison, 2020, p.13). The EBM journey itself involves "actively supporting and openly sharing science and leading-edge innovation that specifically and deliberately contributes to the advancement of one or more EBM elements" (Andison, 2020, p.19).

Literature on EBM often references Grumbine (1994) and Slocombe (1993, 1998) as pioneers in ecosystem management and ecosystem-based management. Grumbine's five key goals for ecosystem-based management include identifying and maintaining viable populations, ecosystem representation, ecological processes, evolutionary processes, and accommodating human use (although the latter is only considered in context of the first four goals) (Grumbine, 1994, p. 31). Another foundational researcher, Slocombe (1998) states the key to effective EBM is that it must focus on the system as a whole, should be an integrated process, and should be defined in local, biophysical, and cultural terms (Slocombe, 1998, p. 486). In addition, similarly to the definition of ecosystem management, EBM needs to be linked to a set of criteria and goals that vary by place, scale, and time and that are pursued in an on-going, adaptive process (Slocombe, 1998, p. 483).

More recent (and just as notable) definitions of EBM have emerged from: the Coast Information Team (CIT) (2004), Arkema, Abramson, & Dewsbury (2006), Foley et al. (2010), Gilani et al. (2018), and Andison (2020). Each of these researchers (and research teams) completed an in-depth review of EBM and related principles. For example, in 2004, during the assessment of EBM for the Central and North Coasts and Haida Gwaii LRMP, the CIT (2004)

completed a comprehensive review of EBM definitions, and came up with the following for EBM that could be equally applicable to the boreal:

> An adaptive approach to managing human activities that seeks to ensure the coexistence of healthy, fully functioning ecosystems and human communities. The intent is to maintain those spatial and temporal characteristics of ecosystems such that component species and ecological processes can be sustained, and human well-being supported and improved (p.12).

Arkema et al. (2006) examined 18 peer-reviewed definitions of EBM relating to marine conservation and the protection of ocean and coastal ecosystems. They developed a number of scientific criteria that have applicability to terrestrial EBM sorted by general, ecological, human, and management criteria. Further, Foley et al. (2010), in their research regarding key principles and approaches of EBM for marine and ocean environments, agreed with the CIT definition, virtually repeating it entirely.

In regard to ecological boundaries and human interactions related to EBM, Gilani et al., in their 2018 study of human well-being domains took it one step further. They defined EBM as "an approach to resource management that considers an entire ecosystem and the people who live in it. Rather than managing using administrative boundaries, EBM uses relevant ecological boundaries, which requires increased cooperation and coordination across jurisdictions" (Gilani et al., 2018, p.1). Additionally, Price (2021) claimed that EBM is essentially, "a big-picture approach to planning and resource management that aims to maintain, or restore, ecological integrity as a foundation for supporting human wellbeing over generations" (Price, 2021, para.1).

As part of the Healthy Landscapes Program in Alberta, Andison (2020) from the Forest Research Institute completed a detailed review of EBM literature, and found that:

i) there is no one definition of the subject

ii) that everyone is at a different starting point in their EBM journey

iii) most forest management agencies are on some sort of EBM journey, and

iv) EBM concepts overlap with other land management approaches and frameworks (p.6).

Andison also recognized that there are multiple pathways to creating and implementing EBM. Andison's comprehensive review focused on formative papers from seminal researchers on the subject such as: Christensen et al., (1996), Franklin (1997), Galindo-Leal and Bunnell (1995), Noss (1999), Pickett et al. (1992), Salwasser (1994), and Swanson and Franklin (1992). From this review Andison (2020) found that any modern EBM framework must be neutral and objective as well as comprehensive, and yet also be understandable (each piece/component), and practical (each element). He summarized and presented 12 key elements of EBM within four broad categories (i.e., Strategy, Process, Partners, and Benchmarks). Building on this work, the Forest Research Institute defined EBM as, "a collaborative, integrated, science-based approach to the management of natural resources that focuses on the health and resilience of entire ecosystems, while allowing for sustainable use by humans of the goods and services they provide" (Andison, 2020, p.16).

Relevant Ecological Concepts

In addition to key definitions, one cannot truly review EBM approaches and methods relating to biodiversity conservation and ecosystem management in the boreal without examining natural disturbance theory and natural range of variability, ecosystem resilience, and consider (in general) climate change impacts.

Natural Disturbance Theory

There is a considerable body of natural disturbance research and theory related to boreal forests that revolves around those disturbance agents most prevalent on the landscape. For example, as described by Whitfield (2019), “disturbance regimes are shifting in time and space due to climate change (e.g., severe storms, frequency and intensity of fire, frequency and severity of drought and flooding, and spread of invasive species and disease)” (Whitfield, 2019, p.3). In boreal BC, natural disturbance regimes are dominated by wildfire events and bark beetle infestations at the landscape level, while windthrow events are more common occurrence at the local or stand level (DeLong, 2007; 2011).

Across the boreal, natural stand-replacing disturbances, such as fire, are common, and occur roughly every 100–200 years (DeLong, 2011, p. 8-9); Province of British Columbia, 1995, p. 29). The average fire size across the boreal ranges from 300-6,000 ha and may occasionally exceed 100,000 ha during extreme events (Province of British Columbia, 1995, p. 29). Within the region, according to provincial records, the average wildfire size over the last 50 years, when considering all fires (regardless of cause), is 665 ha, but average fire size has grown to more than

1,300 ha over the last decade, plus the number of fires has also increased over this time (Province of British Columbia, 2020c).

As outlined by Thom and Seidl (2016), the type of disturbance agent or event affects biodiversity in different ways, as too does the severity of the disturbance. For example, moderate or mixed-severity disturbances may provide the best balance of effects on ecosystem services and biodiversity (p. 762). Thom and Seidl (2016) emphasize this point in their research, claiming that disturbances can be expected to have both positive and negative impacts on possible objectives of ecosystem management; therefore, "disturbance risk and resilience require increased attention in ecosystem management" (p.769). In the case of wildfire in the boreal, burned over areas often leave a patch work of irregular openings, edges, and species composition, as these natural stand-replacing fire events follow naturally occurring differences across the local landscape. For example, the type of fire and degree of catastrophic damage will depend on a variety of natural factors, including forest type, composition, forest structure, and stand density, as well as season, previous and current weather, soil type and moisture level, and topographic position within the landscape. This underscores the importance of understanding and managing ecosystems across the landscape, rather than simply managing forest stands alone. Further, with climate change, more disturbances are likely, and their intensity increased, which underscores the importance of ecosystem management for both climate change mitigation and disturbance management.

Forest management operations and oil and gas exploration and infrastructure have the most wide reaching and significant effects on forest structure and composition at both the

landscape and site-level in boreal BC. With respect to forest management, Kuuluvainen and Grenfell (2012) summarize that a great deal has been learned about forest ecosystem structure and dynamics in relation to boreal forests and find that there is increased diversity in naturally developed forest stands and ecosystems compared to even-aged forest management and harvesting systems (p. 1186). Considerable research has occurred regarding natural disturbance dynamics as a basis for forest management policy directed towards maintaining biological diversity (DeLong, 2007 and 2011; Province of British Columbia, 1995). The underlying assumption, when attempting to emulate natural disturbance in forest management systems, is that the biota of a forest is adapted to the conditions created by natural disturbances and thus should cope more easily with the ecological changes associated with forest management activities if the pattern and structure created resemble those of natural disturbance (DeLong 2011, p. 1).

Many boreal natural disturbance researchers (e.g., Bouchard et al., 2008; De Grandpré et al., 2018; DeLong, 2002, 2007, 2011; Kuuluvainen & Grenfell, 2012; Parminter, 2014; Thom & Seidl, 2016; and Whitfield, 2019) recommend, wherever possible, that forest management operations should replicate the heterogeneous and dynamic stand and landscape structures found in natural disturbance cycles in an attempt to replicate the variability and complexity of the naturally disturbed forests; emulating the size and type of historical natural disturbance with patches designed to follow known fire size and extent as much as practical. For example, DeLong (2011) outlines creating irregular boundaries of harvest openings to increase edge, leaving behind structure from the previous stand, and having a range of opening sizes that follow

natural disturbance theories as much as possible and basically “adopting a forest management practice that approximates the natural range of variability (NRV)… [of boreal forests]…based on estimated stand replacement disturbance cycle” (DeLong, 2011, p.1, 5).

From a biodiversity conservation perspective, evaluating the “NRV of a particular biodiversity element, species, or parameter, at suitable scale, is an appropriate way to assess the status, state, or potential level of threat” (Holt et al., 2003, p.3). Andison (2020) further states that NRV is “one of the primary foundations of EBM” (Andison, 2020, p. 21). From a climate change perspective, maintaining ecological and social processes within the range of variability of disturbance can also facilitate climate adaptation efforts (Whitfield, 2019, p. 3). When considering forest management, at a landscape scale, it is expected that the more forests are managed following natural patterns (following the principles of NRV) the more resilient they will be over time (DeLong, 2011, p. 1).

In addition to NRV forest planning, from a timber harvest timing and distribution perspective, Bouchard et al. (2008) recommends emulating natural disturbance patterns in forest management by completing timber cutting following landscape-based harvest clustering; where harvesting is potentially grouped in a sub-region for up to twenty years, but then there is a fallow period of five to 10 decades with little or no harvesting in the same area. However, these researchers do caution that more research into boreal natural disturbance ‘pulses’ is required to ensure that ecosystem resilience can be maintained over time (p. 1738).

Within the Boreal Plains Natural Disturbance Unit (NDU), which dominates my research study area, DeLong (2011) reports that forest stands rarely exceed 200 years old, but historically

there were relatively large stands of older forest between 140-180 years old that moved around the landscape over time based on the fire cycle in the region. In this boreal unit, according to natural stand replacement disturbance theory and cycle it is expected that between 17-33% of the forests would naturally be more than 140 years old (DeLong, 2011).

Ecosystem Resilience

Another key concept relating to ecosystem management and biodiversity conservation is ecosystem resilience. Ecosystem resilience theory in ecology is generally attributed to Holling (1973, 1986). Holling wrote that resilience "is a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling, 1986, p. 14). Within a technical evaluation of ecological resilience and complexity in BC, Campbell et al. (2009) defined resilience as, "the capacity of an ecosystem to absorb disturbance without collapsing into a qualitatively different state" (Campbell et al., 2009, p. 3). This definition is still used today by the BC Forest Practices Board (FPB) in 2019 (FPB, 2019).

Throughout the literature ecological resilience is often used interchangeably with ecosystem adaptability (Campbell et al., 2009, p. 3). Resilience theory and the adaptive cycle can be explained using the 'Panarchy model' initially developed by Gundersen and Holling in 2002. This model is a conceptual framework that accounts for the dual, and seemingly contradictory, characteristics of all complex systems – stability and change (Gundersen and Holling, 2002). The theory and cycle (Holling, 1986; Gundersen and Holling, 2002; Bunnell, 2019), can be used to

examine, understand, and explain the dynamic nature of ecosystems and the process of change, and natural range of variability within an ecological system at multiple scales.

As part of my investigation, I developed a summarized representation and integrated system as it relates to ecosystems and ecosystem management following the panarchy model outlined by Campbell et al. (2009), Gundersen and Holling (2002), and Bunnell (2019). This adapted model is presented below in Figure 3. The four key phases of my adaptive cycle which follow natural ecological patterns associated with resilience theory (and ecosystem development) include:

- **Ecosystem Growth Phase [r]**: The launch of new, or realignment of existing, ecological interactions (building of species and community composition and structure dynamics within an ecosystem).
- **Ecosystem Conservation and Maturation Phase [K]**: The maturation or maximization of an ecosystem's capacity and/or productivity (relatively long and predictable successional pathway where long-lived stable species dominate the ecosystem).
- **Release (Disturbance) Event [Ω]**: The potential (usually brief and unpredictable) release of energy within the ecosystem resulting from an event/disturbance (e.g., severe burn, vegetation clearing, or soil failure).
- **Reorganization Phase [α]**: The initial restructuring and sometimes gradual development of new processes during reorganization of the ecosystem (e.g., new or pioneer species take hold or re-establish in the area). Ecosystem resilience is at its lowest at the reorganization phase **[α]** when the chances for a divergence (i.e., exit) from normal

ecosystem patterns and species composition are at its highest while the ecological system once again moves towards the growth phase **[r]**.

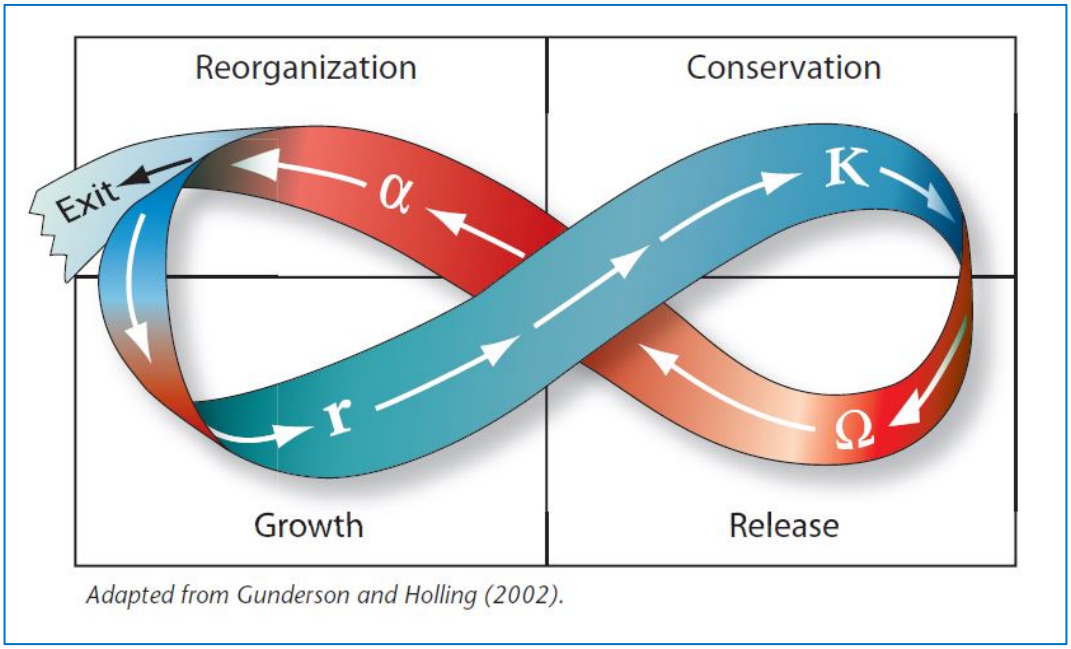

Figure 3. Ecological Panarchy Model Adapted from Campbell et al., 2009

This model can be used to examine ecological systems at multiple temporal and spatial scales. For example, it can help to understand and explain the condition and status of a microsite nested within a larger ecological community which is further linked to an ecological region and/or broader climatic system. This approach helps to understand the different levels of

organization within natural systems rather than just seeing the traditional unchanging model of continuous growth and development, which can be unsustainable.

Panarchy and resilience theory are very relevant to natural boreal systems, ecological processes, and EBM. Boreal ecosystems are in a constant state of flux and are dynamic with many processes and multiple equilibria. Boreal ecosystems are continually experiencing gradual changes in regional and seasonal climate, biochemical and hydrological function inputs and outputs, as well as changes in species composition, ecological structure, and species interactions. As Scheffer et al. (2001; 2009) outline, in natural systems this change from one state to another is usually gradual and often subtle; and can be seen to be in a balanced condition. However, when a significant event, or series of events, push an ecosystem past this equilibrium, and beyond its natural threshold in which it can withstand pressure from an outside force, then the current ecosystem condition can move rather rapidly to a contrasting or alternative state. Of course, not all ecosystems are the same, or in the same current condition (temporally and spatially), and so will have different thresholds (Scheffer et al., 2009, p. 53-54). For example, in an assessment of wildlife habitat supply in BC, Dykstra (2004) stated, “threshold changes appear to occur at low levels of habitat loss for rare species, poor dispersers, and habitat specialists” (p.8).

For some ecosystems, as outlined by Scheffer et al. (2009), once an ecosystem reaches a bifurcation point and is tipped into an alternative state it may take a significant backward shift in environmental conditions to return to the former ecosystem condition (Scheffer et al., 2009, p. 54). In some cases, this alternative state may have negative impacts on landscape, ecosystem,

and species level biodiversity, as well as social and economic consequences. Some examples of this alternative state may be found as a result of significant soil structure changes resulting from a severe forest fire event, or from excessive soil degradation or hydrological changes resulting from substantial or continuous alterations to local water inputs and cycles. Furthermore, forest resilience is increasingly viewed as a critical component in management systems given uncertainty surrounding the effects of climate change. “If resilience is an overarching goal, then the desired future forest can, in part, be defined by the characteristics that promote or sustain its resilience” (FPB, 2019, p. 4). To understand and manage for ecosystem resilience requires identifying species and ecosystem diversity, composition and function at a variety of scales, and assessing ecosystem condition (and integrating the panarchy model) for various ecological communities within boreal BC (Foley et al. 2010, p. 8). Each of these are fundamental attributes that are required for the implementation of an effective ecological management approach or framework like EBM.

Climate Change

One cannot examine ecosystems, biodiversity conservation, and EBM without considering climate change and potential climate change impacts in the boreal. As described by Brandt et al. (20130, the Canadian boreal zone stores a large portion of the world’s carbon in the soils, forests, and wetlands, and these ecosystems are also large sinks for atmospheric carbon p.208). The world’s boreal forest is the largest ‘above-ground’ storage of carbon, storing 208 billion tonnes of carbon, or 11% of the global total carbon storage (Drever, 2020, p.1). Only 25% of this carbon stock (within a managed boreal forest) is estimated to be contained within the

above ground biomass (Kurz et al. 2013, p. 267). Furthermore, according to Roulet (2000) much more carbon is stored in soils, and in particular wetland soils in the boreal store 60% more carbon than the forest soils (p.607).

In more northern and higher elevations within study area, climate change will likely modify the ability of the boreal zone forests and wetlands to act as a carbon sink due to modifications to the cold, wet, anoxic, and frozen conditions that allow the forests and wetlands to act as effective carbon stores (Kurz et al., 2013). Within southern and lower to mid-elevation zones of the study area, climate change impacts may also result in the gradual drying of some wetland soils and lead to the ingress of upland forest species in these areas. Other notable changes could be the gradual change in species composition, such as increased deciduous tree species in these same upland forests. Throughout the boreal landscape climate change is expected to influence the natural disturbance behaviour (Gauthier, 2015; Price et al., 2013), potentially increasing the number and severity of fire events in the region and increasing the intensity of forest pest and damage agents. As Price et al. (2013) state, “climate change will have many effects on ecosystem functioning, some of which can be attributed to increased temperature, but others will manifest through changes in water availability and increases in atmospheric CO_2 concentration” (Price et al., 2013, p.330). Climate change will likely also cause increased stress on ecological systems and processes, such as increase freshet intensity and lower summer flows within boreal BC waterways. Price and Daust (2013) report that as climate change occurs, some species within existing plant communities will become maladapted to local conditions. They further state that, “some of these evolving climatic conditions may exceed

environmental tolerances and change competitive advantages, leading to extirpation, or reduced abundance and range of certain species" (p.2). Price et al. (2013) speculate that a major impact of climate change to land birds in the boreal is the "desynchronization of species phenology from that of their food resources" (Price et al., 2013, p.336). In other words, the timing of important land bird reproductive windows may be impacted by the effects of climate warming as/if the abundance and distribution of food sources, which they depend upon, are altered. This can be particularly important in the boreal where more than 90% of the 186 land birds known to exist in the region are migratory (Blancher, 2003, p.5). However, on the positive side, as outlined by Price et al. (2013), in 2009 Thompson et al. projected a "higher level of resilience to climate change of many boreal ecosystems and species comparatively because many of these communities are already adapted to natural disturbances within the landscape" (p.335).

Overall, the science predicts that species and ecosystems in the boreal will be under increased pressure in the future, and thus it is essential to manage ecosystem resilience across the landscape to adapt to climate change (FPB, 2019, p. 4). In order to best understand resilience and guide future biodiversity management, it is important to evaluate the historical, present, and potential future NRV and attempt to understand the structure and composition and function of ecological systems within the landscape (Cushman & McGarigal, 2019, p. 2-3).

Study Area Environmental Setting

The following section provides a brief description of the North American and Canadian boreal landscape and describes the general ecology of the boreal in northeast BC, and further presents a summary of species and ecosystems at risk in the study area. This information

provides important environment context and condition that is important when evaluating EBM in the region.

The North American Boreal Landscape

The circumpolar boreal zone is one of the world's major biogeoclimatic zones, covering much of North America and Eurasia with forests, woodlands, wetlands, and lakes. It regulates climate, acts as a reservoir for biological and genetic diversity, plays a key role in biogeochemical cycles, and provides renewable resources, habitat, and recreational opportunities (Brandt, 2009, p.101). Within Canada, the boreal is a broad biogeoclimatic zone that contains 309 million ha of forests and other wooded land as well as 71 million ha of water bodies and makes up approximately 29% of the global circumboreal zone (Brandt et al. 2013, p. 208). A general depiction of the extent of the boreal zone within North America is provided by Natural Resources Canada, shown in Figure 4.

Figure 4. Areal Extent of Canadian Boreal Forest from Government of Canada (2020)

The Canadian Boreal

At the national scale, the majority of the study area lies within the Boreal Plains Ecozone, and the Alberta Plateau physiographic region of Canada (Government of Canada, 2017). Broadly speaking this ecozone is characterized as a flat lying to slightly undulating landscape. A small portion of the west side of this region becomes mountainous as the Rocky Mountain foothills give way to the Northern Rocky Mountains (Government of Canada, 2017). Geologically, moraine surficial materials that are directly deposited from glacier ice are dominant in the region.

Plateaus, plains, and drumlins are common throughout the Alberta Plateau. Other materials include extensive areas containing moderately deep to deep organic materials as well as fine-textured glaciolacustrine silts. In localized areas fluvial and glaciofluvial deposits exist along current and historical river systems and mountainous areas also contain some colluvial materials (MoE, 1978, p. 161-162).

This Canadian boreal delivers an enormous variety and quantity of ecosystem services to Canadians, in the form of both provisioning services (e.g., timber, oil and gas, food crops, range, minerals, water, hunting, fishing, and trapping), and non-provisioning services (i.e., water resources and regulation, carbon storage and greenhouse gas (GHG) sequestration, biodiversity conservation, nutrient cycling, and cultural activities) (Brandt et al. 2013, p. 207; Carlson & Browne, 2015, p. 4).

From a biodiversity standpoint, as Andrew et al. (2014) state, “the [Canadian] boreal wilderness is of local, regional, and global importance because it provides the large, unaffected areas necessary to maintain natural systems, ecological processes, and essential ecosystem services” (p.136).

In summary, boreal ecosystems provide a number of important services that protect species, community, and landscape-level biodiversity, and help to maintain overall ecosystem health and sustainability. My review shows that the natural range of ecosystem variability and condition (the natural structure, function, and composition) of these boreal ecosystems provide several environmental benefits. They:

- maintain wildlife habitat

- protect species and communities at risk (including species of ecological importance Federally, provincially, and regionally)
- protect migratory birds and associated habitat
- provide biochemical, hydrological, wildlife wetland functions
- conserve and maintain a productive soil resource
- mitigate climate change impacts, and
- likely maintain ecological resiliency when impacted by natural disturbance.

In addition, these naturally functioning ecosystems are critically important for the maintenance of sociocultural values relating to First Nation traditional use, knowledge, cultural values, and for exercising of Indigenous Treaty Rights and Title in northeast BC.

The Boreal of Northeast British Columbia

At the provincial scale, almost half of my study area occurs within the Central Alberta Upland ecoregion (Demarchi, 2011, p. 130). This landscape rises gradually to the north of the Peace River and extends from the Rocky Mountain Foothills eastward into Alberta. The remaining ecoregions include the extremely flat to gently rolling Central Hay-Slave Lowland, the wide, low elevation Peace River Basin, the rolling and hilly Muskwa Plateau, and the rugged and high elevation Central and Northern Canadian Rocky Mountains (Demarchi, 2011, p. 130-131). The area includes all or part of five major watersheds and is characterized by a handful of dominant river systems, such as the Halfway, the Beatton, the Fort Nelson, the Chinchaga, and the Peace River (Fort St. John Working Group, 1997, p. 7). Lakes of size are uncommon; the

existing lakes tend to be small and shallow with low to moderate productivity, the most significant of these include Charlie and Redfern Lake (Fort St. John Working Group, 1997, p. 7).

Ecologically the province is divided into Natural Disturbance Units (NDUs), adopted from DeLong (2011). Each NDU includes geographic areas that share similar natural disturbance regimes and that can be managed in a way that is based on a more ecological approach, rather than an administrative one. Within northeast BC four NDUs occur in my research study area (see Figure 5). However, the region is dominated almost entirely by the Boreal Plains NDU. The Northern Boreal Mountains, Boreal Foothills, and the Omineca NDUs are limited to the western edge of the study area (DeLong, 2011).

Figure 5 also shows the nine biogeoclimatic (BGC) units that occur within my research study area, although, as shown in the figure, the region is predominantly covered by the Boreal White and Black Spruce (BWBS) BGC unit. In the mountainous (western) portion of the study area lies the Engelmann Spruce-Subalpine Fir (ESSF), the Spruce-Willow-Birch (SWB), and the Boreal Altai Fescue Alpine (BAFA) BGC zones. These zones only cover a very minor portion of the overall study area. As the name suggests, the BWBS climax forests are comprised of white spruce and black spruce. However, a combination of fire history and extensive cultural disturbance due to land clearing and prescribed fire in the BWBS leaves the early seral tree species, trembling aspen, dominating about half or more of the forested landscape (DeLong et al. 2011, p. 11-144; Delong, 2011, p. 4). In the mountainous region in the western portion of the region, in the ESSF zone, Engelmann spruce and subalpine fir dominate the climax forests, although lodgepole pine frequents these stands due to fire disturbances, after which lodgepole

pine establishes (Meidinger and Pojar, 1991, p. 224-225). The SWB zone consists of high elevation forests and subalpine parkland/scrub with scattered grassland mosaics and small wetland complexes. The BAFA zone contains rugged and exposed non-vegetated alpine terrain and low-growing vegetated communities consisting of herbaceous meadows, alpine fellfields, alpine grasslands, tundra, alpine heath, and scrub and shrub communities in more protected and subdued terrain (Meidinger and Pojar, 1991, p. 252-253).

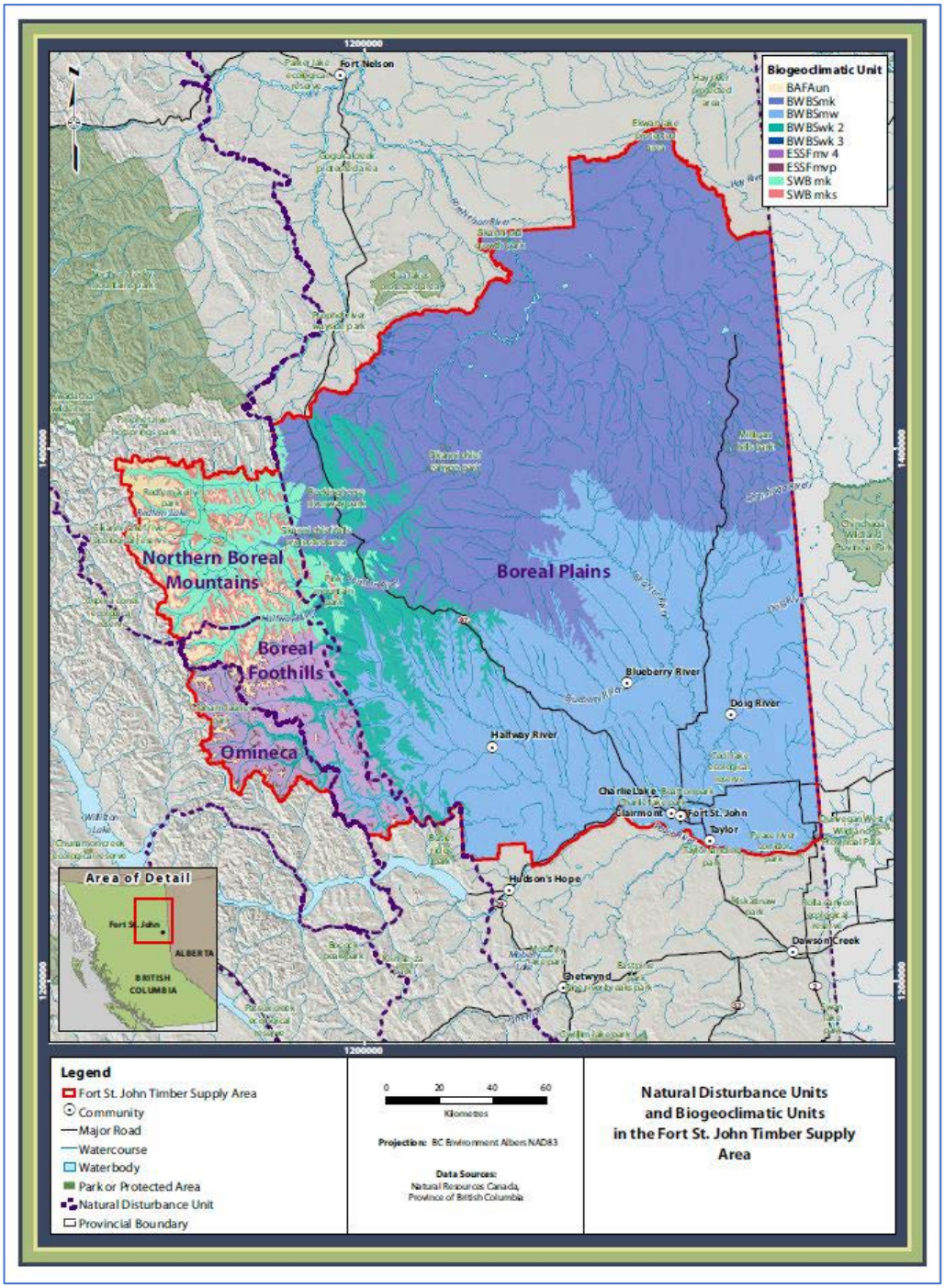

Figure 5. Natural Disturbance Units and Biogeoclimatic Units from Atticus (2021)

Atticus Environmental Services Ltd. (Atticus, 2021) recently provided an overview of the vegetation cover within my research study area.

> Vegetation cover is dominated by upland forests, consisting mostly of coniferous leading forests. Deciduous leading and mixed forests cover less than one-quarter of the area. Mature forest covers approximately one-third of the total upland forest area. Young forest and old forest each cover less than one-quarter of the remaining upland forest area. In addition, one-fourth of the study area consists of shrub and herb communities which are mostly harvested areas or burned early seral communities (p. 41-43).

The predominant natural disturbance that affects stand development within my study area is wildfire (Atticus, 2021). Historically fires in the region averaged approximately one thousand hectares. The number of fires, the size of fires, and the total hectares burned have increased substantially in the last decade, impacting more than 200,000 ha (5%) of the study area during this time (Province of British Columbia, 2020c). Mountain pine beetle and spruce beetle are other natural stand altering disturbances in the region (FLNRORD, 2018, p. 15-17). Mountain pine beetle has caused significant damage over the last twenty years to a wide range of forests containing lodgepole pine, and spruce beetle has become a serious concern in the boreal, with major outbreaks occurring over the last five years (FLNRORD, 2018, p. 17-21).

Anthropogenic disturbances have also substantially influenced land cover over several decades (Atticus, 2021; Creed et al, 2019; Ecora, 2021; Province of British Columbia, 2019c; Fort St. John LRMP Working Group 1997). Virtually all of the anthropogenic disturbances occur

within the Boreal Plains NDU, where agriculture, forestry, and oil and gas activities are more concentrated. (Atticus, 2021, p.34).

At-Risk Species and Ecosystems of Importance

Potential biodiversity considerations and ecological risks within the boreal landscape include species of conservation concern, such as at-risk plant and wildlife species (mammals, birds, and amphibians), as well as ecological communities of concern and known sensitive ecosystems. Given this, when considering a regional EBM framework awareness of these at-risk species, at-risk ecosystems, and sensitive ecosystems is important. With this in mind, I provide a brief overview of the number of species and ecosystems listed by the BC Conservation Data Center (BC CDC) as being of local, regional, provincial, national, or global importance or that are endangered or vulnerable in the study area. In keeping with my research scope this summary does not provide specific species or ecological communities at risk details nor does my summary evaluate or include species at risk, significance, or importance, from a traditional use or cultural importance perspective.

At-Risk Plant and Wildlife Species. In their report, Atticus (2021) described the ecological conditions within my study area, summarizing the current known plant and wildlife species at risk according to the BC CDC.

> Plant species of conservation concern (including vascular, nonvascular, and lichen species) and wildlife species of conservation concern are both listed federally by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or on Schedule

1 of the *Species at Risk Act*, or listed provincially by the BC CDC as red- or blue-listed.[1] Within the study area no 'potentially' occurring federally listed plant species are identified but 33 provincially red- and blue-listed plant species are cataloged as 'potentially occurring'; of these, 20 vascular plants are 'known to occur' in the region (five red-listed and 15 blue-listed) (Atticus, 2021, p. 65). Seventeen (17) federally listed (SARA and COSEWIC) at-risk wildlife species are expected to occur, 13 of these are wildlife species or populations listed provincially by the BC CDC as red- or blue-listed (four red- and nine blue-listed). Further, 12 listed wildlife species (eight bird and four mammal) are identified in the mapped element occurrences spatial dataset as known to occur, or have occurred, in the region (Atticus, 2021, p.76).

Sensitive Ecosystems and At-Risk Ecological Communities. As described by Atticus (2021), sensitive ecosystem communities and at-risk ecological communities are both present within my research study area (Atticus, 2021). In their examination of key elements of biodiversity in BC, Holt and Hatfield (2007) suggested that "key ecosystems would have higher functional importance than other ecosystems, and would be either naturally rare and therefore vulnerable, or typically common but under threat" (Holt & Hatfield, 2007, p.8).

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[1] The BC CDC defines red-listed as any species or ecosystem that is at risk of being lost (extirpated, endangered or threatened), and blue-listed as any species or ecosystem that is of special concern (BC CDC, 2020).

Sensitive Ecosystems. Sensitive ecosystems that are of particular importance within the boreal of northeast BC include a variety of wetlands (bogs, fens, swamps, and shallow open water), old and late-seral forests, riparian and floodplain ecosystems, subalpine and alpine communities, and native grasslands. These ecosystems offer numerous environmental services but are often sensitive or vulnerable to disturbance. They are often biodiversity hot spots that provide important habitat for a variety of animals, birds, insects, fish species, and aquatic organisms (Atticus, 2021, p. 51-52). This includes connectivity and travel corridors for ungulates and large mammals, and shelter, refuge, denning, feeding, and reproductive habitat for small to large mammals and furbearers. These areas also provide habitat for aquatic insects at the adult stage of their development, and feeding, mating, and resting areas for migratory birds (Blancher, 2003, p. 3-4; Brandt, 2009, p. 101).

At-Risk Ecological Communities. At-risk ecological communities are identified based on whether they are particularly sensitive to disturbance, have limited abundance and distribution within the region, may be considered rare provincially, or contain special elements or a specific assemblage of at-risk plant communities (BC CDC, 2020)

> Nineteen red- and blue-listed ecological communities have the ‘potential to occur’ in the area, as identified by the BC CDC. This includes four red-listed (endangered) communities (an upland shrubland community and three floodplain/riparian communities), and 15 blue-listed (special concern) communities (six upland and riparian communities and nine wetland communities). Of these, two blue-listed communities are

documented as ‘known to occur’ with the study area, east of Pink Mountain, and within the Sikanni and Buckinghorse River systems (Atticus, 2021, p.53).

Important Wildlife Species. Several large mammals, including deer, woodland caribou, bison, sheep, goat, and moose occur in the region, with black bear, grizzly bear, wolf, cougar, and Rocky Mountain elk also inhabiting the area (Atticus, 2021, p.74). Almost 200 land birds (including waterfowl, raptors, and songbirds) regularly inhabit the boreal; 90% of these are migratory, spending critical mating and reproductive time in the boreal. In addition, a diverse bat fauna, several amphibian, reptile, and freshwater fish species occur in the area (Atticus, 2021, p.73-75).

My study area contains a number of Wildlife Habitat Areas (WHAs), delineated specifically to conserve important wildlife habitat for identified wildlife species or populations. For example, there are specific Ungulate Winter Range (UWR) areas as well as Government Action Regulation (GAR) Orders for boreal caribou and stone sheep within the study area (FLNRORD, 2015, p. 8). Two ecologically based Bird Conservation Regions for conserving bird populations and species of concern exist across the broad region. Additionally, of note, there are currently six small bull trout WHAs established in the region (FLNRORD, 2015, p. 15).

This comprehensive literature review of key terms and definitions, relevant ecological concepts, and overview of the boreal environment and species and ecosystems at risk within the study area provides valuable context that directed the document analysis phase of the research.

Results

Research findings are presented in two distinct parts: document analysis results and interview data analysis.

Document Analysis Results

Following my research objective, the focus of the document analysis was to evaluate EBM structure and approaches and potentially identify potential key characteristics and components of ecosystem management approaches and EBM frameworks that may be applicable to biodiversity conservation and land and resource management planning in boreal BC. My research considered a number of parameters to assist with the classification of both per-reviewed literature and various technical papers and government produced reports into relevant groupings for further study and examination. Table 3 summarizes 27 of the key peer-reviewed literature determined to be the most relevant to my research objectives. This table presents the framework structure or type and scope and technical depth of the researchers work (e.g., studies of policy, broad concepts relating to ecosystem management, or detailed EBM element review), the domain investigated by various researchers (e.g., marine, freshwater, terrestrial, and social science research), and the spatial boundary or geographical scope studied (e.g., global, provincial, regional, or boreal-specific). Table 3 also identifies whether these researchers examined or reported on key EBM-related components determined from the document analysis such as EBM goals, EBM principles, EBM elements, and important barriers and challenges to consider when seeking to implement an EBM framework.

Table 3

Summary of Relevant EBM Research and Key EBM Components

Researchers/ Author(s)	Framework Structure or Type	Geographical Scope	Discipline(s)	Spatial Boundary	Identified Goals	Identified Principles	Identified Elements	Identified Challenges and Barriers
Andison (2020)	Ecosystem-based management	Boreal Alberta	Forest & forest management	Provincial	X	X	X	X
Andrew et al. (2014)	Protected area strategies	Canadian boreal	Forest & forest management	Federal	X	X	-	X
Arkema et al. (2006)	Ecosystem-based management	International	Marine fisheries	Global marine ecosystems	-	X	-	X
Bensted-Smith & Kirkman (2009)	Ecosystem-based management	International	Marine fisheries	Global marine ecosystems	X	X	X	-
Bourgeois (2008)	Ecosystem-based management	British Columbia	Terrestrial	Provincial	X	X	X	X
Bunsha (2012)	Ecosystem management	Coastal British Columbia	Terrestrial	Pacific coast (Clayoquot Sound and Great Bear Rainforest)	-	X	X	X

Butt & McMillan (2009)	Ecosystem management	Coastal British Columbia	Terrestrial	Pacific coast (Clayoquot Sound)	-	X	X	X
Carlson & Browne (2015)	Ecosystem management	Canadian boreal	Terrestrial	Western Canadian boreal	-	X	X	-
CIT (2004)	Ecosystem-based management	Coastal British Columbia	Terrestrial	Pacific coast (Great Bear Rainforest)	X	X	X	X
DFO (2011)	Ecological and biologically significant areas	Canada	Marine and freshwater ecosystems	Federal	-	-	X	X
Fall et al. (2004)	Ecosystem and forest management	Boreal Quebec	Forest & forest management	Regional	-	X	-	X
Fee et al. (2009)	Ecosystem management	Canada and Germany	Terrestrial	Provincial/State	X	X	X	X
Foley et al. (2010)	Ecosystem-based management	International	Marine fisheries	Global marine ecosystems	-	X	-	-
Giliani et al. (2018)	Ecosystem-based management	Haida Gwaii	Social science research	Pacific coast	-	X	X	-
Grumbine (1994)	Strategic guidance/policy	International	Terrestrial	N/A	X	X		

Leech et al. (2009)	Ecosystem-based management	British Columbia	Terrestrial	Provincial	-	X	X	X
Levin et al. (2009)	Ecosystem-based management	International	Marine fisheries	Global marine ecosystems	-	-	X	-
Mackinnon et al. (2015)	Protected area strategies	Canada	Terrestrial	Federal	X	-	-	X
Montreal Process (1995)	Strategic guidance/policy	International	Forest & forest management	Global temperate & boreal forests	-	X	-	-
Newing (2011)	Conservation science	International	Social science research	N/A	-	-	-	X
Pavlikakis & Tsihrintzis (2003)	Ecosystem management	International	Multi-discipline	N/A	-	X	-	-
Pirot et al. (2010)	Ecosystem-based management	International	Terrestrial	N/A	-	X	X	X
Pitcher et al. (2009)	Ecosystem-based management	International	Marine fisheries	Global marine ecosystems	-	X	X	X
Price et al. (2009)	Ecosystem-based management	Coastal British Columbia	Terrestrial	Pacific coast (Great Bear Rainforest)	X	X	-	X
Shepherd (2004)	Strategic guidance/policy	International	Terrestrial	Global	-	X	X	-

Slocombe (1998)	Strategic guidance/policy	International	Terrestrial	N/A	X	X	X	X
Van Damme et al. (2014)	Ecosystem-based management	Canadian boreal	Terrestrial	Federal & Provincial	-	X	-	X

Applicable boreal-relevant EBM projects to compare and contrast are currently lacking in the literature. However, as shown in the above table several researchers provide ecological management guidance, analyze EBM characteristics, identify key components, and provide important challenges or barriers when considering an EBM approach to the management of various natural regions and resources. Tables 4 through 7 provide the results of my document analysis with each table individually summarizing key EBM goals, EBM principles, and EBM elements, as well as important challenges and barriers when considering an EBM framework or approach.

Key EBM Goals

Table 4 summarizes the key high-level goals found in the applicable EBM literature into three categories: i) ecological, ii) social, and iii) process goals.

Table 4

Identified EBM Goals

Key EBM Goals	**Applicable References**
Ecological Goals	
• Manage ecosystem integrity following a holistically approach (considering health and evolutionary principles)	Andison (2020); Bensted-Smith & Kirkman (2009); CIT (2004); Grumbine (1994); Old Growth Review Panel (2020); Slocombe (1998)]
• Maintain environmental services	Andrew et al. (2014)

• Have the expressed objective to conserve nature	Mackinnon et al. (2015)
Social Goals	
• Maintain human well-being and enhance societal quality of life	Bourgeois (2008); Old Growth Review Panel (2020); Slocombe (1998)
• Respect First Nations history and Rights	CIT (2004)
Process Goals	
• Participatory and collaborative	Bourgeois (2008)
• Explicit and adaptable objectives	CIT (2004); Grumbine (1994); Slocombe (1998)]
• Be long-term	Mackinnon et al. (2015)

Key EBM Principles

The document analysis identified a number of potential EBM principles. The most noteworthy and applicable principles to consider in a boreal EBM context are summarized in Table 5 below. Slocombe (1998), one of the ecosystem management pioneers, categorized ecosystem management principles as either structural (substantive and technical related) or procedural (process-related). Slocombe (1998) defined substantive goals as “desired characteristics or state(s) of an ecosystem being managed, ecosystem dimensions and ecological system components, and ecological processes” (Slocombe, 1998, p.486). Slocombe further

defined procedural goals as “ways to achieve or implement these substantive goals following specific pathways” (Slocombe, 1998, p.486). In my research, key structural EBM principles summarized from the document analysis include the maintenance of sound ecological principles, consideration of multiple views and perspectives, include humans as a key part of the landscape, have a clearly understood direction or path, and follow ecological boundaries. Key procedural EBM principles summarized from the document analysis include scoping collaboratively, planning across all disciplines, addressing uncertainty, making decisions locally, maintaining ongoing support, and being flexible and adaptive throughout the process.

Table 5

Identified EBM Principles

Key EBM Principles	**Applicable References**
Structural Principles	
• Establish a spatially explicit management plan across the entire landscape to maintain a wide range and diversity of species and habitats	Foley et al. (2010)
• Follow a multiple species approach and use both coarse and fine filters to manage for species and habitats to conserve biodiversity	Bourgeois (2008); CIT (2004); OMNR (2010; 2020); Pavlikakis & Tsihrintzis (2003); Pirot et al. (2010)

• Incorporate all views and forms of relevant information into practice, including scientific, Indigenous, and local knowledge	CIT (2004); Fee et al. (2009); Shepherd (2004)
• Manage ecosystems and ecosystem representation across a range of spatial and temporal scales and integrate EBM at various planning scales (i.e., regional, landscape, and watershed)	Andison (2020); Carlson & Browne (2015); CIT (2004); Foley et al. (2010); Price et al. (2009)
• Manage the integrity of the system as a whole	Bourgeois (2008); CIT (2004); Grumbine (1994); Pavlikakis & Tsihrintzis (2003); Pirot et al. (2010); Slocombe (1998)
• Manage the land based on ecological rather than administrative boundaries	Bunsha (2012); Butt & McMillan (2009); Leech et al. (2009)
• Manage the productive capacity of ecosystems within the limit of their function and resilience, focusing on desired condition	Fee et al. (2009); Montreal Process (1995); Shepard (2004)
• Recognize that humans are part of the system. It is essential to integrate ecological integrity and human well-being within the landscape	Bourgeois (2008); Giliani et al. (2018); Pirot et al. (2010)

• Recognize the dynamic nature, variability, and complexity of ecosystems	Andison (2020); Andrew et al. (2014); CIT (2004); Whitfield (2019)
• Set up a clear management direction consisting of a hierarchical set of goals, objectives, processes (requirements), targets, and indicators	CIT (2004); Leech et al. (2009); Montreal Process (1995); Price et al. (2009)
Procedural Principles	
• Apply transdisciplinary and multi-sector approaches and a regulatory framework to conserving biodiversity across the landscape	Slocombe (1998)
• Assess threats and risks across the entire landscape	Butt & McMillan (2009); Fall et al. (2004)
• Decisions must be decentralized and made as close to the situation as possible, respect local needs and values and beliefs, while remaining consistent with provincial direction (regional watershed-scale and community-based planning and management is essential)	Fee et al. (2009)
• Do not plan for the short-term maximization or yield of a single resource but rather manage a	Butt & McMillan (2009); Fall et al. (2004)

longer-term horizon that reduces long-term economic and ecological and social risks.	
• Ecosystem management approaches require strong governance including government facilitation, funding, and data support	Bourgeois (2008); Fee et al. (2009); Old Growth Review Panel (2020)
• Follow a collaborative approach to scope the EBM framework. Develop ecological goals based on consensus which look to incorporate common values and mutually beneficial outcomes based on shared beliefs and understanding	Bourgeois (2008); Pavlikakis & Tsihrintzis (2003); Pirot et al. (2010)
• Follow adaptive management principles (conduct ongoing research, implement a rigourous monitoring program, and incorporate continued learning and feedback mechanisms), and build adaptive capacity building along the entire spectrum of decision making	Bensted-Smith & Kirkman (2009); Leech et al. (2009); Pirot et al. (2010); Pitcher et al. (2009)
• Plan for uncertainty (e.g., fire) in the landscape	Butt & McMillan (2009); Fall et al. (2004)

Key EBM Elements

My research also identified a number of potential EBM elements (required elements to meet the stated principles) applicable to establishing an EBM framework to conserve biodiversity in boreal BC. The most relevant EBM elements are summarized in Table 6 below and are also graphically portrayed in Figure 6.

Table 6

Identified EBM Elements

Key EBM Elements	**Applicable References**
• Build on and incorporate existing and proven science methods	Fee et al. (2009)
• Develop a monitoring plan and adaptive management approach that evaluates ecosystem status over time, and that identifies, reports, and tracks species, habitat, and ecosystem health and condition at various spatial and temporal scales	Andison (2020); FLNRORD (2004); Leech et al. (2009); OMNR (2010;2020); Pitcher et al. (2009)
• Develop a shared vision for the future of the landscape	Pitcher et al. (2009); CIT (2004)
• Develop consensus for definitions, terms, tools, and methods to describe, identify, and manage ecosystems	Andison (2020); Slocombe (1998)
• Develop criteria to identify unique, special elements, vulnerable species, and critical habitats	Holt & Hatfield (2007)
• Develop measurable goals and associated targets for ecosystem condition	Andison (2020); Bourgeois (2008); CIT (2004); Leech et al. (2009)
• Ecosystem identification and mapping scale is important and must be carefully chosen to be able to describe the drivers of ecosystem change objectively and accurately	Levin et al. (2009)

• Establish baselines for species and habitats	CIT (2004); Slocombe (1998)
• Evaluate elements important for biodiversity conservation at an appropriate ecological and regulatory scale	DFO (2011); OMNR (2010; 2020)
• Incorporate economic factors and business drivers, and develop economic incentive measures	Fee et al. (2009); Giliani et al. (2018)
• Manage ecosystems and species at both coarse and fine scales	Andison (2020); Bourgeois (2008); CIT (2004)
• Map ecosystems at the level which you can measure, recognize, and explain drivers of change (threats)	Levin et al. (2009)
• Monitoring plans should link to existing efforts that manage and monitor activities under existing legislation	Old Growth Review Panel (2020)
• Prioritize key species for conservation by evaluating the level of function interaction and probability of significant population change	Holt & Hatfield (2007)
• Set needs and requirements for new inventories, develop funding plans, and execute over time based on jointly developed priorities	Bunsha (2012); Butt & McMillan (2009)
• Provide sufficient funding and staff capacity and commitment throughout the process	Bunsha (2012); Butt & McMillan (2009)
• Update applicable legislation and program management instruments (e.g., reform/modify existing tenure systems)	Bourgeois (2008); Old Growth Review Panel (2020); Pitcher et al. (2009)

Figure 6. Summarized Key EBM Elements

Key EBM Challenges and Barriers

My examination also identified some essential challenges and barriers that may be applicable when attempting to implement a boreal-based EBM. These obstacles are divided into governance and implementation challenges as shown in Figure 7.

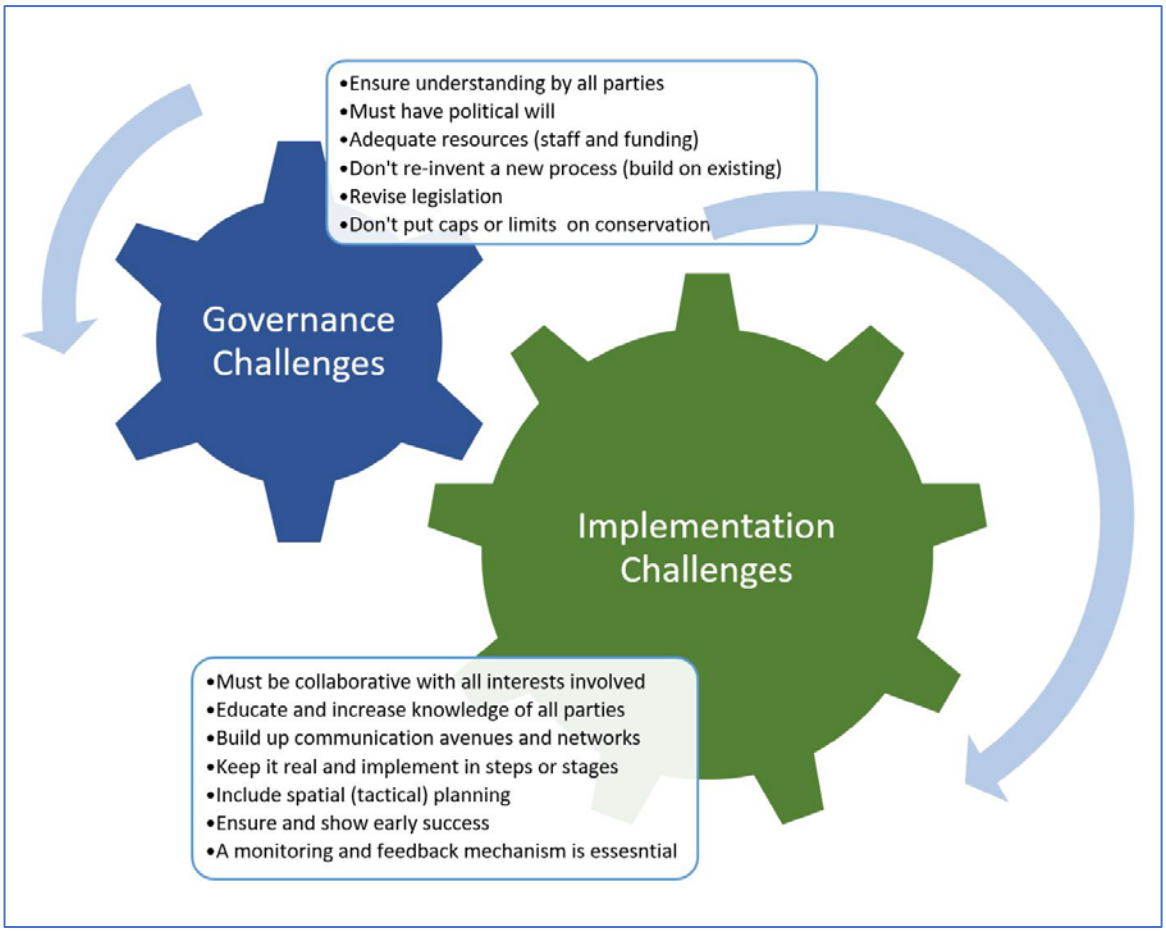

Figure 7. Identified EBM Challenges and Barriers

These governance and implementation hurdles are also presented in detail in Table 7 on the following page.

Table 7

Identified EBM Challenges and Barriers

Key Challenges and Barriers	**Applicable References**
Governance Challenges	
• Lack of understanding: Ensure all parties truly understand and value conservation	Arkema et al. (2006); Fee et al. (2009); Newing (2011)
• Cap on conservation: Biodiversity conservation efforts are currently limited to caps on impacts to regional timber supply quotas	Old Growth Review Panel, 2020; Van Damme et al. (2014)
• Must have political will: Obtain and maintain political, will, commitment, and support	Arkema et al. (2006); Fee et al. (2009); Newing (2011)
• Lack of resources: Ensure sufficient funding and staff capacity and commitment throughout the process (over the long-term)	Fall et al. (2004)
• Revise legislation: Important to update and revise applicable legislation and program management instruments, modifying existing policies and systems; beginning with obvious and easy things first, and work towards more complicated instruments over time	Bourgeois (2008); Old Growth Review Panel, 2020; Pitcher et al., 2009)
• Don't re-invent a new process: Start an EBM process with existing instruments. Take the good parts of what you have and continually improve over time, rather than completely starting over from square one	Bourgeois (2008)
Implementation Challenges	
• Must do it together: Collaboratively scope EBM, identifying goals, threats, and potential outcomes	Andison (2020); Fee et al. (2009)
• Must have a communication plan: Mainstream biodiversity policy into various resource management sectors	Pirot et al. (2010)
• Broad participation is needed: Participation by the full breadth of interests is critical to success	DFO (2011)
• Lack of knowledge: Ensure all parties have pertinent information and participate as knowledgeable individuals	DFO (2011)

• Lack of education: Prepare education and training packages, and take time to educate and gain widespread support and understanding in both the First Nation and broader communities where EBM is planned	Bunsha (2012); Butt & McMillan (2009); Mackinnon et al. (2015); Pitcher et al. (2009)
• Lack of spatial planning: Uncertainty over the location of future resource and road development is problematic for EBM implementation	Van Damme et al. (2014)
• Show early success: It is essential to pilot approach and demonstrate EBM phases in a simplified manner	Leech et al. (2009)
• Poor communication: Support (and build upon) existing communication channels and social networks	Pirot et al. (2010)
• Keep it real and implement in steps: Set attainable goals and expectations (both in terms of scope and timelines). Also work hard to be as practical as possible, executing in stages, with realistic outcomes	Andison (2020); Bourgeois (2008); Bunsha (2012); Butt & McMillan (2009); Leech et al. (2009)
• Monitoring is essential: Effective biodiversity conservation monitoring is lacking	Van Damme et al. (2014)

The document analysis results were used to inform the interview phase of my research, Further, these summarized goals, principles, criteria, and identified challenges and barriers were all considered when constructing a potential recommended EBM framework to conserve biodiversity within boreal BC.

Interview Data Analysis

The document analysis results were used to guide the interview phase of my research and helped develop the questions for the interview participants (please see Appendix A for a list of the interview questions). A great deal of meaningful and valuable information relating to biodiversity conservation, EBM, and land and resource management pertaining specifically to the boreal region of BC was obtained during the interview stage.

A qualitative analysis approach using Nvivo software was used to pull out key concepts and recurring themes and dominant ideas from the interview participants. Several general terms and themes were brought forward that were consistent between the different interviewees and questions. The most mentioned words from the entire group of participants were ecosystem, restoration, planning, key areas, resource, and conservation.

During the interview analysis process, I discovered that the responses to each of the sixteen individual interview questions provided a wealth of in-depth, complex perspectives from almost every participant. With this in mind, given the complexity of each question presented, I ultimately found it most comprehensible and straightforward to summarize the information obtained from the fourteen interviewees for each of the sixteen questions. Overall, the information analyzed and summarized from the interview process was integrated with the literature document analysis to develop a recommended boreal-specific EBM framework.

Interview Results Summary by Question

Question 1: What does biodiversity mean to you? Each participant was asked what biodiversity means to them. Although a variety of responses were given, the participants predominantly defined biodiversity as the complex variety of natural living things or biological components that are linked and interconnected at many different levels of organization. Figure 8 below presents a word cloud of the key terms used by the interviewees to describe what biodiversity means to them.

Figure 8. How do you Define Biodiversity?

Question 2: What does biodiversity conservation look like to you? With respect to biodiversity conservation the predominant responses focused on preserving diversity of many individual ecological components and also conserving ecological systems by maintaining ecosystem representation across the landscape and understanding ecosystem resilience. The various responses are also presented in the below word cloud (Figure 9).

Figure 9. What Does Biodiversity Conservation Look Like to You?

Question 3. What do you think are the most pressing biodiversity conservation needs in boreal British Columbia? The most pressing biodiversity conservation needs in boreal BC according to the interview participants are reducing current disturbance and habitat loss, updating and developing suitable legislative tools, conducting restoration activities, and a paradigm shift in our approach to managing resource, separating the business side of resource extraction from the conservation side of land management. As Participant 1 stated, “there needs to be a transparent and efficient process to identify biodiversity interaction pathways and conservation priorities taking into account cumulative effects and Treaty Rights” (Participant 1,

personal communication, August 26, 2021). Participant 2 thought any conservation effort "should be intrinsically linked to cultural diversity" (Participant 2, personal communication, September 24, 2021). Participant 7 also stated that "conserving biodiversity must include an Indigenous component" (Participant 7, personal communication, August 30, 2021). Three different respondents thought we need to move away from a single species or single management approach, focusing more on the interconnectivity and connectedness of ecosystems across the landscape and taking a multiple species approach (Participant 3, personal communication, August 31, 2021; Participant 8, personal communication, September 30, 2021; Participant 10, personal communication, September 1, 2021). At a tactical level, respondents thought there were a number of particular areas and ecological communities that required conservation. For example, Participant 12 thought we should focus conservation efforts where impacts are currently the highest and ecologically in those areas that are most fragile or sensitive. This includes fragmented areas, old growth, and those ecosystems most impacted by climate change (Participant 12, personal communication, October 8, 2021). Others thought grasslands, riparian areas, and wetlands were very important to conserve (Participant 2, personal communication, September 24, 2021; Participant 4, personal communication, August 30, 2021; and Participant 6, personal communication, September 3, 2021). Participant 13 stated, "the current regulatory system does not support current economic and environmental needs, and that currently land managers are trying to manage through a voluntary system with tremendous uncertainty (Participant 13, personal communication, September 28, 2021). Participant 14 thought from a non-biological perspective we need to acknowledge the inherent value of the boreal plain within

northeast BC stating, that “there is too much emphasis on charismatic landscapes (i.e., within the MKMA). Instead, we should be focusing on biologically conserving functional landscapes and connectivity across the area” (Participant 14, personal communication, October 28, 2021).

Question 4. What is an ecosystem in your own words or terms? The interviews showed that ‘ecosystem’ is defined differently depending on one’s values. Key terms virtually all the participants used to define ecosystem included: system (natural, process, functioning and inclusive), components (biotic, abiotic, chemical, ecological), interactions and reorganization (physical, non-physical, and living), and various scales (spatial and temporal). Participant 6 perhaps captured it best from an ecological standpoint saying that “an ecosystem is an abstract construct that we use to compartmentalize biotic and abiotic systems based on the primary drivers underlying them across a range of function and composition. These ecological components and function are always on a continuum” (Participant 6, personal communication, September 3, 2021).

Question 5. What species, ecosystems, or places, are most important to protect in the region, or in certain parts of the landscape, from your perspective? Much like the previous question, what people thought are important or that should be protected also varied tremendously based on the respondent’s values, technical acumen, and personal background. Some interviewees thought the focus should be on protecting Indigenous way of life. For example, Participant 5 stated that the most important to conserve or protect are “those [areas] identified by First Nations or informed by traditional knowledge” (Participant 5, personal communication, September 23, 2021). While, Participant 8 said to “focus on cultural and spiritual areas allowing

for the key practice of Rights and Title" (Participant 8, personal communication, September 30, 2021). Furthermore, Participant 2 also said to protect those "species and areas that are socially and culturally important to First Nations" (Participant 2, personal communication, September 24, 2021). A number of participants also focused on ecological aspects. Participant 14 thought it was important to "conserve those species, ecosystems, and places that are the best surrogates for biodiversity" ... [and to] …protect the flora and communities that maintain the fauna" (Participant 14, personal communication, October 28, 2021). Similarly, Participant 6 thought it best to protect "those parts of the landscape that are the most at risk or impacted by cumulative effects; including those areas that are fragmented, declining in abundance or negatively impact ecosystem representation" (Participant 6, personal communication, September 3, 2021). Other respondents believed it is vital to keep what is whole and maintain what we have, not just protect islands within the landscape (Participant 2, personal communication, September 24, 2021; Participant 12, personal communication, October 8, 2021).

Figure 10 below portrays the specific species, ecosystems, and places that the interview participants listed as important to protect in boreal BC. This figure shows that wetlands and corridors were most mentioned as important by those people I interviewed along with lowland habitats, grasslands, riparian areas, bear, moose, fish, caribou, and water.

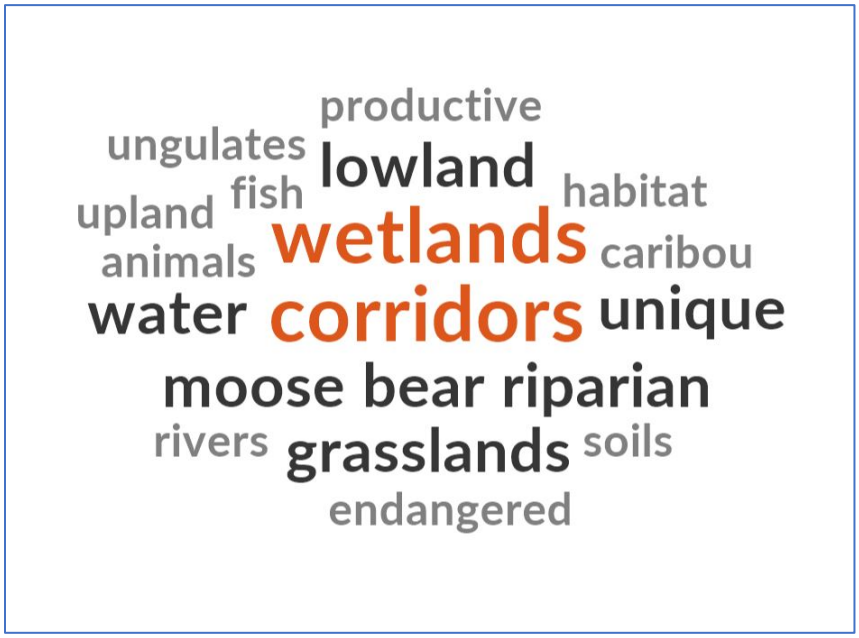

Figure 10. What is Most Important to Protect in the Boreal Landscape?

Question 6. Why do you think they are important? The key reason given by the participants for why the elements identified in Question 5 are important to conserve, is the multitude of ecosystems services provided by boreal ecosystems (Participant 6, personal communication, September 3, 2021; Participant 12, personal communication, October 8, 2021). Also identified was the importance of recognizing rural community perspectives, traditional knowledge, and integrating Indigenous values in any conservation planning (Participant 7, personal communication, August 30, 2021; Participant 9, personal communication, August 31, 2021; and Participant 13, personal communication, September 28, 2021). Furthermore, participants mentioned that it is important to conserve the uniqueness of the boreal within the province while protecting areas grossly under-represented within the province (Participant 9,

personal communication, August 31, 2021; Participant 14, personal communication, October 28, 2021)

Question 7. What land use activities most affect biodiversity in the region? The participants provided a variety of answers to this question. They responded that it is not just one thing, but rather that a multitude of land use activities impact biodiversity in the region. However, there are some land use activities that were top of mind for many who I interviewed when it comes to biodiversity impacts. Oil and gas exploration and development as well as forest harvesting activities were mentioned substantially more than any other land use activity. Multiple participants further stated that oil and gas development have a substantial impact on biodiversity.

Most of the Participants point to activities that lead to landscape fragmentation and result in permanent land alteration (permanently changing the land to a different state). This includes agriculture land conversion and various resource extraction industries (including road networks). However, the way the land is used is also affecting biodiversity from the perspectives obtained through the interview process. For example, the use of recreational vehicles and hunting pressure (specifically trophy hunting and non-community recreational hunting) were identified as impacting biodiversity in the region.

Question 8. What is/are the most pressing gap(s) in current land and resource planning in the area? A large and varied number of gaps were identified through the interview process. From a land-use perspective, almost half of the participants stated that the most pressing gap in land and resource planning in the area is the inadequateness of current legislation. For

example, Participant 11 stated that “the current legislative structure follows a colonial silo legislative framework which is not set up to deal with complexity. We can identify what to do but the system (polices and legislative framework) does not allow you to act” (Participant 11, personal communication, September 3, 2021). Participant 1 pointed out that we “require legislative tools and authority to really manage ecologically” (Participant 1, personal communication, August 26, 2021). Further, as described by Participant 9, “the government’s inability to set land use objectives for all resource users and not having the legislation to address all industries together in a consistent manner are big gaps” (Participant 9, personal communication, August 31, 2021). Others identified the lack of land use planning and integrated plans as a gap (Participant 8, personal communication, September 30, 2021; Participant 12, personal communication, October 8, 2021) or the absence of First Nation worldview and perspectives in planning overall (Participant 2, personal communication, September 24, 2021; Participant 5, personal communication, September 23, 2021). Figure 11 portrays the participant’s views of the dominant gaps identified in current land and resource management planning.

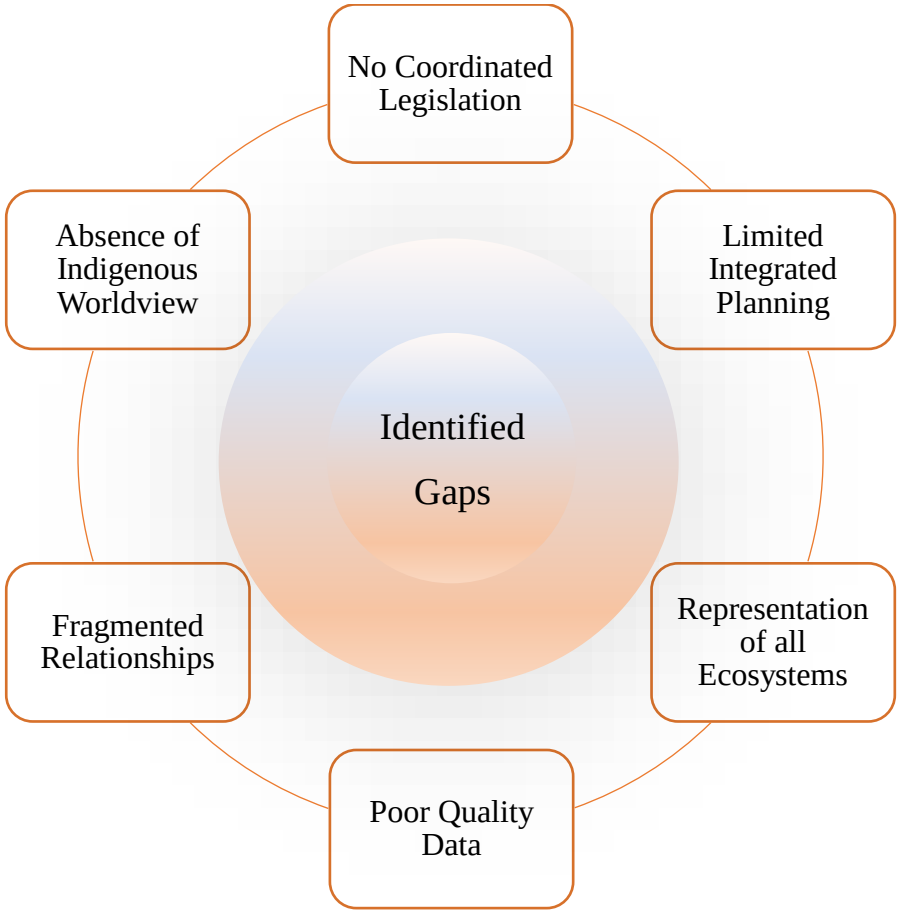

Figure 11. Identified Gaps in Land and Resource Management Planning

Participant 2 declared what is missing is recognition of cultural diversity in biodiversity planning and management; reasoning that what is needed is to revise the current BC Heritage Conservation Act to protect the cultural landscape and not just tangible elements or features on the landscape (Participant 2, personal communication, September 24, 2021).

Some additional identified sociocultural challenges include how to effectively measure Treaty Rights and actually action Section 3 of the BC Declaration on the Rights of Indigenous Peoples Act (Province of British Columbia, November, 28, 2019)by ensuring that provincial

laws are consistent with the declaration (Participant 13, personal communication, September 28, 2021; Participant 14, personal communication, October 28, 2021). As described by Participant 14, “we are currently entering into partnerships, but we don't really have the tools, which then creates winners and losers and results in litigation and commitments ahead of the tools to implement” (Participant 14, personal communication, October 28, 2021).

Other issues or gaps identified by interviewees included: i) the need for true ecosystem representation identification within the boreal landscape (Participant 6, personal communication, September 3, 2021), ii) data limitations and availability (i.e. data to identify, parcel, and prioritize conservation areas (Participant 7, personal communication, August 30, 2021; Participant 9, personal communication, August 31, 2021), and iii) the lack of trust between various parties and poor relationships that have existed over time (Participant 1, personal communication, August 26, 2021; Participant 10, personal communication, September 1, 2021).

Question 9. What may be the best possible way to protect biodiversity at a landscape level in BC’s boreal forests, while respecting sociocultural and socioeconomic values? Many participants believed the only way to protect biodiversity while respecting sociocultural and socioeconomic values was by collaboratively developing a comprehensive long-range multi-value land use plan with real shared decision making. Participant 8 took it one step farther stating that targets and oversight must be incorporated in any planning process (Participant 8, personal communication, September 30, 2021). A few participants noted that it is important to get away from single bottom-line economics and not focus only on, or give in to the pressure to maintain, short-term revenue (Participant 4, personal communication, August 30, 2021; Participant 8,

personal communication, September 30, 2021; Participant 12, personal communication, October 8, 2021). Participant 12 further reasoned that it is “important to broaden the socio-economic definition to allow for community well-being” (Participant 12, personal communication, October 8, 2021). Participant 14 also claimed it is important to find ways to “optimize conservation at the lowest cost to socioeconomic values” (Participant 14, personal communication, October 28, 2021).

Question 10. What key things should be considered that may best integrate First Nations sociocultural beliefs and values with biodiversity protection? Participant 6 thought that language is fundamental as well as how ideas and thoughts are packaged (Participant 6, personal communication, September 3, 2021), while Participant 9 thought “ethical space must be created that does not predispose ideas and outcomes to a western ideology” (Participant 9, personal communication, August 31, 2021). Participant 2 believes that generally we tend to have a self-centered approach to resource management where we look at the environment as something there to provide; and instead believes we must integrate First Nations culture within a biodiversity context (Participant 2, personal communication, September 24, 2021). Participant 8 agrees with this philosophy, saying that that this single-minded approach is most of the problem, and that we need to consider all living things together in a holistic manner following a multi-value, multi-species approach (Participant 8, personal communication, September 30, 2021). Some interviewees focused on the process as a key element to best integrate First Nations sociocultural beliefs and values, pointing out that there must be collaboration from day one! This open collaboration is foundational for integrating Indigenous beliefs and values in biodiversity

conservation. Further, that there must be a process of shared governance with meaningful relationships at the individual table level that includes an in-person joint process (Participant 9, personal communication, August 31, 2021; Participant 11, personal communication, September 3, 2021; Participant 12, personal communication, October 8, 2021).

Question 11. What does ecosystem-based management mean to you? Figure 12 presents the words most often used when the participants were asked what EBM means to them.

Figure 12. What Does Ecosystem-based Management Mean to You?

When asked this question, many participants pointed to their belief that EBM deals with the whole system and that it is a holistic approach to managing the landscape and taking into

account the interactions together rather than only looking at individual pieces. They also stated that EBM is a big picture process or structure that interacts within the landscape and what is contained within the land (Participant 3, personal communication, August 31, 2021; Participant 5, personal communication, September 23, 2021; Participant 10, personal communication, September 1, 2021; Participant 11, personal communication, September 3, 2021). Participant 14 also added that a true EBM approach is one that "optimizes ecological integrity to promote human wellbeing" (Participant 14, personal communication, October 28, 2021). With ecological integrity in mind, Participant 6 stated "In true ecosystem-based management the first priority should be to ensure regardless of economics that on the landscape there is sufficient ecosystem representation. Without that the management regime is something else but is not ecosystem-based management" (Participant 6, personal communication, September 3, 2021). However not all participants were entirely keen on the term EBM. Participant 2 cautioned to be careful using such a term as EBM is often misused and does not include an Indigenous perspective (Participant 2, personal communication, September 24, 2021). Along this line, Participant 9 argued that EBM as a term is too restrictive as it is often too constrained and predefined; however, regardless of what you call it, something like an ecological management framework is all about "understanding inputs and analyzing management scenarios with established criteria to guide responsible extraction" (Participant 9, personal communication, August 31, 2021). Ultimately, as suggested by Participant 11, the key thing is to not worry about what you call it, but rather "develop foundational principles first together and create the concepts, objectives, and the framework name collaboratively" (Participant 11, personal communication, September 3, 2021).

Question 12. Do you think an ecosystem-based framework can help conserve biodiversity in the region? Regardless of what the participants called EBM, or what they understood the term to mean, all thought a framework (like EBM) could help conserve biodiversity in the region. Based on their responses to Question 11, the participants agree such an approach has potential for biodiversity conservation so long as the approach deals with all things in a holistic manner, integrates ecological and human processes in a structured system, and looks to identify and manage multiple values and elements at multiple scales within the landscape.

Question 12a. What would you say are the first steps? A number of participants thought the most important initial steps are collaboratively developing a shared vision in an intentional way with an agreed scope, foundational terms and definitions, and establishing common goals, principles, and objectives (Participant 1, personal communication, August 26, 2021; Participant 11, personal communication, September 3, 2021; Participant 12, personal communication, October 8, 2021; Participant 14, personal communication, October 28, 2021). Otherwise, before EBM could be implemented, bold provincial enablement is required (Participant 11, personal communication, September 3, 2021), and education is required so that the various players may really understand what ecosystem representation is about (Participant 6, personal communication, September 3, 2021). Participant 13 also added that developing bigger partnerships with government and industry with respect to resource development would be beneficial to starting an EBM process (Participant 13, personal communication, September 28, 2021).

Question 12b. What would you think are the key components to consider? At the strategic level, participants thought it is essential to begin with a shared principled approach with common terms and definitions and acknowledge that humans interact with ecosystems (Participant 1, personal communication, August 26, 2021). Also, it is important to recognize that cultural diversity is a big part of the biodiversity picture. With this in mind, a key component is to develop Indigenous partnerships and revise provincial legislation to protect First Nation values. This includes revising the Heritage Conservation Act to define the holistic First Nation way of life (Participant 2, personal communication, September 24, 2021).

At the tactical level, the participants identified a number of components important to an EBM approach. In summary, the components or elements identified include: completing provincial inventories and regional mapping, conducting spatial planning assessments, evaluating ecological status and ecosystem resiliency, mimicking natural conditions across the landscape, collaboratively developing areas for conservation, and identifying restoration priorities, and for the remaining landscape create acceptable risk levels, thresholds, and limits for ecosystem disturbance.

Question 12c. What scale and time period should be covered? Scale and timelines should by defined by the people involved and the values to be managed (Participant 1, personal communication, August 26, 2021; Participant 9, personal communication, August 31, 2021; Participant 12, personal communication, October 8, 2021). Scale should be determined by local people and regional communities but should follow natural and ecological boundaries such as natural disturbance, watersheds, or sub-watersheds. Scale should be based on the maintenance of

healthy functioning ecosystems (Participant 5, personal communication, September 23, 2021; Participant 12, personal communication, October 8, 2021; Participant 14, personal communication, October 28, 2021). Timeline should be long-term but depends on the scope of your objectives and the values being considered. Timelines should mimic natural conditions and disturbance cycles. Follow a natural disturbance mentality (i.e. 300-350 years) and cover centuries to deal with climate change impacts (Participant 5, personal communication, September 23, 2021; Participant 8, personal communication, September 30, 2021; Participant 11, personal communication, September 3, 2021; Participant 12, personal communication, October 8, 2021; Participant 13, personal communication, September 28, 2021; Participant 14, personal communication, October 28, 2021). Participant 7 thought the timeline should include multiple planning cycles and avoid political timelines (Participant 7, personal communication, August 30, 2021). While Participant 14 suggested that "targets and thresholds must be developed and set 100 years out but revisited every 10 years" (Participant 14, personal communication, October 28, 2021).

Question 12d. What do you think are the key benefits of an EBM approach? A number of benefits were identified by the participants. Each of the identified benefits are unique and important in their own right, and are summarized below:

- Should help to deal effectively with cumulative effects analysis (Participant 1, personal communication, August 26, 2021).
- Process has the potential to respect different perspectives and seek common values and interests.

- Potentially incorporates First Nations values into planning and education in Indigenous worldview/perspective regarding the stewardship and safeguarding of ecosystems (Participant 2, personal communication, September 24, 2021).
- Can provide the greatest potential to maintain the basket of ecological goods and services over space and time (Participant 4, personal communication, August 30, 2021).
- Provide baseline knowledge and information about ecological resilience (Participant 5, personal communication, September 23, 2021).
- Conservation of the ecological resource and longevity of goods and services (Participant 6, personal communication, September 3, 2021).
- Broader approach that considers a lot more than a just single resource use/extraction, but also considers other features such as soils, wildlife, and cultural aspects (Participant 7, personal communication, August 30, 2021).
- Manage multi-species and provide for optimum social and economic benefits over time (Participant 8, personal communication, September 30, 2021).
- The incorporation of First Nation sociocultural values and ideology will lead to true sustainability (rather than always following a socioeconomic emphasis) (Participant 9, personal communication, August 31, 2021).
- Allows for a better way to shape reality and adapt from there. “Turn things on its head” …” The world has changed” (Participant 11, personal communication, September 3, 2021).

- Move away from a Wild West mentality while building trust, exploring shared values and opportunities (Participant 12, personal communication, October 8, 2021).
- Provides long term stability and relationship to those that have dependency and interest in the land while investing in the future and build resilience in the system that includes First Nation independence and self-government (Participant 14, personal communication, October 28, 2021).

Question 13. What are the barriers and key challenges to implementing an ecological management framework in the region? Several barriers were identified by the participants if considering an EBM framework for the region. Below summarizes the key challenges expressed by the interviewees:

- Ecological education and awareness at various levels of the community and government (Participant 4, personal communication, August 30, 2021).
- The short-term political cycle (Participant 6, personal communication, September 3, 2021; (Participant 9, personal communication, August 31, 2021).
- Require a paradigm shift away from straight neo-liberal economics, constraint-based thinking, and solely western perspective to land management (Participant 2, personal communication, September 24, 2021; Participant 12, personal communication, October 8, 2021).
- Provincial government department siloes and lack of policies and integration between various resource industries and associated government departments

(Participant 5, personal communication, September 23, 2021; Participant 9, personal communication, August 31, 2021).

- The lack of trust and relationships, and the absence of meaningful First Nation engagement (Participant 1, personal communication, August 26, 2021; Participant 10, personal communication, September 1, 2021).
- Need to move forward on things while allowing for failure and adjustment (Participant 7, personal communication, August 30, 2021).
- Lack of collaboration, and consensus-based or shared decision making (Participant 8, personal communication, September 30, 2021) (Participant 10, personal communication, September 1, 2021).
- Capacity in governance (Participant 14, personal communication, October 28, 2021).
- Tactical level resource planning and less of a project-based approach to land management (Participant 13, personal communication, September 28, 2021; Participant 14, personal communication, October 28, 2021).
- Not enough knowledge of trade-offs and various impacts (socially, ecologically, and economically) to implementing an EBM framework (Participant 13, personal communication, September 28, 2021).

Question 14. What First Nation sociocultural values could potentially be protected by implementing an ecological framework? The participants identified some key First Nation sociocultural values that could be protected by implementing an ecological framework.

Participant 5 indicated that multiple linkages and potential sharing of information between the colonial and the Indigenous worldviews could be possible if implementing an ecological framework (Participant 5, personal communication, September 23, 2021). As well, an ecological framework and linkages to Indigenous culture could lead to improved and meaningful consultation. Participant 8 proclaimed, 'the recent BC Supreme Court Decision was super clear regarding meaningful consultation versus a transactional check box by government and industry" (Participant 8, personal communication, September 30, 2021). Further, participants 7 and 12 thought values that could be protected included the integration of traditional (Elder's) knowledge while also improving mental health (e.g., helping Elder's deal with ecological grief) (Participant 7, personal communication, August 30, 2021; Participant 12, personal communication, October 8, 2021). On a related note, participant 12 also thought an ecologically based process could potentially help First Nation sustenance by conserving ungulates, fish, and clean drinking water, which would equate to improved overall physical and mental health (Participant 12, personal communication, October 8, 2021).

Question 15. How might you begin to implement an ecosystem-based approach to land management without complete information? A number of suggestions were put forward by the participants regarding how to potentially implement an ecologically based framework without complete information. Some notable responses captured the sentiment of many of the provided responses to this question. Participant 2 asserted that meaningful relationships with people [are key], and people must see and walk together on the land. Participant 2 further stated that it is critical to develop Indigenous worldview by socially deconstructing and then socially

constructing this perspective collaboratively (Participant 2, personal communication, September 24, 2021).

Participant 11 thought it is important to first “clearly define the problems and needs, rather than assume that EBM is the tool” (Participant 11, personal communication, September 3, 2021). Participant 7 also added, “follow a process-oriented approach that includes ground rules (including conflict management protocols) and begin, if necessary, with interim measures with mitigating factors where needed” (Participant 7, personal communication, August 30, 2021).

Participant 1 agreed with first taking a collaborative approach, but also offered a suggestion to help with land use planning in the boreal.

> Develop and operate three management levers at the landscape scale: 1) development prohibition 2) development or tenure deferral (sequencings, just not now), and 3) prioritized reclamation. How much you pull on each lever is the difficult part that needs to be discussed and decided upon jointly (Participant 1, personal communication, August 26, 2021).

Participant 9 also believed that any EBM process must include some key elements.

> All partners must be part of the planning process and are part of the entire process (can't plan in isolation). [Also] implement an effectiveness monitoring program with real feedback and adjust the entire plan along the way. This may reveal that the objectives were wrong (Participant 9, personal communication, August 31, 2021).

"As we will never have enough information, we need to adopt a philosophy to embrace uncertainty", said Participant 14. Further stating, "focus on key things that includes both coarse-scale (landscape focused; conserving landscapes) and fine-scale (Participant 14, personal communication, October 28, 2021).

Question 16. If you had limited time and resources, what steps or actions would you prioritize first to protect biodiversity in the region? Participants provided a wide range of responses that revolved around communication and relationships, process, ecological principles and biological conservation initiatives, as well as policy and governance.

Multiple respondents thought the human context must be considered rather than just technical elements. Priority should be given to developing mutual respect and relationships, enabling conversations, and relying on the knowledge and perspectives of local peoples. "Relationships are key [says Participant 7]. It is imperative to build positive trusting relationships (trust bridges roadblocks), while operationally, agreeing on key topics to identify where the hot spots area, and potentially implement interim measures as/if needed" (Participant 7, personal communication, August 30, 2021). Participant 11 agreed saying it is essential to "have open-ended contextual conversations" (Participant 11, personal communication, September 3, 2021).

Concerning an EBM process Participant 4 provided a general outline. "As a starting point create an outline and road map to strategically guide active planning with general and overarching goals. After which set objectives and ways to implement following a consistent approach that is understandable and adaptable" (Participant 4, personal communication, August 30, 2021). At the landscape level, Participant 8 thought, from a planning and land use

perspective, any EBM process must begin with understanding and then following limits and parameters of natural disturbance as well as ecosystem resilience (Participant 8, personal communication, September 30, 2021).

Several respondents also focused on ecological steps or actions. From an ecological perspective participants thought it is important to conduct inventories, improve ecological knowledge, understanding, and awareness while focusing initially on large intact areas, sensitive ecosystems/areas and species conservation, habitat refugia and connectivity, and water resources.

An improved forest inventory (especially forest stand age information) integrated with ecosystem mapping is needed. Once this is done then any quibbling about the accuracy of the perceived extent of ecosystem representation, seral stage distribution, and/or conservation values can stop, and we can then get down to making the tough transparent decisions following the guidance provided by the Cumulative Effects Framework (Participant 6, personal communication, September 3, 2021).

Multiple participants emphasized that restoration is required as a first, and ongoing action within any EBM approach. “Conduct restoration (in particular to reduce and restore roads)” (Participant 12, personal communication, October 8, 2021).

From a conservation and restoration perspective Participant 14 suggested an approach.

> Aggressively adopt large strict interim conservation measures (for current and intact areas of the boreal that become big anchors for biodiversity conservation). Restoration of areas around these anchors, especially those that form important connections to these and other important areas (Participant 14, personal communication, October 28, 2021).

Regarding other priority (short term) steps, Participant 5 simply made a couple of statements: “Make water a priority (water quantity and quality); need to know what we are dealing with respect to water! Also change the open hunting season (Participant 5, personal communication, September 23, 2021).

From the policy and legislative side of things, a number of actions were identified which range from immediately adopting interim measures, reviewing and potentially revising resource subsidies, and pulling together a broad team of knowledgeable people to develop overarching integrated and meaningful policy and tenure reforms.

> Restructure and simplify existing regional planning and government groups and processes. Also restructure oil and gas subsidies. Instead of allowing the deferral of royalties for deep shale gas drilling operations, move to a system of royalty credits that put actual dollars into a general restoration pool (so there is an ongoing budget for restoration activities on the landscape) (Participant 1, personal communication, August 26, 2021)

Participant 12 also offered a number of thoughts pertaining to policy and legislation.

> Attack the problems from multiple angles, both from top down with legislation and also from the bottom with small collaborative planning process with local people. Stop subsidizing fossil fuel exploration and development. Complete tenure reform. Also ensure that industry meets standards and commitments. (Participant 12, personal communication, October 8, 2021).

Discussion

My research provides an overview of ecosystem management and biodiversity conservation in BC, explores important definitions and related ecological concepts, and investigates EBM approaches and applicable frameworks that could contribute to conserving biodiversity in boreal BC. The literature review, document analysis, and information obtained through interviews show that an ecological management (EBM-type) framework has the potential to be a valuable approach to conserve biodiversity and could potentially be used to guide land use planning and resource decision-making in the boreal region of BC.

From a technical and scientific standpoint, the results of my research identify a number of fundamental concepts, notable features, and essential elements that may be most applicable when considering an EBM approach to conserve biodiversity in boreal BC. However, as also shown by my findings, in addition to the technical aspects, it is imperative that any EBM approach be developed jointly, as suggested one of the interview participants, “the key thing is to not worry about what you call it, but rather develop foundational goals and principles first together and create the concepts, objectives, and [also] the framework name collaboratively” (Participant 11, personal communication, September 3, 2021). Furthermore, as several of my interview participants stated or inferred, any process such as this must include the human context; and therefore, must prioritize mutual respect and relationships, having open-ended conversations, and relying on the knowledge and perspectives of local peoples. Additionally, such a framework is not intended to replace tactical and operational resource-based planning, nor is it intended to be a prescriptive listing of site-specific resource management practices. Nevertheless, subsequent

detailed and comprehensive land and resource management prescriptions and operational factors should build upon the foundational goals, principles, elements, and criteria laid out within any holistic ecological management framework. Most of the current literature provides scientific and technical aspects of EBM development that is applicable to boreal BC. However, published research on sociocultural (traditional and Indigenous worldview) as well as socioeconomic aspects of an EBM framework are not common, but are equally important. With this in mind, it is envisaged that the development of an EBM approach for boreal BC would be potentially implemented considering ecological, social, and economic aspects and also developed in conjunction with other ongoing or proposed provincial and regional planning and land management initiatives. Overall, my results highlighted that EBM is as much about the process and journey undertaken as it is the technical aspects, and that the overall process of a particular EBM framework is just as important as the individual components!

Conclusions and Recommendations

The objective of my research was to investigate EBM as a potential framework to potentially conserve biodiversity in boreal BC and improve land use planning and resource decision-making in northeast BC. My research shows that such a framework and process, rooted in the identified key goals, principles, and elements, may provide opportunities to conserve biodiversity within the boreal region of BC. Although, as outlined in their 2020 strategic review of old forest management in BC, developing and implementing an alternative management framework (like EBM) first requires a paradigm shift in how land use planning and resource management are currently implemented (Old Growth Review Panel, 2020, p. 15). My findings

suggest that for an EBM framework to be successful we must change how we view, manage, and integrate both biodiversity conservation and cultural diversity. Further, as Andison (2020) stated, [we must] "make EBM a journey rather than a destination" (p.13). Wenig (2012) further emphasised, "like the principles of 'equality' and 'democracy,' ecosystem management may be impossible to achieve in its purest or absolute form, but it is nevertheless worth pursuing … [and as such] … "it must be approached with caution and humility, but it is nevertheless necessary and urgent" (p.12). Keeping these guiding ideologies front and center, and based on the results of my research, I recommend the following comprehensive EBM framework, one that is particularly focused and applicable to boreal BC, but also has many key and overarching components that may be also applicable to other areas of the province.

Recommended EBM Framework for Boreal British Columbia

One of the goals of my research was to recommend an EBM framework along with associated components that is based on my research results. This framework incorporates my key findings, such as: EBM goals, essential structural and procedural principles, important technical and process elements, and also incorporates features that help to potentially overcome identified challenges and barriers when attempting to implement EBM. I hope the recommended framework presented below can be utilized by governments, regional planning tables, communities, and the resource industry when looking to begin their own EBM journey. I believe such a framework and its components could help direct ecosystem-based land use planning and guide ecological-based land and resource management decision-making in boreal BC.

As my results show, the first step of any framework is to develop an overall strategic process that is jointly created and agreed upon by all parties involved. The intent is to follow a structured approach to direct and guide the various stages of EBM implementation. My recommended EBM framework follows the process shown in Figure 13. This approach is adapted from Foley et al. (2010) during their evaluation of EBM in a marine context. I followed Foley et al.'s (2010) fundamental structure but I revised the components making it more relevant to a terrestrial EBM framework for boreal BC.

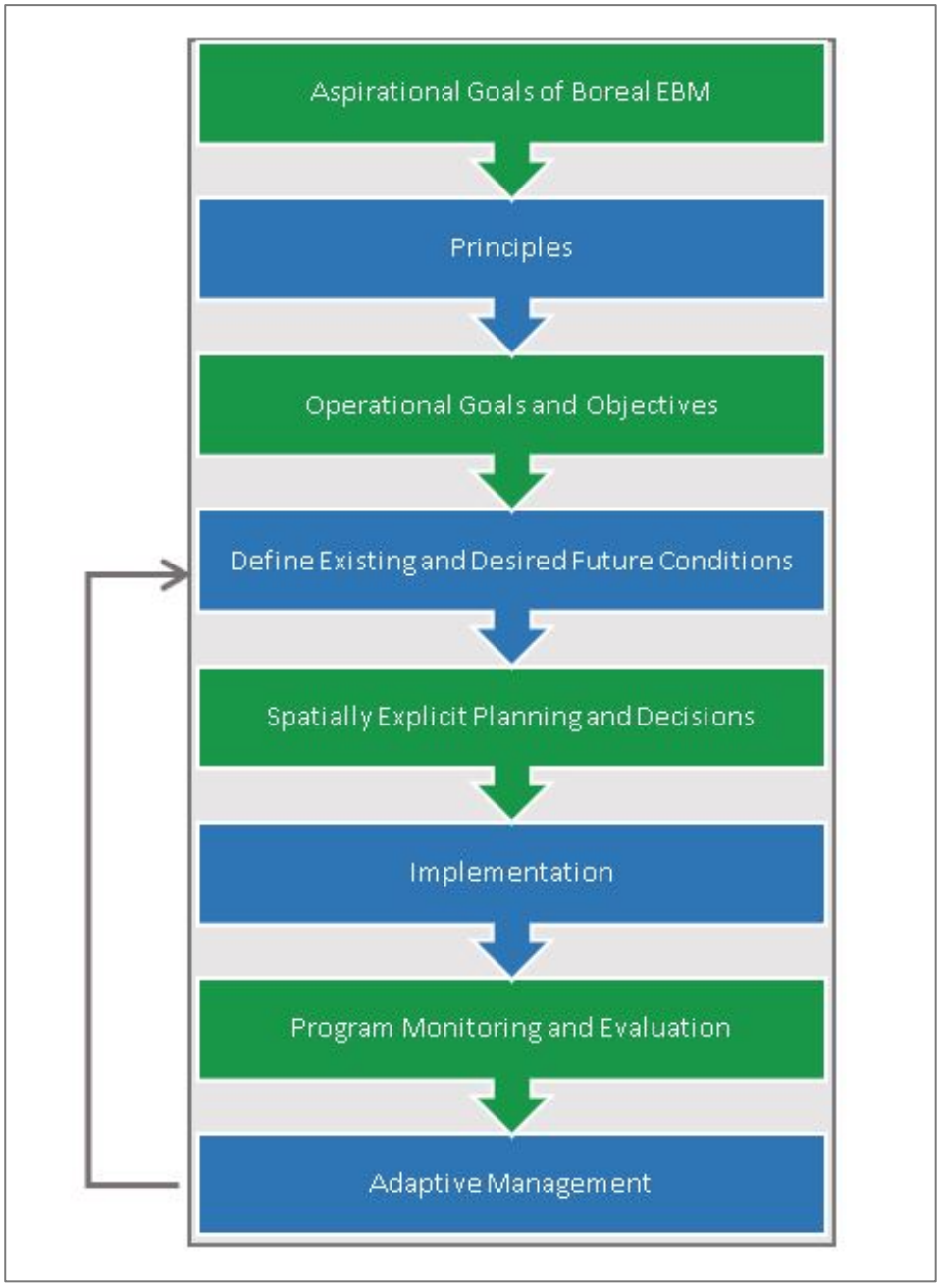

Figure 13. Boreal EBM Process Flow Diagram Adapted from Foley et al. (2010)

The recommended EBM framework includes broad (aspirational) goals and key principles. It also requires setting operational goals and objectives that include ecological-based

goals to help define existing and future desired conditions while guiding EBM implementation. This framework is not complete without including ongoing program monitoring and incorporating adaptive management and feedback mechanisms into the process.

Following this overall approach, I summarize what my research shows are the most essential EBM components to include in a boreal-based EBM framework. These components, presented in Figure 14, include high-level aspirational goals, EBM principles and operational objectives, implementation elements, and program monitoring and adaptive management.

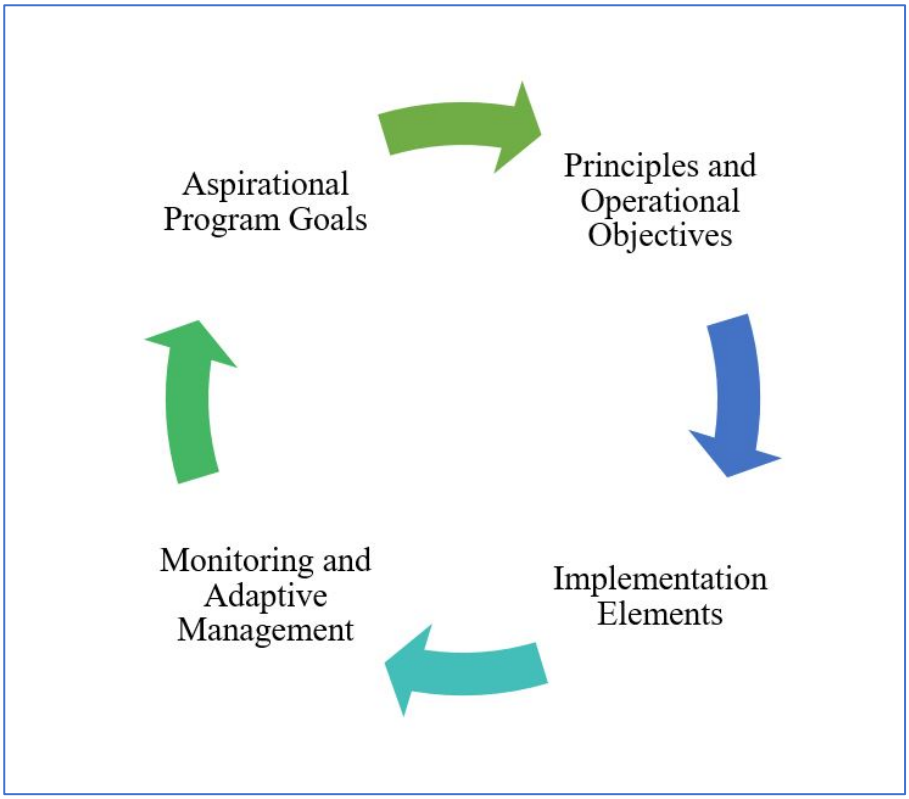

Figure 14. Recommended EBM Components

Recommended (Aspirational) EBM Goals

Aspirational goals need to be collaboratively discussed, defined, and decided upon by those people living, working, and most impacted by resource and land use decisions in the boreal. As Andison (2020) stated, “it is essential that people working within shared landscapes and planning environments need to define EBM together, agree on what EBM is, and means, to them” (Andison, 2020, p.50). Based on my research findings some fundamental high-level goals (tenets) may include:

- joint planning and collaborative decision making
- recognition of First Nation Rights and Title
- integrate Indigenous knowledge at all levels of planning
- preserve ecological systems and integrity at various scales
- maintain or enhance regional human well-being, and
- follow adaptive management principles.

Recommended Principles and Framework Objectives

Several important EBM principles and framework objectives are recommended for a northeast BC EBM framework. While there are many principles that can be followed when considering EBM, Figure 15 summarizes what my research shows are some of the key principles when considering an EBM for boreal BC.

Figure 155. Recommended Key Principles and Operational Objectives

Each of these principles and operational objectives are described in more detail below:

1. A collaborative process is fundamental: Collaboratively develop a boreal-based EBM road map that includes both technical aspects and governance aspects. From a technical point of view jointly scope biodiversity issues and collectively develop a process and approach with agreed upon key EBM definitions, high-level goals, principles, and criteria. This includes working together to set clear management direction and objectives upfront with a set of hierarchical goals, targets, and indicators. From a governance point of view, jointly develop priorities and long-term

funding and staff support plans and execute over time (e.g., identifying needs and budget requirements for new inventories)

2. Incorporate human well-being: Incorporate human well-being throughout the EBM framework process. This consists of integrating a scientific approach to biodiversity conservation with Indigenous traditional and cultural perspectives and worldviews and areas, places, and species of importance to First Nations. Incorporating human well-being also requires including community and regional socioeconomic values and needs into the process from the outset.
3. Recognize First Nations Rights and Title: Assimilate the development of a boreal-based EBM framework with Treaty 8 First Nations to ensure the protection of Indigenous Rights and Title in the region. This includes recognizing the recent June 29, 2021, BC Supreme Court ruling in Blueberry River First Nations (Yahey) versus the Province of British Columbia and building upon the outcomes resulting from ongoing agreement (Province of British Columbia, October 2021). Additionally, build on and leverage other related Provincial–Indigenous government-to-government relationships and processes such as the northeast RSEA conducted under the provincial ESI program (Province of British Columbia, 2019b).
4. Use ecological and sociocultural spatial boundaries: Establish planning areas based on a combination of ecological boundaries (watersheds and BGC zones), Indigenous territories and identified special places, existing administration areas, and identified conservation areas.

5. Identify ecosystems, places, and ecological goals: First, identify all natural and distinct ecological communities and places of importance to Indigenous Peoples. This includes identifying ecological communities where particular species at risk are likely to occur. It also includes identifying special places and areas of cultural significance to First Nation communities and evaluating existing parks and reserves, potential conservation networks, and their condition/status. This step of the EBM process also requires research on natural disturbance patterns, ecological communities NRV, assessing current ecological conditions, and quantifying ecological community and species resilience.

    Second, once these elements are identified and evaluated then the EBM framework needs to develop clear ecological goals that will be used to help define existing and future desired conditions. Multiple interview participants identified ecological goals such as: conducting inventories, improving ecological knowledge and awareness, protecting large intact areas, conserving water resources, protecting sensitive species and ecosystems, and enhancing wildlife habitat and habitat connectivity. Below is a listing of ecological goals that is recommended for a boreal-based EBM. The logic is partially adapted from the work completed by Bensted-Smith and Kirkman (2009) when they evaluated ecological management approaches for large-scale marine areas but is also applicable to a terrestrial EBM approach. The objectives of these particular ecological goals are intended to conserve local, regional, and globally important biodiversity at various spatial and temporal scales, maintain

species and ecosystem resiliency and ecological processes, and preserve essential ecosystem services.

Recommended ecological goals:

- Manage ecosystems and ecosystem representation across a range of spatial and temporal scales. Maintain all natural and distinct ecological communities and assess the risk and threats to the location, distribution, and abundance of these communities at various planning scales (i.e., regional, landscape, and watershed).
- Maintain ecosystem processes and ensure healthy ecosystems are resilient to change (by retaining and monitoring community structure, composition, and function).
- Identify and preserve viable populations of species (i.e., maintain populations of all native species in natural patterns of abundance and distribution, and ensure the viability of species at risk; this goal may require setting targets for umbrella species and related proxies to manage species that are difficult to detect on their own).
- Prevent the introduction and spread of invasive species.

6. Complete a risk analysis: Once the ecological features are identified and the ecological goals are established then the EBM framework must incorporate a risk analysis that evaluates the threats, ecological risks, and ecological impacts of each identified ecosystem or stratified ecosystem unit or group and build on the existing

global, federal, and provincial criteria and lists (i.e. SARA, COSEWIC, BC CDC). A number of interview participants agreed with this approach. In particular, Participant 11 surmised that a risk analysis is required that follows a similar approach to that used for large development proposals and considers a cumulative effects assessment (Participant 11, personal communication, September 3, 2021). A potential structured process to completing an ecological risk analysis in the boreal is recommended for a boreal-based EBM framework (and is partially adapted from that developed by Creed et al., 2019). This approach first requires identifying and understanding the ecosystem elements (spatial and temporal boundaries and conditions), then developing indicators benchmarks and thresholds for each element, identifying risks (threats and evaluating interactions) for each of these elements, and then categorizing and ranking the various risks (characterizing and prioritizing the risks and identifying scenario(s) to meet the ecological goals and objectives). This recommended ecological risk analysis process is portrayed in Figure 16.

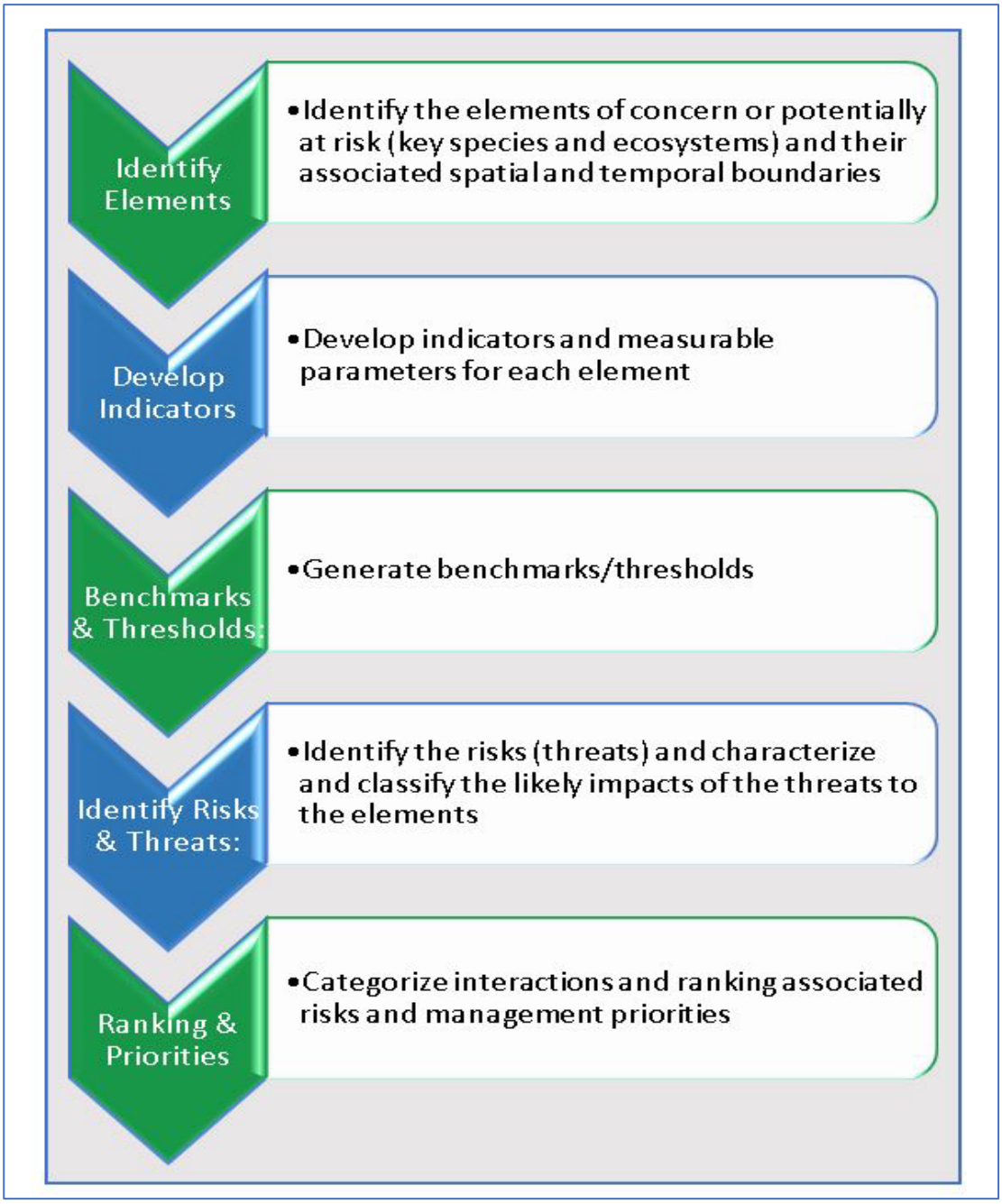
Identify Elements
•Identify the elements of concern or potentially at risk (key species and ecosystems) and their associated spatial and temporal boundaries
Develop Indicators
•Develop indicators and measurable parameters for each element
Benchmarks & Thresholds:
•Generate benchmarks/thresholds
Identify Risks & Threats:
•Identify the risks (threats) and characterize and classify the likely impacts of the threats to the elements
Ranking & Priorities
•Categorize interactions and ranking associated risks and management priorities

Figure 16. Ecological Risk Analysis Process. Adapted from Creed et al., 2019

7. Follow good governance principles: For an EBM framework to be successful within the boreal landscape a number of concurrent initiatives and approaches to resource management and planning are recommended related to governance. These include transdisciplinary coordinated land use planning, revising and integrating legislation, reviewing resource subsidies, potentially instilling interim measures, and developing a management lever approach to land use in the region.
    a) Coordinated planning: It is imperative to create and follow a transdisciplinary (multi-sector) EBM planning process and adaptive framework for conserving biodiversity within northeast BC that addresses and conserves biodiversity at both coarse and fine scales and build from existing plans and ongoing initiatives both provincially and within northeast BC. Integrated legislation and a coordinated land use planning approach is required so that any new resource development (e.g., oil or gas exploration and infrastructure development or timber harvest planning and permitting), would be jointly planned and coordinated to minimize disturbance and biodiversity impacts. This includes implementing a coordinated road planning and integrated access management planning approach (especially for forestry and oil and gas development), particularly where roads may have multiple uses and users. Although, achieving a shift in governance like this is a tall order, the province committed in 2020 to completing a comprehensive review of land

designations under the Land Act, Wildlife Act, the Oil and Gas Activities Act (OGAA), and FRPA (Province of British Columbia, 2020a, p. 13). This review is intended to review gaps and improve cross-sector effectiveness for wildlife habitat conservation into the future considering habitat modifications and climate change (Province of British Columbia, 2020a, p. 13).

b) Legislative review: Pull together a broad team of knowledgeable people to develop overarching integrated and meaningful policy and tenure reforms. This includes reviewing and incorporating existing provincial and regional biodiversity related plans, guides, and assessments. For example, review the currently approved FSJ SFMP (Fort St. John Pilot Project, 2018), existing cumulative effects policy, provincial old growth policy updates and wildlife habitat orders (e.g., boreal caribou), regional FRPA evaluation and monitoring programs, environmental legislation under the OGAA, and the most recent 2018 FSJ TSA annual allowable cut determination (FLNRORD, 2018). This evaluation should also include a review of the effectiveness of the existing plans and identify overlap and gaps in biodiversity protection in the region. This should also include reviewing existing sector-based resource subsidies that impact land and biodiversity conservation.

c) Interim measures and management levers: While the EBM process is being developed, and as many of the interview participants suggested, it may be important to adopt jointly determined interim measures and develop regional-

> specific management levers. With respect to management levers, as interview Participant 1 suggested, implementing a jointly developed management lever approach can help with land use and planning in the boreal by identifying no-go or off-limit areas, deferral or other interim management areas, or areas and priorities for reclamation.

Overall, these aspirational EBM goals and key principles and framework objectives form the valuable strategic level guidance to direct an EBM framework for boreal BC. However, a strategic plan is one thing, and is only one part of the framework. With this in mind, the following also provides several important operational elements for provincial government, Nation government, and regional planning tables to consider when looking to implement an EBM framework in boreal BC.

Recommended EBM Implementation Elements

For an EBM framework to be effective it must bridge the theoretical concepts, goals, and principles with boreal-specific EBM implementation criteria and elements that could be used to drive spatially explicit planning and land management decisions. Figure 17 presents several important EBM implementation elements recommended for boreal BC. Each of these individual elements are presented below.

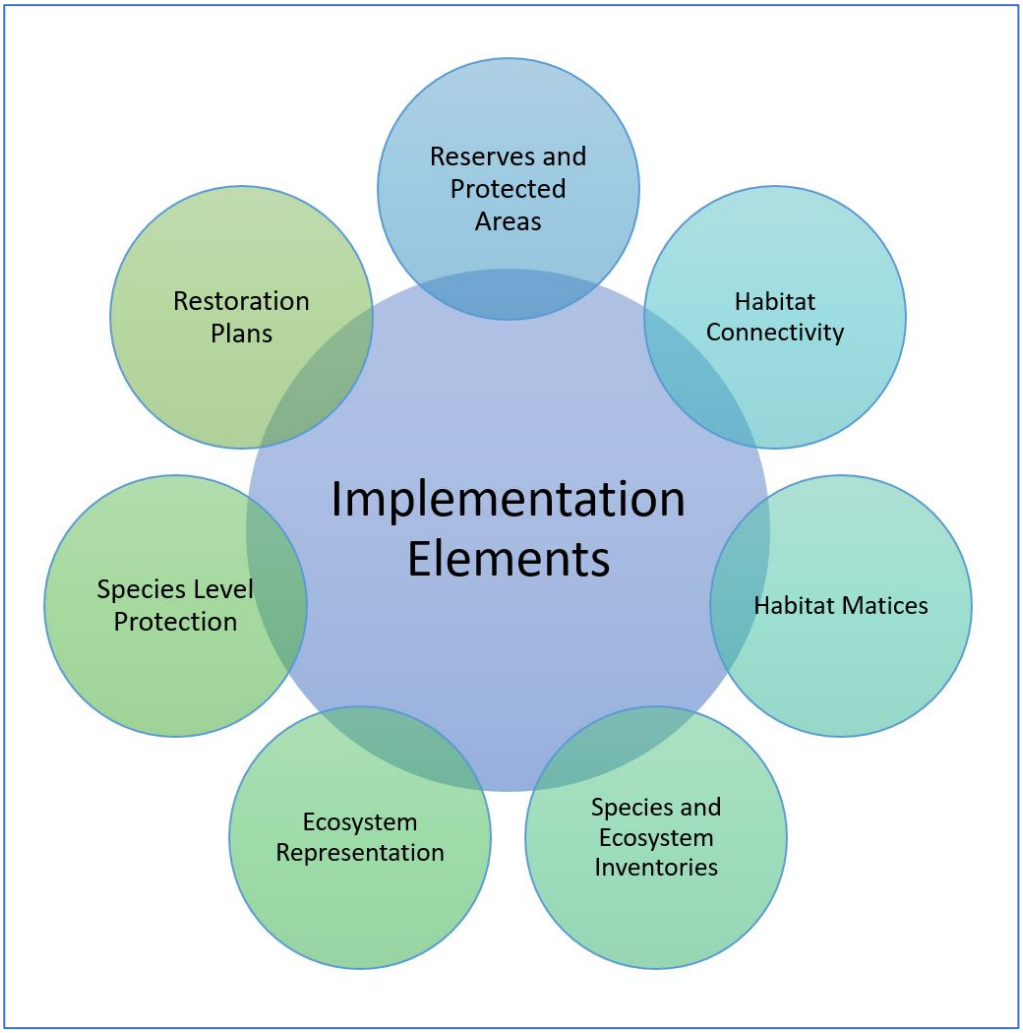

Figure 17. Recommended EBM Implementation Elements

Reserves and Protected Areas. At coarse scale (landscape level), boreal forest management should consider a combination of permanent reserves that conserve specific local, regional, provincial, national, First Nation, or global elements of cultural and ecological importance (e.g., areas culturally important to Indigenous peoples, at-risk species or sensitive ecosystems). Multiple interview participants stated the importance of protecting large portions of what remains of intact landscape and increasing the representation of the boreal within the

province's protected areas. An overall strategy for reserves requires an evaluation of the original reasons behind the creation of existing parks in the region, while assessing the environmental services that the current parks and protected areas provide, as well as a review of current/static park boundaries. Although some protected areas within the study area were established for the conservation and protection of certain species, were they created with ecosystem management principles in mind? Do they currently help to conserve or protect cultural diversity on the landscape? Do these permanent reserves conserve both large keystone species and also small but important species and ecosystems across the boreal landscape? For example, do some or any of the existing reserves protect boreal caribou core habitat? Furthermore, the size of the protected area or reserve is fundamentally important. The Boreal Ecosystems Analysis for Conservation Networks (BEACONS) Project states that protected areas are best when they are at least larger than the minimum fire size in the region (BEACONS, 2017, p. 2). It is also important to consider special management zones around existing protected areas so that industrial development does not jeopardize the intent or the effectiveness of the protected area.

In 2004, the CIT recommended an approach for reserve selection for the Central and North Coasts and Haida Gwaii LRMP applicable to boreal BC. This approach includes: a gap analysis for representation, reserve selection algorithm development, and the incorporation of the protection of special elements (CIT, 2004, p. 52). Additionally, a reserve strategy for boreal BC should also consider the potential long-term impacts of climate change. More recently, MacKinnon et al. (2015) reviewed area-based conservation strategies considering Canada's

Aichi Biodiversity Target No. 11. Through this process they recommended a protected area screening approach. They contend that effective area-based conservation measures should:

- have the expressed objective to conserve nature
- be long term
- generate effective conservation outcomes, and
- be managed by governance regimes to ensure effective management (MacKinnon et al., 2015, p. 3569).

Habitat Connectivity (corridors and conservation area networks). In addition to protected areas a boreal EBM framework should consider a system of dynamic reserves over time that provides core habitat protection, prevents breeding populations from becoming isolated, facilitates elevational movements of species, and geographical shifts related to climate change responses (Cushman & McGarigal, 2019; Hilty et al., 2019). A boreal-based EBM framework should develop conservation area networks that emulate regional landscape dynamics and natural disturbance regimes as much as possible.

- Integrate existing permanent parks and protected areas with additional conservation management areas that incorporate the known location of rare species, sensitive ecosystems, WHAs and designated GAR zones, and other areas normally subject to timber harvesting and oil and gas constraints (i.e., wetlands, riparian areas, and areas of unstable terrain).

- Examine methods to rotate these non-permanent (flexible) reserves across the landscape following a design similar to regional ecological patterns based on regional species and ecosystem diversity requirements and NRV principles.
- Conserve large enough contiguous areas of natural habitat to ensure ecosystem services function and resilience (i.e., provide sizable areas of habitat for wide-ranging mammals that also are resilient to disturbances and long-term structural changes).
- Investigate the establishment of a "Corridor Success Index (as described in Gregory & Beier, 2014)" (Belote et al., 2020, p. 123, Fig.1).

Habitat Matrix. In addition to a system of reserves, as one pioneer landscape ecologist Franklin (1993) noted, the entire landscape 'matrix' should be managed and provide both buffers and connections to large parks and protected areas. Franklin (1993) recommends that small organisms, not just large charismatic megafauna need to be protected across the landscape, and not just within isolated large, protected areas. To protect biodiversity at all levels, the lesser known and/or poorly understood habitats and ecological subsystems (such as microbiota and microbiomes) need to be protected at smaller scales and across all communities. This includes the less or under-studied tree canopies, forest floors, and complex soil and detritus communities (Franklin, 1993, p. 202-204). Although, as noted above, setting targets for certain umbrella species and related habitat may help to conserve a wide range of species, including those that are difficult to detect on their own. Overall, however, as Foley et al. (2010) state from their research, the important thing to do is to establish a spatially explicit management plan across the entire landscape to maintain a wide range and diversity of species and habitats (Foley et al., 2010, p. 8).

Species Inventories and Ecosystem Mapping. An EBM framework should provide an ecosystem-based approach for both the assessment of cumulative effects at the landscape level and the long-term monitoring of environmental and socio-cultural values. The framework should first identify and map a wide range of habitats and vegetation communities, assess natural disturbances and patterns within the planning area, and evaluate anthropogenic development activities and proposals (both independently and jointly). The landscape mapping should:

- Identify, classify, and map ecosystems across the entire landbase, not solely within the crown forest land base (CFLB) or timber harvesting land base (THLB).
- Review (and potentially revise) special elements (i.e., sensitive or at-risk communities), and their location(s) within the landscape. These include identified species and sensitive ecological communities or at-risk populations, critical habitats, and noted special places.
- Identify what combination of ecosystems (or ecosystem groups) and vegetation succession (structural stage) should be mapped, and at what scale. This requires assessing the correct scale for each ecosystem component (as they likely differ) and evaluate elements important for biodiversity conservation at an appropriate ecological and regulatory scale (DFO, 2011, p. 2).
- Follow the most current provincial standards, and as Levin et al. (2009) state, map at the level which you can measure, recognize, and explain drivers of change (threats) to ecosystems (Levin et al., 2009, p. 24).
- Develop an integrated living database (collating and tracking biodiversity information between E-Flora BC and E-Fauna BC (Klinkenberg, 2020), the BC CDC, and the

Environmental Information Resources System for Biodiversity (Province of British Columbia, n.d.).

Once mapped and described, it is important to then stratify the landscape based on natural and existing conditions, then jointly develop measurable goals and associated targets with a long-term vision of ecosystem conditions across the region. This process should manage ecosystem groups following ecological rather than administrative boundaries, potentially incorporating both watershed and landscape units, much like what was potentially initially envisioned during the initial stages of the 1997 FSJ LRMP.

Ecosystem Representation. The EBM framework should produce a spatial 'ecosystem representation' (and aspatial) dynamic dataset (as well as an associated aspatial information) that is transparent, readily useable, and updatable. This tool should be constructed to be used at various temporal and spatial scales for the reporting an 'index of ecological integrity' based on the composition, structure, and function of ecosystems within each landscape planning sub-unit in the region. The ecological integrity index allows the continuous evaluation of resources, land use elements, and ecological status over time in order to achieve both specific location objectives as well as strategic land use and cultural goals while minimizing program and business costs.

Species Level Management. At the species (often referred to as the fine-filter) level boreal-based EBM should include the protection, conservation, and maintenance of genetic and species diversity, including species richness/abundance, composition, and distribution (i.e., viability of plant species of interest, species-level diversity at both the local and landscape level). For example, developing plans for the protection for identified plant and animal species at risk,

including threatened and endangered BC CDC provincially blue and red-listed species, special traditional plant areas, and/or critical wildlife habitat (such as core calving areas for woodland caribou). Also, to prioritize key species for conservation Holt and Hatfield (2007) recommend evaluating the level of function interaction and probability of significant population change. As Holt and Hatfield explain, the criteria for a special element should consider:

- critical habitat
- unique ecosystem of element of biodiversity
- global or international recognition
- vulnerability, and
- those ecosystems not included elsewhere in the plan [but deemed important] (Holt and Hatfield, 2007, p. 5-8).

Restoration Plans. Multiple interview participants stated the critical importance of restoration within northeast BC, advising that ecosystem restoration activities be incorporated at all levels of land management (strategic, tactical, and site-level). This includes reclaiming old roads and continuing to conduct research and programs to reclaim and encourage natural plant and tree growth along linear corridors, wherever practical. The BC Oil and Gas Research and Innovation Society (BC OGRIS) is currently supporting a wide range of restoration projects in northeast BC in partnership with many Treaty 8 First Nations (BC OGRIS, 2021, November).

A boreal EBM approach must include a region-wide reclamation plan where active restoration activities are based on ecological priorities, but also are determined by a combination

of least cost and best overall ecological return on investment. Additionally, multiple respondents also suggested that industrial permitting should include a bond for reclamation and restoration.

In summary, based on my research, I believe these implementation elements capture some of the most important and impactful aspects to consider when implementing a boreal-based EBM framework for northeast BC.

Recommended Monitoring and Adaptive Management

As shown by the overall recommended EBM framework, a boreal EBM approach should also incorporate program monitoring and evaluations and integrate adaptive management through an ongoing feedback mechanism. All parts of the process should be included in the monitoring and adaptive management process, including goals, objectives, and targets (Andison, 2020). For example, the monitoring plan and adaptive management approach should be designed to assess ecosystem status over time (Leech et al., 2009; Pitcher et al., 2009). Such a plan must be integrated and multi-level in order to identify, report, and track species, habitat, and ecosystem health and condition at various spatial and temporal scales (Leech et al., 2009; Pitcher et al., 2009). In addition to site level ecological resilience monitoring, a monitoring framework needs to assess the structure and composition of ecological conditions within the landscape (Cushman & McGarigal, 2019, p. 2-3).

At the landscape level, the monitoring program should be constructed to include regular visual-based evaluations of a variety of ecosystem patterns within the region using current, cost-effective, and best resolution available. For example, using this approach the monitoring plan should assess disturbances and disturbance types, their duration and magnitude (or severity), land

use changes, vegetation classification/type, soil productivity, and vegetation structure, composition, and succession patterns. Other monitoring could involve a (spatial and temporal) series of direct site-level assessments using a combination of formal plots and direct observations to evaluate species and ecosystem occurrence, composition, abundance, distribution, and function.

A landscape and species-level monitoring system must consider both scientific data and Indigenous knowledge and the monitoring program should follow a rigourous site selection process. The monitoring program must cover a range of species and ecosystems, follow acceptable standards (what is measured and how it is measured), and use indicators that have a consistent and reliable quantitative response to change (CIT, 2004, p. 58-59; Pavlikakis & Tsihrintzis, 2003, p. 1). A key aspect of the monitoring plan is to link to existing efforts to manage and monitor activities under the legislation like the OGAA and FRPA (Old Growth Review Panel, 2020, p. 58). In addition, as stated above with respect to ecosystem identification and mapping, scale is important and must be carefully chosen to be able to describe the drivers of ecosystem change objectively and accurately (Levin et al., 2009, p. 24-26).

Conclusion

In conclusion, from a process perspective, an EBM framework for boreal BC needs to be collaboratively developed by the people and communities in the region and based on consensus that incorporates a range of values and mutually beneficial outcomes and shared beliefs, understanding, and vision of future desired condition(s). An EBM framework implemented for the region must be an open and transparent process that is comprehensive and defendable while

incorporating an adaptive management process into the overall approach. My research shows that an EBM framework can only be successful if it follows several fundamental procedural ideologies, as shown in Figure 18.

Figure 18. Fundamental Procedural Ideologies for Successful EBM Implementation

With respect to technical biodiversity conservation, an EBM framework built for boreal BC needs to be practical and scalable while delivering accurate and continuous ecosystem, environmental assessment, and monitoring information. This includes knowing what is present and where things are within the landscape, as well as understanding the associated threats and risks to both individual species and habitats. A comprehensive framework must also build on existing plans and assimilate tactical land-use planning, incorporate restoration priorities and action plans, and integrate a rigourous feedback system for long-term biodiversity monitoring to ensure conservation.

Further, to protect and conserve biodiversity an EBM framework for boreal BC must be rooted in ecological principles but at the same time must also include and integrate the human dimension (i.e., sociocultural beliefs and values, and socioeconomic values and needs). Focusing on ecological issues alone is entirely insufficient without considering social perspectives, asserted Newing (2011). Giliani et al. (2018) added, "most of the drivers of environmental change are social and many of the biggest challenges facing conservationists are social, economic, and political. Our current understanding of social issues in conservation is fragmented and limited, and this is also true of EBM" (Gilani et al., 2018, p.1). Taking this dual approach will not only help to conserve biodiversity but will also help protect cultural diversity; and therefore, increase confidence in ongoing management strategies and land use planning decisions. In summary, a comprehensive EBM framework for boreal BC is about assimilating different perspectives, preserving and integrating social and ecological systems, all while following an agreed upon local process rooted in a structure with foundational goals, clear principles and practicable objectives.

Mang and Haggard (2016) summarize the need for and importance of considering new approaches to land use planning and resource decision making today, such as an EBM framework. They state that "building a world different from the one we've built so far calls for a different approach. This is why designing the… process is as important a responsibility as designing the project itself" (Mang & Haggard, 2016, p.110).

This research builds upon the work conducted by many scholars and leading practitioners in terrestrial ecology and ecosystem management over the years. It is my hope that the results of

my investigation and the recommended framework add to this knowledge and provide governments, communities, land managers, and planning groups with a valuable guide and practical tools when looking to commence their own EBM journey in boreal BC.

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Appendix A Research Participation Request and Guide

Purpose of this Document

The purpose of this document is to inform you about my research project, explain the research principles I will follow during your participation, and seek your free and informed consent to participant in an interview in relation to the research project.

Research Title: Can an Ecosystem Management Approach to Land Management Preserve Biodiversity?

Researcher/Principal Investigator: Terry Conville, Master of Arts in Environment and Management Graduate Student, School of Environment and Sustainability, Royal Roads University, Victoria, BC

Thesis Supervisor: Dr. Leslie A. King PhD MCIP

Research Question

The main research question is: How can an EBM approach and structure potentially contribute to conserving biodiversity in boreal BC?

Research Sub-Questions

My research sub-questions are:

- Can an ecosystem management approach provide an effective framework for the protection of biodiversity in Boreal British Columbia?
- What are the principles, criteria, and key characteristics of EBM applicable to a boreal-based EBM? What are the barriers and challenges to implementing a potential EBM framework in the region? and

- What may be a suitable EBM framework and recommended components for boreal BC that could potentially help improve land use planning and guide resource management decision-making in the region?

Significance of the Research

An EBM framework designed to conserve biodiversity could potentially support existing government to government land use planning in northeast BC. Such a framework can be used to guide provincial government resource management decisions at various spatial and temporal scales, while supporting cumulative environmental assessment, long-term resource monitoring, and related land stewardship programs.

Participation Overview

As stated in the letter of invitation, I would like to interview you and ask you some questions about your views and understanding related to ecosystem management approaches in the boreal landscape as it relates to biodiversity conservation. I am asking you to provide your consent using this form. Upon receiving your consent by signing, and returning this form, I will then contact you via email to set up a mutually agreeable time to conduct the interview. I will also email you the interview questions ahead of time for your preliminary review. Please let me know if you require additional clarification to any question or if you just are not comfortable answering a specific question (or questions). The interview will be carried out by way of a phone call or virtual (zoom or google meets) session and should take no more than an hour of your time. If using the meeting software, I will send you an individual meeting invitation with a passcode.

Please review the below important research principles which I will follow throughout the entire process and fill out the consent information at the end of this document should you wish to participate.

Research Principles

Part I – Use of Information

I want to be very clear that this interview request and any and all information potentially gathered through this process (information gathered directly or indirectly) will only be used in the research project, and will **NOT** be shared or communicated, in whole or in part, with any other party. All the principles outlined in this document will be strictly followed. Nothing obtained or gained through discussions or interviews with any person in relation to the thesis work will be used outside of my research, or communicated, either in whole or in part, in any work I may undertake technically with the province.

Part II - The Interview

- Your name, affiliation, views, opinions, and thoughts will be held in the strict confidence, and your anonymity will be preserved, and your contact information and personal data will be protected at all times.
- By participating, I do not anticipate any personal risks to you, your community, or organization. However, I also understand that by consenting to participate you have not waived any rights to legal recourse in the event of research-related harm.
- The information gathered will be strictly used for the independent research project. None of the information sought, or obtained, during the interview, or follow-up communication will be used for any other purpose or used commercially.

- You are free to withdraw from the interview process at any time. You are also free request that any or all of your responses be withdrawn at any time up until all the data is consolidated into an anonymous dataset to be used in my research.
- No compensation or reimbursement of any kind will be paid to you for your participation.

Part III – Virtual Meeting Risk and Media

- I will only take hardcopy notes of your responses to the questions posed. I will not be taking an audio or video recording of the conversation.
- I am also obligated to inform you that, if using virtual meeting software (such as Zoom), that there is a small risk that the interview session may be recorded and stored in the USA. Data stored on US servers may be subject to examination by the US government under the USA Patriot Act.
- Any hardcopy notes that I plan to take of our interview will be destroyed immediately after all the interview data is consolidated into a single anonymous summary document.

Part IV - Data Analysis and Research Dissemination

- Only the Principal Researcher will have access to raw data or identifying information during the research study. The hardcopy notes will be scanned and stored on my password protected personal computer. The files will be identified using only a code known to me rather than documented and stored using your name, interview date, or any other identifiable information. All data will be kept in a secure confidential location and will not be disseminated to any other party.

- Individual participant information will be tracked confidentially prior to consolidating the data into an anonymous data set. This summarized data set will be compared to my literature data analysis findings and be used to finalize EBM framework recommendations. Until data consolidation individual participant data can be removed at their request; however, once I consolidate all the responses together into an anonymous data set then individual contributions can no longer be withdrawn. The summarized research findings will be collated into the final report which will form the ENVR690 Research Project submission to Royal Roads University (RRU), as required by the RRU Master of Arts in Environmental and Management program. If requested, the final research paper will be provided to you. No private or personal opinions or data will be released to any party at any time.
- The final research report will not disclose any interview participant information. Confidentiality of all parties will be honoured throughout the research process and reporting. For example, although your valuable ideas and opinions will be summarized/consolidated in the final report, no personal information such as your name or personally identifiable information will be used to attribute any comments to you (either directly or indirectly).
- All records and documentation will be securely archived on a stand-alone independent hard drive, and then destroyed within 30 days of the completion of the research project.

Part V - RRU Approval and Contact Information

This research project has received approval from the Royal Roads University Research Ethics Board. Any questions you may have can be addressed to ethicalreview@royalroads.ca.

Interview Questions

The following is a list of questions I would like to ask you during our interview session. I look forward to engaging with you and seeking your input to any, or all of, these questions. I am interested in your point of view. I also want you to ensure you this is not a test, and there are no right answer(s). Simply, I hope to seek your views about biodiversity, ecosystems, special places, land use, and ecosystem-based management approaches related to boreal British Columbia.

1. What does biodiversity mean to you?

2. What does biodiversity conservation look like to you?

3. What do you think are the most pressing biodiversity conservation needs in boreal British Columbia?

4. What is an ecosystem in your own words/terms?

5. What species, ecosystems, or places, are most important to protect in the region, or in certain parts of the landscape, from your perspective?

6. Why do you think they are important? To whom are they important?

7. What land use activities most affect biodiversity in the region, why?

8. What is/are the most pressing gap(s) in current land and resource planning in the area?

9. What may be the best possible way to protect biodiversity at a landscape level in BC's boreal forests, while respecting sociocultural and socioeconomic values?

10. What key things should be considered that may best integrate First Nations sociocultural beliefs and values with biodiversity protection?

11. What does ecosystem-based management mean to you?

12. Do you think an ecosystem-based framework could help land and resource planning? If yes, see sub questions (a-d immediately below), otherwise please continue to question 13.

    a. What would you say are the first steps?

    b. What would you think are the key components to consider?

    c. What scale and time period should be covered? Why?

    d. What do you think are the key benefits of an EBM approach?

13. What are the barriers and key challenges to implementing an ecological management framework in the region? How might you overcome these?
14. What First Nation sociocultural values could potentially be protected by implementing an ecological framework?

15. How might you begin to implement an ecosystem-based approach to land management without complete information?

16. If you had limited time and resources, what steps or actions would you prioritize first to protect biodiversity in the region? What would be the next priority?

Closure

Although these questions are provided in a structured way to compare responses from a research point of view, I also encourage you to feel free to inform me ahead of time if there are any additional related topics or thoughts you would like to add to our interview. Further, with regards to any of the questions, it is also absolutely fine to simply respond with "I don't know", "am not sure" or, "I have no opinion". As mentioned, if you prefer to respond in writing (i.e., via email) that is fine, but please just let know. In any case, and in whatever form, I value your thoughts and opinion(s), and am truly grateful for any time and information you are willing to provide for this research project.

Sincerely,

Terry *(signed)*

Terry Conville
RRU MEM 2018 Masters Candidate

Please find the interview consent form on the next (last) page.

Interview Consent

If you are interested, and able to, participate in an interview then please fill in your name and date below and send this document to Terry Conville via email. I will then also sign and return the fully signed copy back to you.

I provide my free and informed consent to be interviewed by Terry Conville for the above identified research project, and for the information to be used exclusively for the identified research project, following the principles outlined in this document.

Name: [sign] _____ Date: _____

[Signature]

_____

[Print name]

_____ Date: _____

Terry Conville