Greater Than the Sum of Its Parts: Toward Integrated Natural Resource Management in Canada

The Expert Panel on the State of Knowledge and Practice of Integrated Approaches to Natural Resource Management in Canada

CCA | CAC

ASSESSING **EVIDENCE**
INFORMING **DECISIONS**

GREATER THAN THE SUM OF ITS PARTS: TOWARD INTEGRATED NATURAL RESOURCE MANAGEMENT IN CANADA

The Expert Panel on the State of Knowledge and Practice of Integrated Approaches to Natural Resource Management in Canada

THE COUNCIL OF CANADIAN ACADEMIES
180 Elgin Street, Suite 1401, Ottawa, ON, Canada K2P 2K3

Notice: The project that is the subject of this report was undertaken with the approval of the Board of Directors of the Council of Canadian Academies (CCA). Board members are drawn from the Royal Society of Canada (RSC), the Canadian Academy of Engineering (CAE), and the Canadian Academy of Health Sciences (CAHS), as well as from the general public. The members of the expert panel responsible for the report were selected by the CCA for their special competencies and with regard for appropriate balance.

This report was prepared for the Government of Canada in response to a request from Natural Resources Canada, supported by Agriculture and Agri-Food Canada, and Environment and Climate Change Canada. Any opinions, findings, or conclusions expressed in this publication are those of the authors, the Expert Panel on the State of Knowledge and Practice of Integrated Approaches to Natural Resource Management in Canada, and do not necessarily represent the views of their organizations of affiliation or employment, or the sponsoring organizations, Natural Resources Canada, Agriculture and Agri-Food Canada, and Environment and Climate Change Canada.

Library and Archives Canada

ISBN: 978-1-926522-61-6 (Electronic book) 978-1-926522-60-9 (Paperback)

This report should be cited as:

Council of Canadian Academies, 2019. *Greater Than the Sum of Its Parts: Toward Integrated Natural Resource Management in Canada.* Ottawa (ON): The Expert Panel on the State of Knowledge and Practice of Integrated Approaches to Natural Resource Management in Canada.

Disclaimer: The internet data and information referenced in this report were correct, to the best of the CCA's knowledge, at the time of publication. Due to the dynamic nature of the internet, resources that are free and publicly available may subsequently require a fee or restrict access, and the location of items may change as menus and webpages are reorganized.

Printed in Ottawa, Canada

CCA | CAC

Canada This project was made possible with the support of the Government of Canada

The Council of Canadian Academies

The Council of Canadian Academies (CCA) is an independent, not-for-profit organization that supports independent, science-based, authoritative expert assessments to inform public policy development in Canada. Led by a Board of Directors and advised by a Scientific Advisory Committee, the CCA's work encompasses a broad definition of science, incorporating the natural, social and health sciences as well as engineering and the humanities. CCA assessments are conducted by independent, multidisciplinary panels of experts from across Canada and abroad. Assessments strive to identify emerging issues, gaps in knowledge, Canadian strengths, and international trends and practices. Upon completion, assessments provide government decision-makers, researchers, and stakeholders with high-quality information required to develop informed and innovative public policy.

All CCA assessments undergo a formal report review and are published and made available to the public free of charge. Assessments can be referred to the CCA by foundations, non-governmental organizations, the private sector, or any level of government.

The CCA is also supported by its three founding Academies:

The Royal Society of Canada (RSC)
Founded in 1882, the RSC comprises the Academies of Arts, Humanities and Sciences, as well as Canada's first national system of multidisciplinary recognition for the emerging generation of Canadian intellectual leadership: the College of New Scholars, Artists and Scientists. Its mission is to recognize scholarly, research and artistic excellence, to advise governments and organizations, and to promote a culture of knowledge and innovation in Canada and with other national academies around the world.

The Canadian Academy of Engineering (CAE)
The CAE is the national institution through which Canada's most distinguished and experienced engineers provide strategic advice on matters of critical importance to Canada. The Academy is an independent, self-governing, non-profit organization established in 1987. Fellows are nominated and elected by their peers in recognition of their distinguished achievements and career-long service to the engineering profession. Fellows of the Academy, who number approximately 740, are committed to ensuring that Canada's engineering expertise is applied to the benefit of all Canadians.

The Canadian Academy of Health Sciences (CAHS)

The CAHS recognizes excellence in the health sciences by appointing Fellows based on their outstanding achievements in the academic health sciences in Canada and on their willingness to serve the Canadian public. The Academy provides timely, informed and unbiased assessments of issues affecting the health of Canadians and recommends strategic, actionable solutions. Founded in 2004, CAHS now has 670 Fellows and appoints new Fellows on an annual basis. The organization is managed by a voluntary Board of Directors and a Board Executive.

www.scienceadvice.ca
@scienceadvice

The Expert Panel on the State of Knowledge and Practice of Integrated Approaches to Natural Resource Management in Canada

Under the guidance of its Scientific Advisory Committee, Board of Directors, and founding Academies, the CCA assembled the Expert Panel on the State of Knowledge and Practice of Integrated Approaches to Natural Resource Management in Canada to undertake this project. Each expert was selected for their expertise, experience, and demonstrated leadership in fields relevant to this project.

Cassie J. Doyle (Chair), Former Deputy Minister, Natural Resources Canada; Former Associate Deputy Minister, Environment and Climate Change Canada; Strategic Advisor and former CEO, Canadian International Resources and Development Institute (Vancouver, BC)

Fikret Berkes, FRSC, Distinguished Professor Emeritus, Natural Resources Institute, University of Manitoba (Winnipeg, MB)

Stan Boutin, FRSC, Science Co-Director, Alberta Biodiversity Monitoring Institute; Professor and Alberta Biodiversity Conservation Chair, Biological Sciences, University of Alberta (Edmonton, AB)

Matthew Carlson, Ecologist, ALCES (Ottawa, ON)

Thomas Dietz, Professor, Sociology and Environmental Science and Policy, Michigan State University (East Lansing, MI)

George Greene, Founding Chair, Stratos Inc. (Ottawa, ON)

Bram Noble, Professor, Department of Geography and Planning and School of Environment and Sustainability, University of Saskatchewan (Saskatoon, SK)

Nancy Olewiler, Professor, School of Public Policy, Simon Fraser University (Vancouver, BC)

Rachel Olson, Team Co-Lead, Traditional Knowledge and Use Studies, Firelight Group (Vancouver, BC)

Martin Olszynski, Associate Professor, Faculty of Law, University of Calgary (Calgary, AB)

Kirstie E. M. Simpson, Retired Senior Advisor, Sustainable and Integrated Resource Management, Energy, Mines and Resources, Yukon Government (Whitehorse, YT)

Ione L. Taylor, Executive Director, Earth and Energy Resources Leadership, Department of Geological Sciences and Geological Engineering, Queen's University (Kingston, ON)

Alain Tremblay, Senior Environmental Advisor, Hydro-Québec (Montréal, QC)

Message from the Chair

Natural resources constitute a key element of Canada's identity. The ongoing debates and division regarding how these resources are being developed underscore the importance and timeliness of this report, which explores integrated natural resources management in Canada. In the last few decades, the health of many of Canada's diverse ecosystems has been increasingly threatened and there has been a loss of public confidence in our system of natural resource management. The limitations of project-level management practices are becoming more evident, leading to conflict and delays. Several significant court cases in recent years have challenged the status quo approach to resource management. At the same time, there is real concern over the competitiveness of Canada's resource industries. It is clear that Canada needs to shift the way it plans and manages natural resource development away from siloed project-level processes toward more integrated approaches. The Expert Panel on the State of Knowledge and Practice of Integrated Approaches to Natural Resource Management in Canada hopes this report will support enhanced implementation of INRM in Canada to strengthen the sustainability and legitimacy of our systems of resource management.

The Panel found that while INRM has currency and is practiced to some extent in Canada today, little consensus exists on what this approach actually means and most importantly, how to achieve true integration. To help address this challenge, the Panel developed a definition and a corresponding set of eight critical characteristics of INRM, along with guidance on implementation drawing from both research and practice. The Panel recognizes that context is very important for INRM and thus there is no prescriptive implementation formula; however, INRM does call for a move away from a focus on individual projects toward wider geographic and temporal scales. The report was informed by some excellent models of INRM in Canada, although the Panel observed that the effectiveness of these approaches is often limited by a lack of resources or sustained implementation. The Panel also observed the importance of the legislative context for resource management and found that while current legislation is not a barrier to INRM, there remains room for improvement.

INRM is inherently complex, necessitating strong governance to incorporate a wide range of knowledge sources and ensure the involvement of a diverse group of actors. The complexity is compounded by the role of multiple jurisdictions in natural resource management, incomplete information and uncertainty, and a lack of documentation of lessons learned implementing INRM to date. The Panel grappled with this complexity throughout its assessment and has established a framework designed to capture and combine the many essential elements of INRM.

Considerable effort by the Panel went into highlighting the role of Indigenous and local knowledge in INRM, as well as the importance of Indigenous participation in natural resource management decision-making. The Panel was concerned that while the Government of Canada is making commitments to implement the *United Nations Declaration on the Rights of Indigenous Peoples*, we have not adequately advanced our understanding of how to meaningfully bridge Indigenous rights, knowledge, history, and culture into resource decision-making in Canada. There is real potential for INRM to support reconciliation through shared decision-making, recognition of Indigenous rights, and mechanisms for bridging different ways of knowing. The Panel drew lessons from the experiences of co-management regimes which have been early leaders in implementing INRM in Canada.

I wish to acknowledge Natural Resources Canada, Agriculture and Agri-Food Canada, and Environment and Climate Change Canada for referring this important topic to the Council of Canadian Academies (CCA) for expert review. The Panel benefited from valuable inputs from several practitioners throughout the assessment who are acknowledged in the report. On behalf of all the Panel members, I want to express my deep appreciation to the CCA staff who provided expert support to the Panel throughout the assessment. Finally, I am very grateful to the members of the Panel for their generous contribution of expertise and collaborative engagement throughout this process.

Cassie J. Doyle, Chair
Expert Panel on the State of Knowledge and Practice of Integrated Approaches to Natural Resource Management in Canada

Message from the President and CEO

Canada is recognized the world over for its wealth of natural resources. However, efforts by public and private sector actors to care for, steward, and responsibly manage them have, at times, generated conflict. This is not unexpected at a time when climate change, environmental stress, coupled with economic opportunities, and other societal expectations are at work.

Some of the disputes are about the optimal way to collectively or individually manage these resources; others reflect broader societal, political, economic, and cultural issues. These issues help explain the timeliness of this assessment request from Natural Resources Canada, Agriculture and Agri-Food Canada, and Environment and Climate Change Canada — that the Council of Canadian Academies (CCA) convene an Expert Panel to review the evidence and current natural resource management practices and to consider ways in which an integrated approach to natural resources management could be used. Here, "integrated" refers not only to the attention given to multiple resources (e.g., land, water, and timber), but also to the multiple participants involved in the management process itself. It is for this reason that the title of the report is so apt: integrated natural resources management (INRM) is more than just the application of individual metrics and models; INRM involves individuals, groups, and communities, each with different sources of knowledge, ways of knowing, values, and rights. By definition, it must be "greater than the sum of its parts."

Taking on a topic of such importance for Canada requires leadership and expertise. I offer my sincere thanks to the Expert Panel Chair, Cassie Doyle, and the Panel members who volunteered their time and expertise to produce a comprehensive report that offers meaningful guidance to decision-makers and practitioners in moving forward to implement INRM across Canada. I would also like to thank the CCA Board of Directors, Scientific Advisory Committee, and our three founding Academies — the Royal Society of Canada, Canadian Academy of Engineering, and Canadian Academy of Health Sciences — for their guidance, leadership, and insight throughout the assessment process.

Eric M. Meslin, PhD, FCAHS
President and CEO, Council of Canadian Academies

Acknowledgements

Over the course of its deliberations, the Panel reached out to several individuals and organizations who shared their experiences of the practice of INRM in Canada. The Panel wishes to thank the following people for their participation: Sandra Honour from the Government of Alberta for sharing her experience with the Integrated Resource Management System in Alberta; Brad Stelfox for providing expertise on land use sustainability at the start of this assessment; Diane Wilson (Parks Canada) and Thomas Nesbitt (Avati Associates) for sharing knowledge about the practice of co-management agreements in northern Canada; Jeremy Benson (BC Hydro) for discussing BC Hydro's Water Use Planning; and Derek Thompson (former Deputy Minister of Environment, Land and Parks, Government of British Columbia) for providing his views on shared governance in Haida Gwaii. Rob Smith and Peter Morrison (Midsummer Analytics) provided the Panel with a review of the approaches used to assess the values and costs of INRM.

Project Staff of the Council of Canadian Academies

Assessment Team:	Jérôme Marty, Project Director Rebecca Chapman, Research Associate Hilary Davies, Research Associate Joanne Linnay, Project Coordinator Suzanne Loney, Research Associate Lennart Trouborst, Researcher Weronika Zych, Senior Project Coordinator
With Assistance from:	Tijs Creutzberg, Director of Assessments, CCA Madison Downe, GIS Analysis, CCA
and:	Clare Walker, Editor Jody Cooper, Editorial Consultant François Abraham, Communications Léon Inc., Certified Translator, Translation English-French

Report Review

This report was reviewed in draft form by reviewers selected by the CCA for their diverse perspectives and areas of expertise.

The reviewers assessed the objectivity and quality of the report. Their submissions — which will remain confidential — were considered in full by the Panel, and many of their suggestions were incorporated into the report. They were not asked to endorse the conclusions, nor did they see final report drafts before release. Responsibility for the final content of this report rests entirely with the authoring Expert Panel and the CCA.

The CCA wishes to thank the following individuals for their review of this report:

Wiktor Adamowicz, FRSC, Vice Dean and Professor, University of Alberta (Edmonton, AB)

David Browne, Director of Conservation, Canadian Wildlife Federation (Ottawa, ON)

Elston Dzus, Forest Ecologist, Alberta-Pacific Forest Industries Inc. (Boyle, AB)

Lorne Greig, Independent Environmental Scientist; Emeritus Environmental Scientist, ESSA Technologies Ltd. (Richmond Hill, ON)

Thomas Gunton, Director and Professor, Resource and Environmental Planning Program, Simon Fraser University (Burnaby, BC)

Henry P. Huntington, Owner, Huntington Consulting (Eagle River, AK)

Merrell-Ann S. Phare, Executive Director, Centre for Indigenous Environmental Resources (Winnipeg, MB)

Jamie Snook, Executive Director, Torngat Wildlife Plants and Fisheries Secretariat (Happy Valley-Goose Bay, NL)

Brad Stelfox, Founder and Landscape Ecologist, ALCES Landscape and Land-Use Ltd. (Calgary, AB)

The report review procedure was monitored on behalf of the CCA's Board of Directors and Scientific Advisory Committee by **Barbara Neis, C.M., FRSC,** John Paton Lewis Distinguished University Professor, Memorial University of Newfoundland. The role of the peer review monitor is to ensure that the Panel gives full and fair consideration to the submissions of the report reviewers. The Board of the CCA authorizes public release of an expert panel report only after the peer review monitor confirms that the CCA's report review requirements have been satisfied. The CCA thanks Dr. Neis for her diligent contribution as peer review monitor.

Executive Summary

Canada's culture and economy have always been linked with its natural resources. These resources are diverse and include wildlife and other components of biodiversity, water, forests, minerals, energy, and arable land for agriculture, among others. While demands on, and concerns for, Canada's natural resources reveal competing interests and values, they can also foster common goals and opportunities for new approaches to resource management.

In Canada, natural resource management decisions have historically been made on a project-by-project or sector-by-sector basis, and usually by a single government entity. This approach has come up significantly short, lacking a broad, "bird's-eye" perspective on project effects and often with a limited diversity of knowledge and viewpoints used to support informed decision-making. Integrated natural resource management (INRM) holds promise because it takes into account complexity, multiple scales, and competing interests, and brings these together to make informed decisions.

The Charge to the Panel

Natural Resources Canada (the Sponsor) asked the Council of Canadian Academies (CCA) to conduct an evidence-based assessment to answer the following question:

> *What is the state of knowledge and practice of integrated approaches to natural resource management in Canada?*

To address the charge, the CCA assembled a multidisciplinary panel of 13 experts (the Panel) from across Canada and abroad. The Panel included both academic experts and practitioners of integrated approaches to natural resource management. The Panel and the Sponsor underscored the importance of recognizing the rights and values of Indigenous Peoples for this assessment, particularly the role of Indigenous and local knowledge (ILK) and the involvement of Indigenous Peoples in natural resource management decision-making.

Current Context and the Integration Imperative

Integration is needed to address current realities, and overcome the limitations of conventional approaches which focus on managing individual activities and resources.

Natural resource managers are confronted by challenges that include the intensification of environmental and social pressures, increasingly global competition, regulatory uncertainty, the impacts of climate change, and public

distrust. In the Canadian context, resource management is also undergoing changes in response to growing jurisdictional complexity, increased recognition of the rights of Indigenous Peoples, and commitment to reconciliation. As such, it is often difficult to make decisions about natural resources in Canada that are widely accepted.

INRM can leverage promising practices to address these challenges. Some INRM features that are particularly well suited for this task include extensive engagement processes, regional orientation, evaluation of trade-offs, and inclusion of all relevant jurisdictions. In the Panel's view, INRM is needed because conventional approaches to managing individual activities and resources are no longer sufficient.

A Framework for INRM

As the Panel undertook the charge, members quickly observed that INRM, as a concept, is subject to many interpretations and, as such, is difficult to define. To guide deliberations, the Panel defined INRM as:

> a way of managing human activities and natural resources that weighs and integrates multiple land uses, rights, needs, ways of knowing, and values across jurisdictional, temporal, and spatial scales to achieve environmental, economic, social, and cultural objectives.

The Panel's definition assumes a holistic account of *natural resources* that reflects the full spectrum of human activities. It includes a range of resources, services, and uses, including oil, gas, minerals, agricultural lands, forest, water, soil, wildlife and fish and, more broadly, ecosystems and the biodiversity they contain. Importantly, the definition also includes the other ecosystem services natural resources provide, such as water supply and regulation, erosion control, carbon sequestration, recreation, and cultural uses.

The Panel also identified eight defining characteristics of INRM. *An integrated approach to natural resource management is one that:*

- *pursues clear and comprehensive goals and objectives;*
- *plans, manages, and monitors at appropriate geographic scales and timeframes;*
- *engages all relevant jurisdictions;*
- *involves rights holders and interested and affected parties;*
- *weighs multiple values, uses, and functions;*
- *assesses alternatives and trade-offs;*
- *includes multiple ways of knowing; and*
- *addresses uncertainty.*

Every natural resource management system is unique so some of these characteristics may be more relevant than others. However, robust efforts to implement INRM are likely to encompass all eight of these characteristics to some degree.

INRM calls for higher-order decision-making that embraces land-use planning and strategic assessment at regional scales, enabling better and more efficient decision-making at project-specific stages.

In INRM, decision-makers emphasize scale-appropriate planning and evaluation in order to assess the cumulative effects of resource use; to weigh and consider the multiple values, uses, and functions of an ecosystem; and to identify trade-offs in resource management. Current project-based approval processes often exclude small projects, impose artificially narrow temporal and spatial scales, and ignore cumulative effects. While many existing regimes emphasize project-specific environmental assessments and permitting processes, leading practices for implementing INRM are characterized by a greater focus on land-use plans, and regional and strategic environmental assessments early in the process. The effectiveness of project-level approvals would be enhanced if they were implemented within the context of a regional plan or more strategically focused regional environmental assessment initiatives. Likewise, effective INRM includes strong links among regional-level plans and targets and project-level decisions.

INRM includes integration across the continuum of decision-making, as summarized in Figure 1. From the outset INRM is underpinned by legislation, treaties, and policies (which are themselves a function of societal rights, values, and norms). These then lay the foundation for regional planning processes that are inclusive, comprehensive, and informed by multiple ways of knowing. Land-use plans in turn inform the development of regional and strategic environmental assessments that consider cumulative effects and then inform and simplify project-level environmental assessments. Licensing and permitting decisions flow from these assessments. Monitoring, evaluation, and learning by doing are relevant across the continuum.

The Panel notes that INRM is not an all-or-nothing proposition. Incremental progress can be made to implement resource management approaches that increasingly satisfy the eight defining characteristics of INRM. In the Panel's view, rather than calling for an entirely new approach to decision-making, INRM puts a greater focus on regional planning processes early in the continuum.

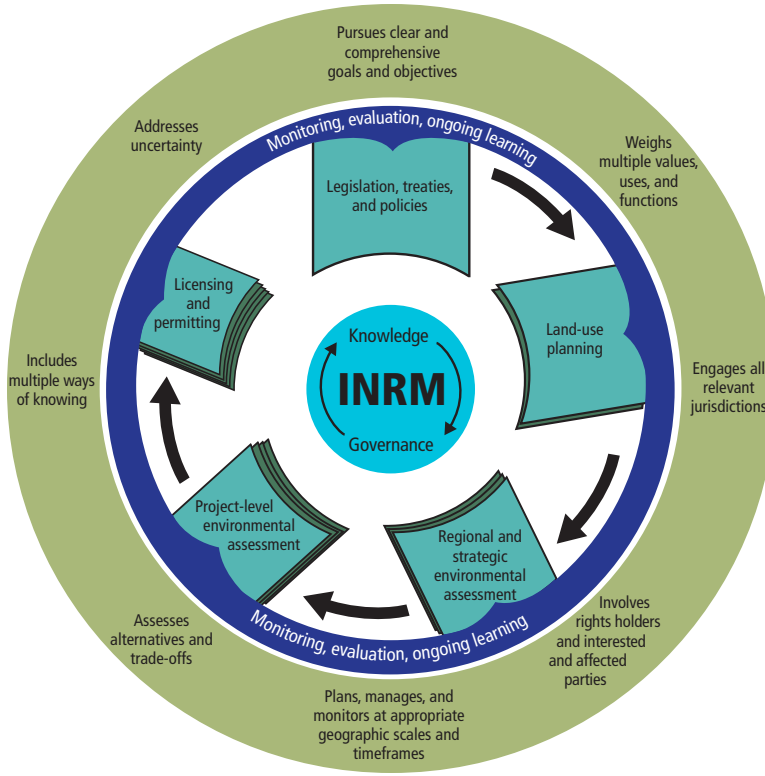


Figure 1

Continuum of Integrated Natural Resource Management Decision-Making

INRM applies across the continuum of natural resource management decision-making. It originates in legislation, treaties, and policies that lay the foundation for regional land-use planning. This in turn informs regional and strategic environmental assessments and subsequent project-level environmental assessments, which can then lead to licensing and permitting decisions. Process and outcome monitoring and evaluation can apply across the continuum to support ongoing learning. The eight characteristics of INRM are relevant throughout.

Knowledge for INRM

We know enough to act.

The foundation of knowledge and supporting tools related to resource management is sufficiently developed to enable INRM. Knowledge plays a critical role in INRM decision-making, improving the quality of decisions, building confidence, and understanding the values and limitations of information used to make a decision. There is growing recognition that the dynamics of

complex systems require an inclusive approach to knowledge-gathering so as to increase the range of knowledge brought to bear on a question. Multiple temporal and geographical scales are also important features of INRM, as is the need to recognize and account for multifunctional landscapes. The collection of new knowledge through monitoring is also important in INRM — it allows for the assessment of the performance of resource management strategies. Current monitoring efforts tend to be fragmented; to inform INRM, greater emphasis is needed on comprehensive monitoring of ecosystems across large regions and long timeframes.

Effective INRM depends not just on a wide range of knowledge but also on how that knowledge is applied. Reliance on emerging data-sharing tools and networks, as well as new strategies for applying this knowledge to decision-making, are contributing to our ability to practice INRM. Examples of tools for data sharing include geographic information system (GIS) and modelling, while tools for applying knowledge to decision-making include threshold analysis, trade-off analysis, and cumulative effects assessment. Knowledge diversity and application tools both support inclusive, comprehensive, and adaptive resource management and appropriately communicate and manage uncertainties.

While the theory behind INRM is well described in the literature, there is less empirical evidence on successes and challenges where INRM has been implemented. Initiatives across Canada, including the British Columbia Cumulative Effects Framework, Alberta's *Land Stewardship Act*, and the *Mackenzie Valley Resource Management Act*, show the growing inclusion and importance of practitioner insights that supplement theoretical and academic knowledge. While there is a wealth of experience in implementing management approaches in Canada that include several characteristics of INRM, in general undertakings have not been comprehensive and are often ultimately scaled back. Documentation of ongoing efforts by the provincial governments in British Columbia and Alberta to manage cumulative effects will help demonstrate learnings that can be applied to future initiatives.

Knowledge-sharing networks, a tolerance for decision-making under uncertainty, and better coordination of research and monitoring efforts can foster interdisciplinary knowledge creation and knowledge exchange at scales relevant to INRM. Actors can start to make better-informed decisions with existing knowledge while continuing to strengthen the creation and systematic distribution of information to fill knowledge gaps.

INRM is built on a foundation of knowledge that effectively bridges Western science and Indigenous and local knowledge.

Knowledge is the foundation for making informed decisions and implementing adaptation measures for changing environments and conditions. The complexity, uncertainty, and multiscaled nature of natural resources calls for a commensurate sophistication in the knowledge used to inform decision-making. INRM takes advantage of all relevant knowledge and ways of knowing. In Canada, both Western science and ILK are particularly important for INRM.

The bridging of knowledge systems can increase the effectiveness of INRM because consideration of multiple forms of knowledge produces better decisions. The Panel suggests that co-design of a bridging process will best incorporate ILK. The goal of bridging knowledge is not to reduce each source of data into one unified collection of information, but rather to consider and weigh each piece of knowledge in the context of its source. Early examples of success in bridging Western science with ILK offer a model for incorporating different ways of knowing. However, considerable work remains to ensure that practitioners are comfortable in co-designing processes for ensuring knowledge integrity. Challenges include a lack of well-established methodologies for bridging knowledge, the fact that knowledge is often based in different scales, and significant inequities in power among knowledge holders at times, with deference given to Western science. While these challenges may serve to deter resource managers from attempting to incorporate ILK in decision-making, making good-faith efforts to bridge ways of knowing is an essential first step. The Government of Canada's commitment to reconciliation and to the *United Nations Declaration on the Rights of Indigenous Peoples* (UNDRIP) calls for further efforts to elevate our collective capacity and mainstream methods for incorporating ILK into resource decision-making.

Governance for INRM

Careful and inclusive design of INRM governance is essential to its success.

The value of INRM comes from applying knowledge to decision-making through a carefully designed and implemented governance process. INRM calls for more inclusive forms of governance involving a broader set of actors and expanded ways of knowing, thereby legitimizing and improving the quality of decision-making. Research and practical experience have shown that effective governance involves a range of approaches that correspond with the nature and complexity of the resource management issues and processes under consideration. The governance approaches that have evolved in Canada over recent decades can be placed along a spectrum, from consultative to collaborative to shared (Figure 2).

Moving along the consultative-collaborative-shared spectrum, each approach represents an increasing and more substantive involvement of more than one actor in decision-making and accountability. Although progression along this spectrum is often desirable, there may be one or more aspects of INRM (e.g., legislation, policy, planning, project review, monitoring) for any given circumstance that dictate a more consultative approach.

Regardless of the approach, governance in INRM extends beyond whichever government has authority over the resource (e.g., federal, provincial, territorial, Indigenous) to include all relevant actors. Actors are more likely to buy into results, help identify solutions, and put them into practice if they are involved in decision-making. This begins with process design; in the Panel's experience, effective design is co-design — that is, the relevant actors collaboratively design the governance system from the outset. Governance that is inclusive in design and decision-making brings legitimacy and improves outcomes.

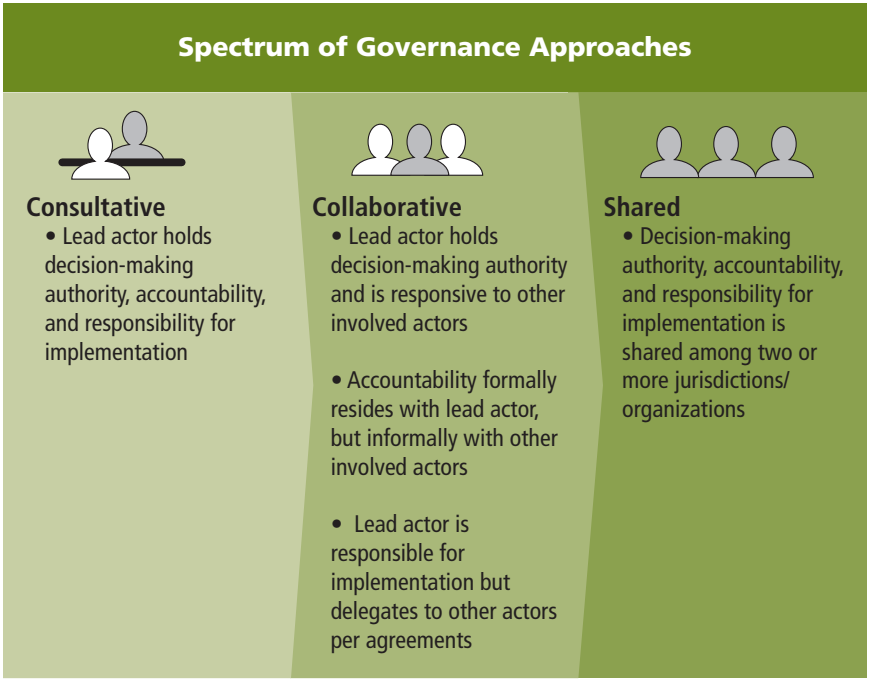


Figure 2

A Spectrum of Natural Resource Governance Approaches in Canada

Governance approaches can exist along a spectrum from consultative to collaborative through to shared governance.

Laws and regulations establish the boundaries of, and conditions for, resource-based decision-making in Canada, and can create a space in which INRM can thrive. Conversely, without supporting regulations and policies, implementing INRM processes may be difficult. With a few notable exceptions, most environmental and natural resource laws in Canada were passed before INRM garnered significant interest, and with limited recognition of Indigenous governments. However, the laws governing natural resource management in Canada do not prohibit and, in some cases, foster INRM.

Final Reflections

The Panel designed this report to be of value to leaders working to strengthen the legitimacy of resource management systems, and to the practitioners and actors wishing to implement or improve INRM. Canada is in a state of transition in resource management: from exclusively project-level planning to planning on a regional level; from consultative to collaborative or shared governance; and from recognition of single to multiple ways of knowing. At first glance, the eight defining characteristics of INRM described in this report appear to call for a complete overhaul of current resource management practices — which in turn appears out of reach for many actors. However, the Panel came across many promising emerging practices over the course of the assessment. Although Canada is still experimenting with INRM, these examples are early indicators that suggest progress is already being made. There is a need for enhanced documentation and sharing of lessons learned from these and other initiatives so that such lessons can be applied in other contexts.

INRM is a work in progress that will take time and resources to implement, and that needs to be both carefully designed and thoroughly implemented. INRM requires ongoing resourcing to support its operations, as well as regional and long-term monitoring efforts; information collection and sharing; and research. An INRM regime has the authority to carry out decisions. INRM requires leadership to bring about a change in culture within government, industry, and communities, and accountability to ensure objectives are being met on a sustained basis. Ultimately, for INRM to be effective, a greater level of commitment is needed on the part of governments to enhance knowledge and governance beyond the consideration of individual resource projects. However, in the Panel's view, widespread INRM implementation is crucial for addressing the scale and complexity of 21st century problems and to allow for Canada's continued prosperity.

List of Acronyms and Abbreviations Used in the Report

ABEKS	Arctic Borderlands Ecological Knowledge Society
ACM	adaptive co-management
ALSA	Alberta Land Stewardship Act
AMB	Archipelago Management Board
AQMS	Air Quality Management System
BBOP	Business and Biodiversity Offset Program
CEAA	Canadian Environmental Assessment Agency
CLI	Canada Land Inventory
EA	environmental assessment
ELOKA	Exchange for Local Observations and Knowledge of the Arctic
GIS	geographic information system
GLWQA	Great Lakes Water Quality Agreement
IJC	International Joint Commission
ILK	Indigenous and local knowledge
IPCC	Intergovernmental Panel on Climate Change
INRM	integrated natural resource management
MVEIRB	Mackenzie Valley Environmental Impact Review Board
MVRMA	Mackenzie Valley Resource Management Act
NGO	non-governmental organization
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples
WRRP	Watershed Resilience and Restoration Program
WUP	water use planning

Table of Contents

1

Introduction

- The Charge to the Panel
- The Panel's Approach and Methodology
- Organization of the Report

1 Introduction

Canada's history, identity, and economy have been shaped by its reliance on, and trade in, natural resources. The rich diversity of Canada's natural resources — wildlife and other components of biodiversity, water, forests, minerals, energy, and arable land for agriculture — has always played an important role in the culture, health, safety, and livelihood of the people of Canada. Demands on, and concerns for, Canada's natural resources result in competing interests and values, but they can also foster common goals and opportunities for new approaches to resource management.

In resource-rich regions across the country, natural resource uses often overlap, which can give rise to multiple opportunities and challenges. There may exist competing claims for the same land base by many land users and sectors (e.g., agriculture, mining, urban expansion, oil and gas exploration) and these activities can occur simultaneously and in close proximity, or one may preclude the other. While having multiple different users and sectors can create greater disturbances on a given land base, competing claims — if managed in an integrated manner — can result in: the sharing of infrastructure (e.g., resource roads); the creation of common support services; and collaboration among sectors to reduce the overall footprint of multiple activities occurring on the same land base at the same time. Though each land user and sector will create its own set of environmental, economic, and social impacts, additional cumulative effects will also result from having multiple land uses in the same area.

While stewardship or environmentally conscious resource management practices exist, such as crop rotations on farmlands, selective harvesting of trees, and recognition of habitat refugia for wildlife in trapping and harvesting practices, other management practices have led to cumulative and complex environmental and societal effects. Impacts can be significant with long-term effects on ecosystems. Examples of negative effects stemming from natural resource management practices include bioaccumulation of pollutants, large-scale conversion of natural land cover in regions such as the Prairies and Carolinian Forest, fragmentation of natural land cover by linear disturbance such as roads and seismic lines, overharvesting of timber, excessive nutrient releases from agriculture and urban areas, and overharvesting of wildlife (e.g., bison in the Prairies, cod on the East Coast).

As natural resource development intensifies and urban expansion continues to put pressure on agricultural lands and forests, concerns over environmental degradation and cumulative effects point to the need for more integrated ways of managing land. In Canada, natural resource management decisions have historically been made on a project-by-project or sector-by-sector basis. This approach has come up significantly short in terms of addressing cumulative environmental, social, and economic effects; of considering uncertainty; and of providing adequate environmental protection.

Beyond the competing objectives across resource interests and rights holders, the growing impacts of climate change must be addressed. Additionally, federal government devolution of resource management responsibilities to the territories, modern land claim and self-government treaties and agreements, and legal recognition of Indigenous rights have altered the governance of resources in Canada. Expectations for transparency and participation in resource management decisions have also expanded among actors, including rights holders and the general public, and there is now greater recognition of non-extractive values (e.g., wilderness tourism).

A central challenge in natural resource management is making decisions when overlapping rights, interests, and values bring together diverse actors. Integrated approaches to natural resource management consider the individual and combined impacts of several activities occurring in an area, apply different ways of knowing, consider a range of spatial and temporal scales, and involve a spectrum of interests to inform and make decisions on natural resource management. These approaches promote informed decision-making by collectively considering priorities and finding solutions that attempt to weigh competing needs, interests, and uses in the same area to support the long-term management of all resources.

1.1 THE CHARGE TO THE PANEL

To better understand how to efficiently implement integrated approaches to natural resource management in Canada, Natural Resources Canada (the Sponsor), supported by Agriculture and Agri-Food Canada and Environment and Climate Change Canada, asked the Council of Canadian Academies (CCA) to conduct an evidence-based assessment to answer the following question:

> *What is the state of knowledge and practice of integrated approaches to natural resource management in Canada?*

The Sponsor also asked three sub-questions:

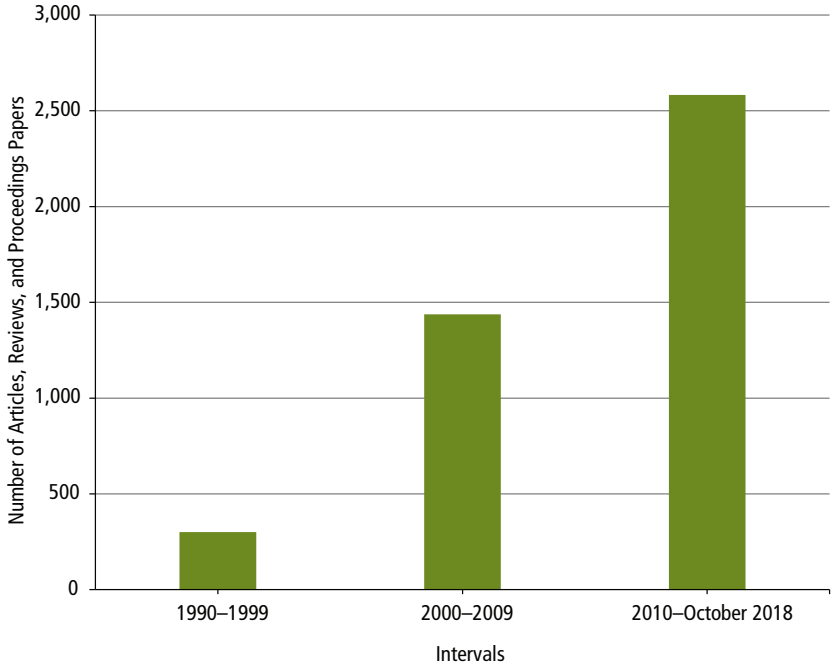
> *What are the main concepts and trends in science and in governance underpinning integrated approaches to natural resource management, and what influence are they having on the practice of natural resource management in Canada?*
>
> *What barriers are affecting the understanding of integrated approaches to natural resource management, their effectiveness, and their practical application in Canada?*
>
> *What best and promising practices and/or lessons learned exist in Canada or internationally with respect to practically implementing science- and traditional knowledge-informed approaches to integrated natural resource management?*

To address the charge, the CCA assembled a multidisciplinary panel of 13 experts (the Panel) from across Canada and abroad. Panel members brought expertise related to biology, ecology, economics, human geography, geoscience, law, natural resource management and development, public administration, sociology, and traditional knowledge. The Panel included both academic experts and practitioners of integrated approaches to natural resource management.

The Panel and the Sponsor agreed on the importance of recognizing the rights and values of Indigenous Peoples in this assessment, particularly the role of Indigenous and local knowledge (ILK) and the involvement of Indigenous Peoples in natural resource management decision-making. Although oceans provide significant natural resources in Canada, they were excluded from the scope of this report.

1.2 THE PANEL'S APPROACH AND METHODOLOGY

One of the Panel's first tasks was to determine the various research fields, terminology, and applied practices that can be classified as *integrated natural resource management*, and to decide on a consistent term and definition to inform the development of this report. Integrated natural resource management comprises a set of practices, approaches, and philosophies that have received increasing attention in recent decades, as shown by the number of articles, reviews, and proceedings papers indexed on scientific search engines such as Web of Science (Figure 1.1).



Data Source: Web of Science, 2018

Figure 1.1

Trends in the Number of Articles, Reviews, and Proceedings Papers Indexed on Web of Science That Use the Terms Integrated Natural Resource(s) Management

Although other terms may have been used in the past, the terms *integrated natural resource(s) management* have appeared significantly more frequently over the past two decades in peer-reviewed scientific literature. This is illustrated by the increase in the number of articles, reviews, and proceedings papers indexed on Web of Science (as of October 22, 2018) that are found when searching the terms integrated AND natural AND resource(s) AND management as the topic. No publications before 1994 were identified.

The Panel found that the literature on integrated approaches to natural resource management was complicated by the use of many similar and overlapping terms, such as *integrated landscape/land management*, *regional land use planning*, *ecosystem management*, and *integrated resource management*, among others. While all of these terms broadly describe "proactive, holistic, systems-based, and integrated approach[es] to environmental problems" (Carlson & Stelfox, 2009), they vary in context, focus, and how they are applied at an operational level. The Panel notes that the integrated approaches described in the literature often focus

exclusively on resource and environmental issues, and do not explicitly (or adequately) consider social and economic issues. For this report, the Panel adopted the general term *integrated natural resource management* (INRM) to encompass the essential features of the integrated approaches to resource management.

While the Panel reviewed examples of INRM practice in international settings, it focused its efforts on exploring learnings from Canadian INRM practice. This was intentional as Canada's unique natural resource management context limits the applicability of international INRM examples to the Canadian setting. This uniqueness is due to Canada's size, overlapping base of natural resource uses, diverse landscapes, constitutional division of powers, historical evolution across jurisdictions and orders of government, and historical and legal relationships with Indigenous Peoples. Selected international examples are presented in the text where they provide unique or novel insights applicable to Canada.

INRM attempts in Canada can be traced to the early 20th century. Past examples include Ontario's 1946 *Conservation Authorities Act*, which facilitated the creation of watershed groups that manage a diverse set of natural resources within their boundaries (Mitchell, 1986). INRM implemented by the Canadian Council of Resource Ministers and joint federal/provincial/territorial watershed studies, and in various provincial and territorial strategic approaches between the 1960s and 1980s, yielded mixed results (Mitchell, 1986). Writing in 1986, Mitchell described integration in natural resource management at that time as having "a long history even though successful implementation of it has been infrequent" (Mitchell, 1986). Interest in INRM has been on the rise in recent decades, catching the attention of academia, government, and industry (Margerum, 1997; Brown *et al.*, 2005; Stucki & Smith, 2011). The voices calling for better integration in natural resource management are growing louder (NAS, 2016a; Parkes *et al.*, 2016; Gélinas *et al.*, 2017; Worte, 2017).

1.2.1 Defining INRM

For the purpose of this assessment, the Panel defined INRM as:

> a way of managing human activities and natural resources that weighs and integrates multiple land uses, rights, needs, ways of knowing, and values across jurisdictional, temporal, and spatial scales to achieve environmental, economic, social, and cultural objectives.

This definition refers to a range of processes that make up the INRM lifecycle. These include coordinating, policy-making, regional or strategic planning, project review, regulation, operational implementation, and monitoring.

The Panel's definition assumes a holistic account of *natural resources* that reflects the full range of human activities. It consists of many resources that produce goods and services, including oil, gas, minerals, forest, soil, water, land, wildlife, and fish as well as ecosystem services such as water supply and regulation, erosion control, carbon sequestration, recreation, biodiversity conservation, and cultural uses. This way of thinking about natural resources is not new. Regional land-use planning and watershed-level planning and management have reflected this approach for many years. For example, 25 years ago, Slocombe (1993) noted that, "[i]f the goal is management of an entire watershed, bioregion, or ecosystem… [then] the management unit includes people, their social and economic activities, and their shared and individual beliefs." The Panel notes that, while all natural resources need to be considered in INRM, many examples in this report focus primarily on resource extraction (oil, gas, minerals), forests, water, and traditional ecosystems because of their importance to Canada and their inherent role in the discussion of integrated land use. Despite finding fewer examples related to agriculture and urban development, the Panel notes that these sectors are relevant to INRM, are very important in the Canadian context, and contribute greatly to the overall footprint of resource development.

Integration refers to an inclusive and holistic approach that is transdisciplinary and includes many decision-makers and many ways of knowing. *Ways of knowing* refers to the process of understanding, while *knowledge* refers to information (Berkes, 2018). Integration therefore applies to governance, occurring within and across governments and resource managers. The Panel uses the term *integration* based on the charge and its use in the field, but notes that some have expressed concern with the term because of how it has been used in other contexts. For example, on the subject of knowledge, Nadasdy (1999) states that knowledge integration "compartmentalize[s] and distill[s] Aboriginal people's beliefs, values, and experiences according to external criteria of relevance, seriously distorting them in the process."

Finally, the use of the term *weighs* in the definition indicates that all costs, benefits, values, objectives, and needs are considered; however, these may not be given the same importance or priority. For example, potential land uses for an area may include species and habitat conservation, resource extraction, hunting and trapping, or agriculture, while the development of one of these activities may affect the others. In INRM, each potential use is evaluated under a management approach that considers different priorities depending on overall acceptable costs and desired benefits. This weighting may be based on a number of factors, including the desires of users or organizations, general needs of the public, other nearby land uses and values, government policies and goals, and cultural values and priorities. This process also allows for explicit consideration of the trade-offs.

1.2.2 The Roles of Knowledge and Governance in INRM

In exploring the theory, practice, and application of INRM, the Panel highlighted the importance of different sources and types of knowledge and the views and interests of multiple actors in decision-making. Panel members underscored that all relevant forms and sources of knowledge, including Western science, ILK, and other local knowledge, should be considered. The most relevant sources of knowledge for INRM, and how they can best be applied, will vary depending on the specific context.

The Panel acknowledged the essential role of governance in INRM. In the context of INRM, the Panel defines *governance* as the functions, institutions, and processes for developing norms, for decision-making and exercise of accountability, and for how relationships among actors proceed. In this definition, *norms* refer to principles, laws, regulations, guidelines, and standards (both public and private) that societies and actors establish and to which they commit — they guide decisions and actions on the management of natural resources. *Decision-making* encompasses the substance of the decisions that are made, who makes them, and how they are made. Those making decisions are accountable to a variety of people, including citizens, rights holders, and interested and affected parties. *Relationships* refer to how those involved interact in developing norms, decision-making, and the exercise of accountability. The distinction between governance and management is important in INRM because of differences in roles and responsibilities. In the view of the Panel, *governance* involves decision-making and accountability for the implementation of these decisions, while *management* refers to the implementation of activities as a result of governance decisions and is a process that involves planning, coordinating, and taking action to achieve defined objectives. In Canada there are governance differences with respect to public and private lands. While the Panel focuses on the former in the report, governance around development of private lands is also important.

In the Panel's view, any discussion of integrated decision-making recognizes all those who participate in or are affected by natural resource management decisions, including those who hold resource and land rights. These groups, organizations, or individuals are referred to in this report as *actors*. In Canada,

relevant actors include federal, provincial, territorial, Indigenous, and municipal governments and their agencies; regulatory bodies; industry; boards and councils; non-governmental organizations (NGOs); communities; local resource users; and the public.

1.2.3 Evidence Considered in the Report

As a starting point for identifying evidence on INRM, the Panel conducted searches of the published academic literature using many overlapping terms related to integrated approaches for natural resource management (e.g., *INRM*, *landscape/land management*). This exercise was supplemented by a search of the grey literature drawing on the Panel's diverse expertise and experience. This report is not based on a systematic review, but rather a detailed analysis of the key references identified by the Panel.

The review of the literature and the expertise of the Panel highlight several important gaps. For example, there are insufficient data to adequately assess the quantity and quality of different resources across the country (e.g., agricultural land, groundwater). Some of this information used to be collected for the Canada Land Inventory, but it shuttered in the 1990s due to budget constraints (Pierce & Ward, 2013). Statistics Canada does collect and publish environmental and resource accounts about some natural resources in Canada (StatCan, 2015), however gaps remain.

Another knowledge gap of particular importance relates to the real-world application of INRM. Based on members' collective expertise and review of the evidence, the Panel concluded that, although the theory behind INRM is well described in the literature, much less empirical evidence exists on the successes and challenges where implemented. To fill this gap, the Panel used its own collective expertise and supplemented member knowledge by inviting several practitioners to Panel meetings to share their experiences and expertise in natural resource management and co-management in British Columbia, Yukon, Northwest Territories, and Alberta. Practitioners discussed the motivation, objectives, structure, and challenges of their respective experiences with the Panel.

1.3 ORGANIZATION OF THE REPORT

The Panel organized the report as follows:

- Chapter 2 describes the main forces driving INRM in Canada and the imperative for integration.
- Chapter 3 identifies and briefly describes eight characteristics of INRM.
- Chapter 4 focuses on the role of knowledge in INRM: the aspects of knowledge in natural resource management, the types of knowledge relevant to INRM, and ways to use and apply that knowledge in planning and management.
- Chapter 5 addresses the role of governance in INRM: the main actors in natural resource management, three types of governance approaches (consultative, collaborative, and shared), and the role of laws and regulations in enabling the governance of INRM.
- Chapter 6 explores several significant barriers to implementing INRM in Canada, outlines potential solutions, and offers examples of leading practices.
- Chapter 7 presents the Panel's key findings and final reflections.

2

Natural Resource Management in Canada: Context and the Need for Integration

- Key Drivers Reshaping the Resource Management Context in Canada
- The Integration Imperative
- Conclusion

2 Natural Resource Management in Canada: Context and the Need for Integration

Key Findings

Natural resources are a major driver of Canada's economy, providing significant employment and revenues as global demand for resources persists.

Declines in both the quantity and quality of natural resources, and increasing and cumulative pressures on the environment, underscore the need for implementing INRM.

Recognition of Indigenous Peoples' rights and the Government of Canada's commitment to reconciliation create obligations and opportunities to develop improved approaches to natural resource management, ones that are informed by different ways of knowing and that consider the needs of all rights holders.

The jurisdictional context in which natural resources are managed in Canada is characterized by complexity, overlap, and evolution over time, all of which call for enhanced coordination.

Confidence in natural resource management has been undermined by rising conflict over natural resource decisions, and practices have not kept up with evolving public expectations for transparency and meaningful engagement.

The confluence of these trends creates an opportunity to redesign natural resource decision-making and demonstrates the integration imperative.

People in Canada derive considerable value from the natural environment. Energy production, agriculture and agri-food products, and lands containing a wealth of forest and mineral resources, are among the features that have made Canada a major producer and exporter of resources globally. The value of the natural environment goes well beyond the market value of the extracted goods and services derived from it. In developing this report, the Panel adopted a broad understanding of natural resources that includes Canada's economically important energy, mineral, agriculture, and forestry resources and also encompasses the wide range of benefits provided by all ecosystem goods and services. Ecosystem services include provisioning (e.g., fuel, water); regulating (e.g., air or water quality, pollination); cultural (e.g., cultural identity, recreation); and supporting services needed to produce other services (e.g., primary/secondary production, water cycling) (Millennium Ecosystem

Assessment, 2005b; VNCST, 2017).[1] Ecosystem goods and services maintain ecosystem integrity and functions, and, more generally, play a role in human health and well-being (e.g., Costanza, 2017; VNCST, 2017). They also provide direct and indirect contributions to economic activities, such as through wilderness tourism, an industry that has been valued at approximately $2 billion dollars per annum in British Columbia alone (Wilderness Tourism Association of BC, n.d.).

Competing demands on and for Canada's natural resources have led to growing interest in developing integrated approaches to managing natural resources and land use in Canada that include all actors, and that consider a comprehensive range of needs, uses, and the sustainability of resources over the long term. This chapter explores the convergence of key trends that are driving the demand for new resource management approaches, situating INRM as a promising option for addressing growing challenges and harnessing emerging opportunities in the management of Canada's natural resources.

2.1 KEY DRIVERS RESHAPING THE RESOURCE MANAGEMENT CONTEXT IN CANADA

The Panel identified six important trends that are influencing resource management in Canada — these drivers are reshaping the economic, environmental, legal, and social context for decision-making, while at the same time creating new opportunities for the advancement of INRM. They are explored in no particular order.

2.1.1 Increasing Demand for Natural Resources

The global demand for natural resources continues to increase, driven primarily by economic development and population growth (Bringezu *et al.*, 2017). The United Nations Environment Programme's International Resource Panel predicts that global material resource use in 2050 could be more than twice the 2015 levels if existing trends continue (Bringezu *et al.*, 2017). Increasing and sometimes competing demands on the same land base can contribute to conflict and place stress on the environment. Population projections suggest that, by 2050, Canada could be home to approximately 45 million people — 10 million more than the 2015 population (Bohnert *et al.*, 2015). Demand for Canadian agriculture, water, and other resources may also rise as global food demand is anticipated to increase by roughly 60 to 100% from 2005 levels by 2050 (Valin *et al.*, 2014; NEB, 2016). Additionally, while new renewable energy technologies

1 More recent analysis undertaken by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has used a framework of nature's contributions to people to understand and analyze these services (Díaz *et al.*, 2018).

may reduce the demand for certain natural resources such as fossil fuels over time, these savings are likely to be at least partially offset by an increased burden on a different suite of natural resources. Substitution away from carbon-intensive fuels depends, at least in part, on the world's ability to produce non-carbon clean technologies, which themselves rely on many raw materials (Ali *et al.*, 2017). These materials include certain metals that are critical for renewable power generation and battery technologies (e.g., silver for some types of solar cells, lithium for batteries, aluminum for wind turbines) (MAC, 2017a; The World Bank, 2017). Energy storage technologies (primarily batteries) are predicted to cause an estimated 10-fold increase in demand for certain metals by 2050 (The World Bank, 2017). At the same time, people in Canada value the environment and choose to spend time in nature (FPTGC, 2014), and this must be balanced with the growing demand for natural resources.

Ensuring the Competitiveness of Canada's Resource Industries

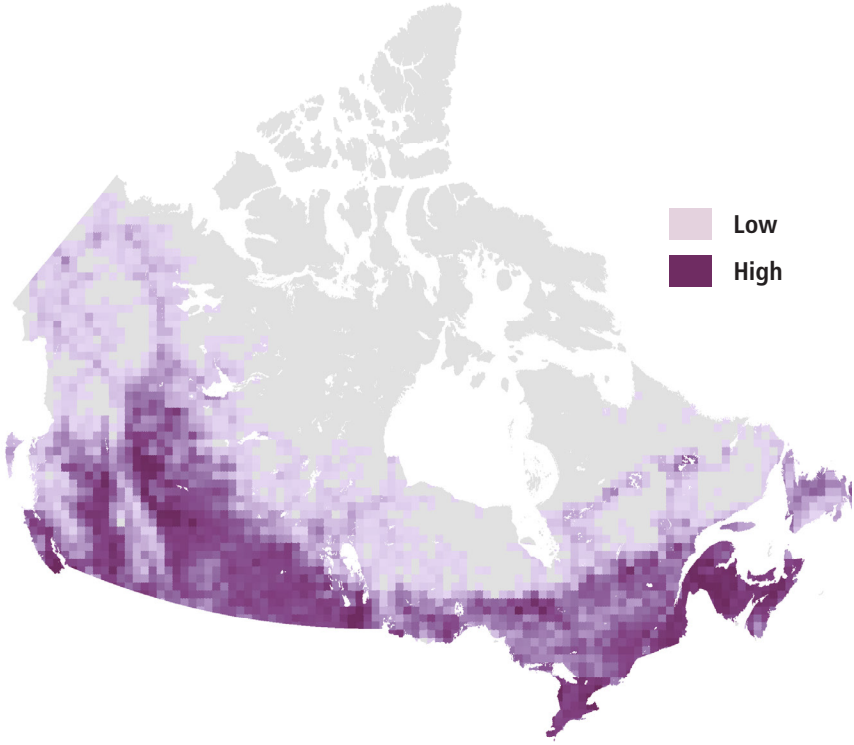
Natural resources contribute greatly to Canada's economy and society, directly and indirectly accounting for 1.82 million jobs (10% of all jobs) and 17% of Canada's nominal GDP in 2017 (NRCan, 2018). Many regional economies rely on natural resources, and supply chains for goods and services extend across the country. Canada's Economic Strategy Table on Resources of the Future — a group of leading experts from the commercial, non-profit, academic, and government sectors — recently positioned natural resources as "Canada's enduring strength in a world where capital and talent are increasingly mobile" (CEST, 2018). The rapid growth of emerging economies such as China and India creates tremendous opportunity for Canada's resource sector as demand and commodity prices rise, but this opportunity will only be realized if Canadian resource exports are competitive with those of other countries (EMMC, 2014).

Industry groups — including the Canadian Association of Petroleum Producers, the Canadian Energy Pipeline Association, the Forest Products Association of Canada, the Prospectors & Developers Association of Canada, and the Canadian Electricity Association — continue to cite regulatory burden and regulatory uncertainty as two key competitiveness challenges (PDAC, 2016; CAPP, 2018; CEA, 2018; CEPA, 2018; FPAC, 2018). A 2017 survey of executives ranked "inefficient government bureaucracy" as the most problematic factor for doing business in Canada (WEF, 2018). Canada's Economic Strategy Table on Resources of the Future identified "declining competitiveness of resource projects, created by regulatory complexity, insufficient infrastructure, and uncertainty around land base and land use decision-making" as a key challenge that needs to be overcome (CEST, 2018).

2.1.2 Growing Environmental Pressures

The increasing global demand for natural resources contributes to the intensification of environmental pressures, observed at both local and global scales. For example, the decline in the abundance and habitats of wildlife species is related to the conversion of natural areas to urban, commercial, and industrial land uses, causing a rapid global change in biodiversity (Rockström *et al.*, 2009; Newbold *et al.*, 2014). Extensive development across the Canadian landscape has led to declines in habitat for key species such as caribou (Ray, 2014). Between 2000 and 2013, Canada lost nearly 5% of its intact forest landscapes, with 92% of this landscape degradation occurring in areas containing species at risk (Smith & Cheng, 2016). Since the early 1900s, it is estimated that up to 70% of wetlands in the Prairie region have been lost or degraded (Serran & Creed, 2016).

Data needed to provide a full assessment of the impacts of natural resource use in Canada are limited or incomplete, and the Panel was unable to create an accurate map of the distribution of natural resource use across the country. While the Panel is aware that provinces and territories keep comprehensive databases of human activity, these data are sometimes focused on one resource sector and are not always publicly accessible. Global Forest Watch Canada compiled a series of publicly available datasets to provide an approximation of human access across the country (Figure 2.1). The definition of *access* used by Global Forest Watch Canada in this dataset is "the combined land surface anthropogenic [i.e., human-created] disturbances caused mainly by industrial activities, which include, but are not limited to, roads [including urban roads], mines, clearcuts, wellsites, pipelines, transmission lines, and agricultural clearings" (Data Basin, 2017). This map should not be considered a fully accurate representation of human disturbance in Canada, as there are important elements of human access not visible (e.g., Diavik Diamond Mine in the Northwest Territories), and some areas are disturbed less intensely than indicated (e.g., New Brunswick). Rather, Figure 2.1 illustrates how human activity occurs throughout Canada. Although activity is concentrated in southern Canada, where the majority of people live, anthropogenic disturbances can be observed in rural and remote parts of the country. See Section 6.1 for more details on problems associated with a lack of data on natural resources in Canada.



Data Source: Global Forest Watch Canada, 2014

Figure 2.1

Relative Densities (from Low to High) of Human Access in Canada

An approximation of human access across Canada due to roads (including urban roads), mines, pipelines, agriculture, and other human activities. Due to data limitations, the map should not be considered a fully accurate representation of human disturbance in Canada. Some important elements of human access are not incorporated, and some areas are disturbed less intensely than indicated. An ecological buffer of 500 metres is applied to the dataset used to create the map. More information on the methodology behind the data used to create the map can be found in Lee and Cheng (2014).

Cumulative effects are defined as "change[s] in the environment caused by multiple interactions among human activities and natural processes that accumulate across space and time" (CCME, 2014a). Cumulative effects can result from a number of different uses occurring at the same time on the same landscape (e.g., forestry, agriculture, residential, hunting), and/or from the same activity occurring at a high frequency (e.g., many individual water withdrawals from the same river). When cumulative effects are not adequately considered, "we are not

only missing additive dimensions, but also emergent and unexpected factors which are invisible and, therefore, overlooked within the assessment of any one particular project" (Parkes *et al.*, 2016). As urban expansion, agriculture, and other uses put more pressure on the land, the potential for cumulative effects also increases (Kennett, 2004). By way of example, Box 2.1 provides a snapshot of the cumulative pressures of land use and natural resource development in the traditional territory of the Blueberry River First Nations. Although the need to consider cumulative effects in environmental decision-making is well accepted, a lack of consensus exists on how to address them (Squires *et al.*, 2010). Some have argued that current approaches may be doing more harm than good, and cumulative effects literature suggests overall that more integrated approaches are needed (Duinker & Greig, 2006; Noble, 2015b).

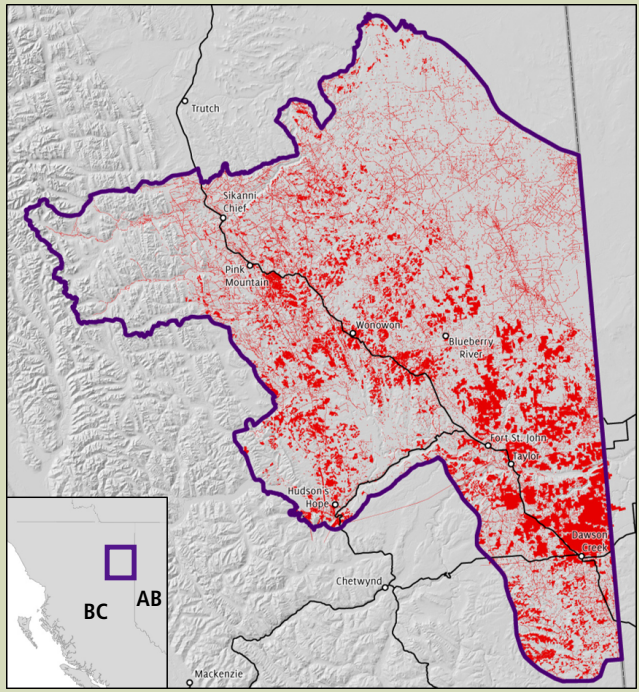
While water quantity and quality in many parts of the country remain satisfactory (ECCC, 2018b, 2018c), some of Canada's water resources are under stress. For instance, the Athabasca River saw its water withdrawals increase nearly 50-fold between 1966 and 2006 due to cumulative development in urban land uses, agriculture, pulp mills, and oil sands (Squires *et al.*, 2010). This increase in withdrawals has coincided with a decrease in the river's water flows (Squires *et al.*, 2010). The watersheds across Canada that have experienced the greatest increase in stress lie in Nova Scotia and in the northern regions of British Columbia, Alberta, Saskatchewan, and Ontario due to many factors (e.g., number of dwellings, density of petroleum manufacturers, number of crop farms) (Chu *et al.*, 2015). Overall, Chu *et al.* (2015) found that between 20 and 28% of Canada's watersheds have critical conservation priority (i.e., a very high need of conservation measures), based on indices representing freshwater fish biodiversity, environmental conditions, and anthropogenic stress.

2.1.3 Intensifying Climate Change

Changes in climate variables such as temperature and precipitation affect both environmental and human activities. Climate change is expected to cause increasingly frequent disturbances (e.g., forest fires, pest outbreaks, droughts, permafrost thaw, rapid landscape change), and transform water flows, habitats, and biodiversity (Warren & Lemmen, 2014). Climate changes have and will continue to influence the availability and distribution of natural resources (Warren & Lemmen, 2014) and may amplify the observed cumulative effects associated with natural resource extraction. Figure 2.3 identifies several examples of potential climate change impacts on natural resources in different regions of Canada.

Box 2.1
Cumulative Pressures in the Traditional Territory of the Blueberry River First Nations

The Blueberry River First Nations territory of northeast British Columbia is characterized by extensive overlapping land uses. The 38,327-square-kilometre territory is home to nearly 20,000 oil and gas wells and over 110,000 kilometres of roads, pipelines, and transmission and seismic lines (Macdonald, 2016). Nearly 70% of the landscape contains active petroleum and natural gas tenures, and less than 14% is covered by intact forests (Macdonald, 2016) (Figure 2.2). Cumulative effects have been identified as the driver preventing the Nations from using the land as guaranteed by its treaty (Brend, 2017). Declining populations of moose, marten, beaver, lynx, and caribou have compromised hunting and fishing rights (Brend, 2017).

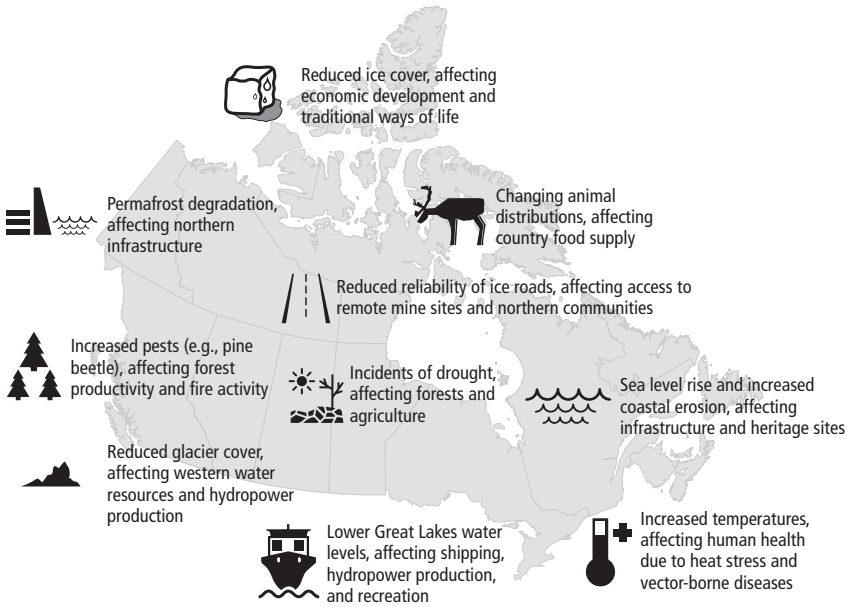


Adapted with permission from Macdonald (2016)

Figure 2.2

Cumulative Effects Footprint in the Traditional Territory of the Blueberry River First Nations

The industrial use footprint (in red) includes roads (5 metre buffer), transmission lines (5 metre buffer), pipeline tenure, consolidated cutblocks, and agricultural areas. Over 70% of the area of the Blueberry River First Nations traditional territory is within 250 metres of an industrial use.



Adapted with permission from GC (2014)

Figure 2.3

Negative Climate Change Impacts in Canada

Canada is experiencing a wide range of negative effects from climate change, which vary by region.

Increased temperatures correlate with higher rates of forest fires, which in turn are likely to have economic and environmental implications such as reduced logging capacity and alteration of habitat (Gillett *et al.*, 2004; NRT, 2011; Stralberg *et al.*, 2018). Similarly, rising mean temperatures lead to increased evaporation, which is associated with drier conditions (Schindler, 2001; Warren & Lemmen, 2014). As has already been observed in central Canada, these droughts affect agricultural production (Cherneski, 2018) and have caused environmental impacts such as vegetation stress and reduction in the number of ponds (Hanesiak *et al.*, 2011). Although Canada has one of the largest supplies of freshwater in the world, reduced availability and quality due to climate change has become a concern (Schindler, 2001).

Overall, the increasing frequency of extreme events (e.g., fires, droughts, floods) may directly impair industrial operations along with the availability of resources by reducing renewal or supply in the case of hydropower generation or timber harvest (Warren & Lemmen, 2014), contributing to uncertainty in the sector. More profound ecological impacts of climate change are being observed at large spatial scales, significantly changing ecosystems and species distribution (Warren & Lemmen, 2014), which in turn can affect the availability of and access to resources. These large-scale changes include the thawing of permafrost, which can lead to the release of methane from gas hydrate deposits and, in turn, the loss of structural integrity in the ground (Maslin *et al.*, 2010).

2.1.4 Recognition of Indigenous Rights and Renewed Commitment to Reconciliation

Recognition of Indigenous Rights

For millennia, Indigenous people in Canada have used land and natural resources as an essential source of subsistence, and for social, cultural, spiritual, and economic value (RCAP, 1996b; Lewis & Sheppard, 2005; Ehrlich, 2010; Mameamskum *et al.*, 2016). The relationship between European settlers and Indigenous Peoples started in eastern Canada through treaties on trade and security that were perceived to benefit both parties (TRC, 2015). While Indigenous Peoples viewed the Treaty process as a means to establish "a reciprocal relationship that would be lasting," the intent of the federal government's policies at the time were to "assimilate Aboriginal people into broader Canadian society" (TRC, 2015). By 1923, when the last of these historical treaties was signed, they stretched across many parts of Canada with the exception of Quebec, the land that would become Newfoundland and Labrador, and significant portions of British Columbia and the North (Figure 2.4).

Data Source: GC, 2018b

Figure 2.4

Historic Treaties in Canada (Pre-1975)

This map illustrates various historic treaties created between the Crown and Indigenous Peoples across Canada. The geographic boundaries illustrated are estimates only. Treaties with no geographic boundary (e.g., Anglo-Huron Treaty) are not represented. This map has been created using the Pre-1975 Treaties (Historic Treaties) dataset downloaded from the Government of Canada's open data portal in November 2018 and may not be comprehensive.

Indigenous Peoples, which include First Nations, Inuit, and Métis Peoples, are prominent rights holders in Canada. These rights are rooted in Indigenous Peoples' prior occupation of North America, the Royal Proclamation of 1763, the *Constitution Act, 1867* (originally the *British North America Act, 1867*), and various historical and modern treaties (RCAP, 1996b; TRC, 2015). Although Section 35 of the *Constitution Act, 1982* gives constitutional protection to the rights of Indigenous Peoples in Canada, it does not set out in detail what these rights are; instead, landmark court decisions over the years have identified and confirmed many of them (GC, 2012a). These include, but are not limited to, the right to:

- carry out traditional activities on the land (e.g., hunting, fishing, trapping);
- conclude treaties;
- customary law;
- honourable treatment by the Crown;
- ancestral territory (e.g., Indigenous title);
- cultural integrity; and
- self-government.

(Slattery, 2007)

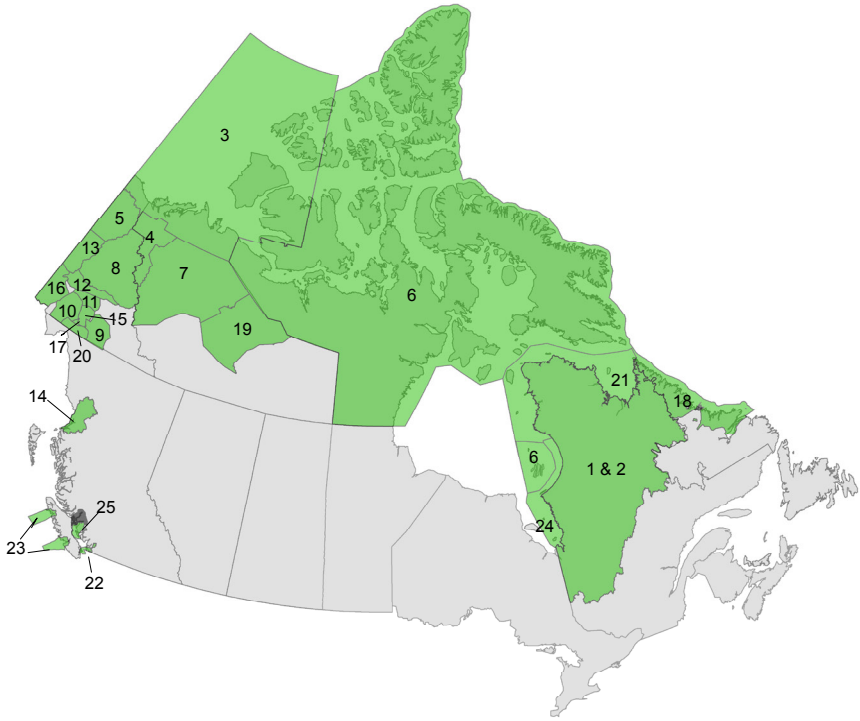
In recent decades, these rights have been legally tested, reaffirmed, and articulated in modern treaties that have taken root since 1973, many in the form of comprehensive land claims agreements. According to Crown-Indigenous Relations and Northern Affairs Canada, as of 2018, 25 comprehensive land claims agreements have been signed, 22 of which have self-government provisions, covering about 40% of Canada's land mass (CIRNAC, 2018a, 2018b) (Figure 2.5). Self-government arrangements take many forms based on the particular historical, cultural, political, and economic context. Another 100 or so comprehensive land claims agreements, affecting over 350,000 people, are still in negotiation, 70% of which are over 15 years in the making (INAC, 2014a). The federal government has committed to work to "[i]ncrease the number of comprehensive modern treaties and new self-government agreements in a manner that reflects a recognition of rights approach and reconciliation" (GC, 2018c).

Federal, provincial, territorial, and municipal governments in Canada have a duty to consult and accommodate Indigenous Peoples when undertaking actions that may impact their rights, whether they be established, proven, or claimed rights (e.g., SCC, 2004, 2010, 2014). This duty is triggered most commonly in the context of natural resource development and is rooted in Section 35

of the Constitution (Olszynski, 2016), which recognizes and affirms "existing aboriginal and treaty rights of the aboriginal peoples of Canada" (GC, 2012a). Courts, including the Supreme Court of Canada, have clarified several principles related to duty to consult through several court cases (e.g., SCC, 2004, 2005, 2014). These include (but are not limited to): the duty is triggered wherever the Crown has knowledge, actual or constructive, of established or claimed rights and contemplates conduct that might adversely impact them (SCC, 2014); the content of the duty to consult and accommodate is generally proportional to the strength of the claim and the significance of the potential adverse effect on the Indigenous right(s) (SCC, 2014); and the Crown cannot delegate their legal duty to consult and accommodate to a third party (SCC, 2004). While industry often consults with Indigenous Peoples during regulatory processes such as environmental assessment (EA) (Craik, 2015), the level and method of consultation and accommodation that is required for any given project is highly contextual and may not be clear (INAC, 2015).

As prominent rights holders, Indigenous Peoples play a key role in natural resource management in Canada (CILMC, 2005). Indeed, the treaty rights and Indigenous rights (which include land claims and self-government agreements) provide a framework for on-going cooperation and partnership, including a range of control over decisions for land and resources (CIRNAC, 2018b).

Indigenous Peoples in Canada have legal traditions distinct from European traditions that can support effective resource management. As there are many Indigenous communities across the country, there are many different and unique legal traditions (Borrows, 2005). These traditions developed over time "whenever human interactions create expectations about proper conduct" (Borrows, 2005). The political, social, and spiritual customs that guide relationships among Indigenous people serve as the foundation for the many different systems of laws. Indigenous traditions may be communicated through oral history or through the use of memory objects (e.g., totem poles); many may not be written down (Borrows, 2005).



1 James Bay and Northern Quebec Agreement (JBNQA) (1975)
2 The Northeastern Quebec Agreement (NQA) (1978)
3 Inuvialuit Final Agreement/Western Arctic Claim (1984)
4 Gwich'in Comprehensive Land Claim Agreement (1992)
5 Vuntut Gwitchin First Nation Final Agreement (1992)
6 Nunavut Land Claims Agreement (1993)
7 Sahtu Dene and Métis Comprehensive Land Claim Agreement (1994)
8 First Nation of Nacho Nyak Dun Final Agreement (1995)
9 Teslin Tlingit Council Final Agreement (1995)
10 Champagne and Aishihik First Nations Final Agreement (1995)
11 Little Salmon/Carmacks First Nation Final Agreement (1997)
12 Selkirk First Nation Final Agreement (1997)
13 Tr'ondëk Hwëch'in Final Agreement (1998)
14 Nisga'a Final Agreement (2000)
15 Ta'an Kwach'an Council Final Agreement (2002)
16 Kluane First Nation Final Agreement (2004)
17 Kwanlin Dun First Nation Final Agreement (2005)
18 Labrador Inuit Land Claims Agreement (2005)
19 Tlicho Agreement (2005)
20 Carcross/Tagish First Nation Final Agreement (2005)
21 Nunavik Inuit Land Claims Agreement (2008)
22 Tsawwassen First Nation Final Agreement (2009)
23 Maa-nulth First Nations Final Agreement (2011)
24 Eeyou Marine Region Land Claims Agreement - Cree (2012)
25 Tla'amin Nation Final Agreement (2016)

Data Source: GC, 2018a

Figure 2.5

Modern Treaties in Canada (Post-1975)

Modern treaties arising from the post-1975 land claims process currently cover much of northern Canada, and most involve land not covered by historic treaties. Not all of the treaty boundaries are surveyed. This map has been created using the Post-1975 Treaties (Modern Treaties) dataset downloaded from the Government of Canada's open data portal in November 2018 and may not be comprehensive. The hatched grey area represents shared harvesting areas associated with the Tla'amin Nation Final Agreement Modern Treaty.

Importantly, Indigenous legal traditions can include concepts of environmental rights and responsibilities that are not separated (i.e., the discussion of rights also includes discussion of responsibilities). While Indigenous legal traditions have been communicated through generations using oral history, more recently rights and responsibilities have been recognized in some written Indigenous legal systems. For example, the *Labrador Inuit Constitution* explicitly states:

> Every Labrador Inuk has the right to an environment that is not harmful to his or her health or well being and to have the environment protected for the benefit of present and future generations… and every Labrador Inuk has a responsibility to use and enjoy Nunatsiavut and its environment and renewable and non-renewable resources with care and respect, without waste or greed and as a steward for future generations of Labrador Inuit.
>
> (Nunatsiavut Government, 2005)

Commitment to Reconciliation

In 2016, the Government of Canada signalled a commitment to building a nation-to-nation relationship with Indigenous Peoples by signing the *United Nations Declaration on the Rights of Indigenous Peoples* (UNDRIP) (UN, 2008). UNDRIP acknowledges several rights of Indigenous Peoples to manage the natural resources on their land. Article 26 notes that "Indigenous peoples have the right to own, use, develop and control the lands, territories and resources that they possess by reason of traditional ownership or other traditional occupation or use, as well as those which they have otherwise acquired." Additionally, Article 32 explicitly notes that governments "shall consult and cooperate in good faith" in order to obtain free, prior, and informed consent from Indigenous Peoples prior to the approval of any development project (UN, 2008). Although UNDRIP is not a formally binding international treaty, the federal government has announced that it fully supports the Declaration and is evaluating changes in laws and regulations in light of this commitment (INAC, 2017a, 2017b). In addition, the House of Commons adopted Bill C-262 (*An Act to Ensure That the Laws of Canada Are in Harmony with the United Nations Declaration on the Rights of Indigenous Peoples*) in May 2018 (House of Commons, 2018a).

In 2017, the federal government committed to work toward a set of 10 principles for its relations with Indigenous Peoples in Canada (JUS, 2018). Principle 6 is particularly relevant in the context of INRM and UNDRIP: "[m]eaningful engagement with Indigenous peoples aims to secure their free, prior, and informed consent when Canada proposes to take actions which impact them and their rights, including their lands, territories and resources." The federal

government states it is committed to going beyond the legal duty to consult, and notes that the importance of free, prior, and informed consent extends beyond title lands (JUS, 2018).

A commitment to reconciliation is further demonstrated by the 2017 *Inuit Nunangat Declaration on Inuit-Crown Partnership*, which affirms a commitment by the Government of Canada to work towards socio-economic and cultural equity in partnership with the people of Inuit Nunangat. The Declaration further recognizes that the goal of equity will require the "full implementation of land claims agreements as well as reconciliation" (GC *et al.*, 2017).

2.1.5 Growing Jurisdictional and Legal Complexity

The legal framework within which natural resources are managed in Canada has always been complex, with all orders of government involved. Provinces and territories have significant control within their jurisdictions, with all 10 provinces and 2 of the 3 territories possessing constitutional rights to manage the production and extraction of non-renewable resources, energy, forest resources, and related revenue.[2] The constitution establishes federal jurisdictions over sea coast and inland fisheries, navigation, commerce, and federal taxation regulations (GC, 2012a). Federal, provincial, territorial, and Indigenous governments also manage large tracts of Crown land. The division of forest ownership as of 2016, for example, is that 77% are provincial, 13% territorial, 6% private, 2% Indigenous, and 2% federal (NRCan, 2016b). Municipal governments, empowered through provincial or territorial law, generally influence natural resource management through zoning and other local regulations (NRCan, 2016a).

Indigenous governments, which exist in different forms in many parts of Canada, also have control over lands and resources with differing rights and responsibilities depending on the mechanism of authority. This can include fee simple land ownership; subsurface rights ownership; co-management and joint management systems, such as those found in the Northwest Territories and Nunavut (e.g., Nunavut Land Claims Agreement (INAC, 2016a)); and referred authority from another government (e.g., Eeyou Istchee James Bay Regional Government (Gov. of QC, 2017)). Self-government agreements — which may or may not coincide with land claims agreements — ensure that Indigenous governments have greater autonomy over decision-making within their jurisdictions (CIRNAC, 2018a).

2 Negotiations are ongoing among the Government of Nunavut, the Government of Canada, and Nunavut Tunngavik Inc. to establish a devolution agreement that would transfer resource management responsibilities to the territory (INAC, 2014b, 2016b).

Each level of government also plays a significant role in maintaining environmental quality. While Canada's 1867 Constitution clearly sets out jurisdiction over many extractable natural resources to federal, provincial, or territorial governments, it does not do the same for the environment. This is because the concept of jurisdiction over the environment did not exist at the time of the drafting of the Constitution (Doelle & Tollefson, 2013). The Supreme Court of Canada has held that "the environment is not an independent matter of legislation under the Constitution Act, 1867 and… does not comfortably fit within the existing division of powers without considerable overlap and uncertainty" (SCC, 1992).

The federal government has passed environmental laws such as the *Canadian Environmental Protection Act*, *Canadian Environmental Assessment Act*, *Yukon Environmental and Socio-economic Assessment Act, Mackenzie Valley Resource Management Act,* and *Fisheries Act.* Provinces and territories have also passed environmental laws (e.g., Nova Scotia's *Environment Act*). Municipalities, though limited to the scope granted to them by their province or territory, may have the ability to regulate some environmental matters (e.g., water intake and treatment), define land-use development via zoning and planning, or implement specific regulations aimed at protecting the environment (e.g., use of pesticides) (Benidickson, 2013). Environmental laws also stem from modern land claims agreements (Noble, 2015b). For instance, the *Mackenzie Valley Resource Management Act* created the Mackenzie Valley Environmental Impact Review Board, which supersedes the *Canadian Environmental Assessment Act* in the Northwest Territories, as does the *Yukon Environmental and Socio-economic Assessment Act* (INAC, 2007; White *et al.*, 2007; GC, 2017a). This legal context is constantly evolving in response to legislative changes and court decisions. For example, proposed federal changes to the *Fisheries Act* (Bill C-68) include mandatory consideration of cumulative effects and Indigenous knowledge where available, among other changes, while the *Impact Assessment Act* (Bill C-69) provides increased public participation relative to the existing *Canadian Environmental Assessment Act, 2012* and expands the project assessment to include not only environmental but also economic, health, and social considerations (GC, 2012b; House of Commons, 2018b, 2018c). Both Bill C-68 and C-69 were adopted by the House of Commons in June, 2018.

Legislation in each jurisdiction may overlap, conflict, or supersede that of other governments (Doelle & Tollefson, 2013). For instance, in Ontario the federal *Species at Risk Act* and the provincial *Endangered Species Act* co-exist — and overlap. Although provincial or territorial regulations may be present, the federal *Species at Risk Act* can also protect a species as needed (GC, 2017b). There is no one level of government that has the ultimate authority over all of

these matters, and disagreement can result in legal conflicts (SCC, 1992). These complex and overlapping circumstances increase the need for collaboration among governments.

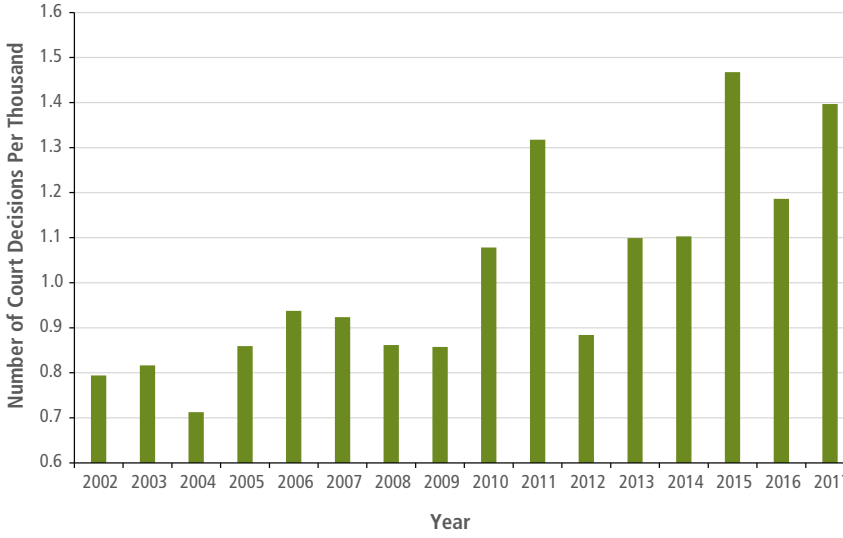
2.1.6 Declining Public Trust in Decision-Making

The public lacks trust in natural resource management decision-making in Canada, particularly of government and resource industries, with an increasing share of resource management projects subject to controversy and delay (Cleland *et al.*, 2016). In a 2018 public opinion survey, about half of respondents believed that Canada does a poor or very poor job at several dimensions of resource management, including "balancing the concerns of local communities… with broader regional, provincial or national interests," "providing a clear, predictable and competitive policy and regulatory environment for energy investors," and "developing a shared long-term vision for Canada's energy future" (Nanos, 2018). This proportion was higher than in 2017, when about 40% of respondents identified Canada as doing a poor or very poor job on these same dimensions (Nanos, 2018).

The Panel believes that increasing dissatisfaction about natural resource management is illustrated by increasing litigation related to EA matters in Canada (Figure 2.6). This increase is notwithstanding the fact that, following legislative changes in 2012, there are several thousand fewer EAs now being conducted at the federal level (CEAA, 2017).

The complexities created by large-scale policy issues (e.g., climate change) and a shifting social context characterized by "the decline of deference, fragmentation, risk aversion and modern communications" have been identified as factors contributing to a lack of public trust in energy authorities (Cleland *et al.*, 2016). Additionally, the information needed to promote public trust in decision-making is not always available or accessible (Booth & Halseth, 2011; Cleland *et al.*, 2016).

Pipelines, hydroelectric dams, and wind turbines are all examples of development projects that have witnessed a range of public attitudes including opposition, which sometimes differ geographically (Shaw *et al.*, 2015; Parkins *et al.*, 2017). Trust may be lost over time if communities feel there is an absence of procedural and distributive fairness in governance decisions (Shaw *et al.*, 2015). As explained by Shaw *et al.* (2015) in relation to energy projects, "a lack of trust developed because many communities saw government as a facilitator of project development rather than an arbiter of costs and benefits." The costs of a lack of trust are felt in the time, energy, and resources spent repairing relationships (Booth & Halseth, 2011) or compensating for past wrongs.



Data Source: CANLII, 2018

Figure 2.6

Proportion of Canadian Court Decisions That Include the Term "Environmental Assessment," 2002–2017

In general, the proportion of court cases (number of cases per thousand) for which decisions include the term *environmental assessment* has been increasing in Canada since 2002.

2.2 THE INTEGRATION IMPERATIVE

In the Panel's view, all of the drivers identified above point to the need to better integrate natural resource management. Others have recognized the need for INRM, with Gillingham *et al.* (2016) terming it an *integration imperative*. INRM includes knowledge collection, analysis processes, and governance structures designed to take a broader perspective on environmental, social, and economic impacts, and considers a diversity of knowledge and views in decision-making. This section draws a tighter link between the drivers set out above and INRM features that could be particularly effective in responding to each.

The Business Council of Canada has called for changes that increase public confidence in decision-making, clarify regulatory requirements, produce clear results in a timely manner, and make Canada a good place to invest (BCC, 2017; Manley, 2017). In this context, strategic and regional assessments are identified as forums for addressing broader policy issues and cumulative effects. Similarly, they identify the need for new forums to engage with the public on important

policy issues in order to "avoid the tendency to try and hold individual project assessments accountable for broader societal issues and impacts" (BCC, 2017). Canada's Economic Strategy Table on Resources of the Future has suggested piloting regional impact assessments that can help guide project approvals as part of the implementation of Bill C-69 (CEST, 2018). There appears to be growing support for the idea that regional approaches could be a tool for overcoming current regulatory burdens and uncertainty.

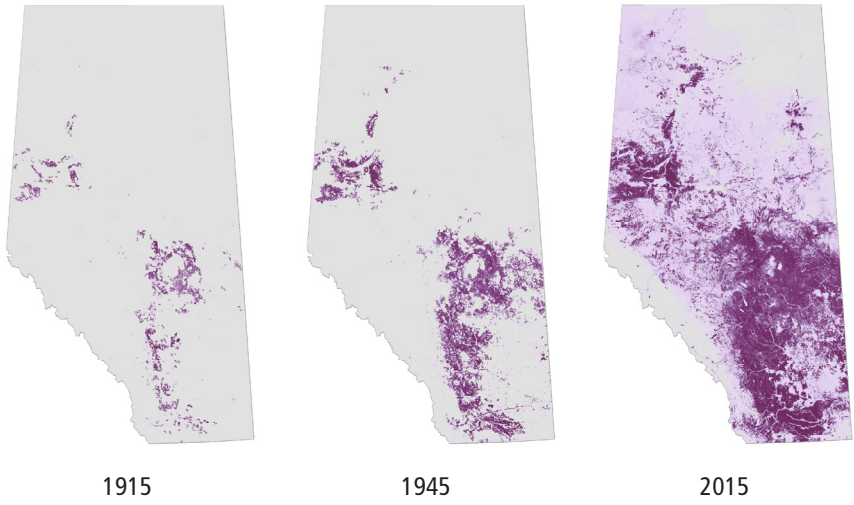


Figure 2.7

Land-Use Changes in Alberta, 1915–2015

Alberta has seen extensive changes in land use over the past century. The maps show the increase in anthropogenic land use in terms of coverage and density from 1915 to 2015. The point of 1945 was selected because it precedes the emergence of the oil sector in 1947, which has generated substantial economic growth, thereby stimulating population growth and subsequent expansion of other sectors.

Indeed, the Government of Alberta has recognized that growing demand and expansion of multiple natural resource uses, and subsequent impacts on the landscape, call for integration (Gov. of AB, 2008). In Alberta, agriculture, logging, energy, and mining industries have expanded their footprints considerably since the 1950s, alongside other land uses such as human settlement and transportation. Increased natural resource production, especially hydrocarbon extraction but also agriculture and forestry, led to economic growth and, as a result, population growth and expansion of settlements. Figure 2.7 shows the combined changes between 1915 and 2015 in Alberta's five major land uses: agriculture, forestry, oil and gas, transportation, and human settlement. The large changes observed after 1945 coincide with the first major crude oil discovery (Leduc No. 1 oil well), while agriculture — which has also increased in extent and intensity — remains the dominant land-use footprint in the province. In announcing its Land Use Framework, Alberta explicitly recognized that "what worked before will not work for the future" (Gov. of AB, 2008).

As environmental stressors become more complex, there is a need for novel integrated approaches that enable assessment of the cumulative effects of these stressors on ecosystems. There is consensus among scientists, governments, and Indigenous leadership that more integrated approaches to the management of cumulative effects are needed to ensure the sustainability of environmental systems (Noble, 2015a). The Panel notes that a significant challenge associated with managing cumulative effects is the need for knowledge and collaboration that extend well beyond the scale and scope of individual project reviews and project-based decisions. Therefore, managing cumulative effects requires:

- knowledge about how environmental, social, and economic conditions change over time in response to a combination of multiple anthropogenic and natural stressors;
- long-term monitoring at multiple spatial scales;
- assessments of how changes in environmental conditions affect people; and
- new collaborative leadership models and a coordinated and integrated approach to management and decision-making about resource use and allocation.

The importance of natural resources to Canada makes the country particularly sensitive to any changes that affect them, such as climate change, and calls for management approaches that can better balance competing interests in a changing environment.

In addition, as noted throughout this report, natural resources and the environment in general do not respect spatial or jurisdictional boundaries. Negative environmental impacts from natural resource projects outside of these boundaries may travel by air, water, or wildlife onto land far from the source. This phenomenon, as well as the number, size, and pace of development activities, has made Indigenous people "increasingly concerned about the cumulative effect that numerous projects on the landscape are having on their ability to exercise their rights" (Olszynski, 2016). Additionally, there is growing recognition of the importance of meeting the duty to consult and achieving free, prior, and informed consent for every resource project that impacts the rights of Indigenous Peoples. In the Panel's view, INRM processes that emphasize ongoing regional consultations support meaningful engagement and thereby facilitate meeting the duty to consult at the project level effectively and efficiently. At the same time, the knowledge and practices of Indigenous Peoples are now seen to enhance effective resource management (e.g., Berkes, 2018). Finally, unresolved land claims create obligations for non-Indigenous governments in terms of resource management, but also create opportunities to implement INRM processes based on partnerships between non-Indigenous and Indigenous governments.

Changes to the *Fisheries Act* alongside the new *Impact Assessment Act*, will affect natural resource management in Canada. The *Impact Assessment Act* will provide for, but not mandate, regional assessment and strategic assessments. Sustainability and cumulative effects are both important concepts in these regimes and yet their project-by-project focus undermines their ability to consider them.

Finally, restoring the public's trust in natural resource management is important to the integrity of the decision-making process. Bringing together different actors and priorities for land use in an equitable, transparent, and responsible way is essential to INRM. The planning and incorporation of science and other sources of knowledge that occur in INRM can facilitate better-informed decision-making and restore trust. The way that many integrated approaches bring together different voices in a long-term and cooperative process further encourages decision-makers who seek to avoid conflict (including legal battles) and fosters trust among both participants and observers.

2.3 CONCLUSION

In the Panel's view, many current practices for managing natural resources are becoming increasingly untenable from environmental, social, and economic perspectives. Conventional approaches to resource management are being challenged by growing demand for a range of resources and by environmental changes — including climate change. Other changes include recognition of the rights of Indigenous Peoples and a commitment to reconciliation, increasing legal complexity, and mounting public distrust in resource decision-making. The six drivers described in this chapter call for an urgent rethinking of natural resource decision-making in Canada. INRM holds promise as a means for considering complexity, multiple scales, and varying interests, and bringing these together to make reasoned decisions. Some INRM features that are particularly well suited to addressing today's challenges include extensive engagement processes, regional orientation, evaluation of trade-offs, and inclusion of all relevant jurisdictions. Having established the importance of INRM for Canada, the next chapter proceeds to unpack the concept and identifies its eight defining characteristics.

3

Understanding INRM: Eight Defining Characteristics

3 Understanding INRM: Eight Defining Characteristics

Key Findings

The value of INRM comes from applying knowledge to decision-making through carefully designed and implemented governance processes.

The Panel established the following eight defining characteristics of INRM:

- Pursues clear and comprehensive goals and objectives
- Plans, manages, and monitors at appropriate geographic scales and timeframes
- Engages all relevant jurisdictions
- Involves rights holders and interested and affected parties
- Weighs multiple values, uses, and functions
- Assesses alternatives and trade-offs
- Includes multiple ways of knowing
- Addresses uncertainty

This chapter introduces defining concepts relevant to INRM, laying the groundwork for more detailed descriptions and analysis in Chapters 4 through 6. INRM is an inherently complex undertaking, and the challenges are magnified by the lack of a common understanding of the concept among practitioners and policy-makers. To structure its analysis and clarify its own interpretation of INRM, the Panel explored the state of knowledge of INRM under two broad themes: knowledge and governance. The analysis was supported by the Panel's identification of eight defining characteristics related to knowledge and governance (Figure 3.1) that were derived from an extensive body of existing work (e.g., Lang, 1986; Margerum, 1999; Pavlikakis & Tsihrintzis, 2000; Douthwaite *et al.*, 2004; Kennett, 2004; CILMC, 2005; Keough & Blahna, 2006; Slocombe & Hanna, 2007; Carlson & Stelfox, 2009; Mitchell *et al.*, 2014; Parkes *et al.*, 2016).

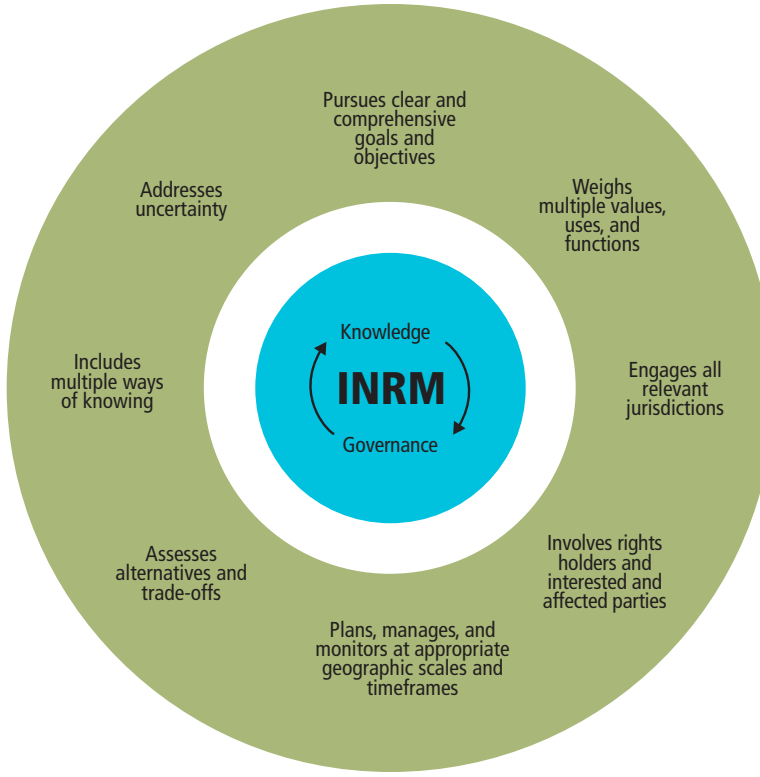


Figure 3.1

Defining Characteristics of INRM

INRM, as described by the Panel, has eight defining characteristics. These characteristics relate to both the creation and application of knowledge, as well as to the development and implementation of meaningful governance processes.

3.1 INRM PURSUES CLEAR AND COMPREHENSIVE GOALS AND OBJECTIVES

In the Panel's view, the identification and pursuit of clear and comprehensive goals and objectives — related to both process and desired outcomes — is a defining INRM characteristic. Goals may be elevated, aspirational, and not directly assessable, but objectives need to be practical and measurable. For example, a process goal could refer to ensuring transparency and a corresponding objective could be ensuring public release of all results from monitoring within a certain timeframe; an outcome goal could be maintaining river health and

a corresponding objective could be keeping pollutant levels below a given threshold. Goals and objectives may be environmental, economic, social, and/or cultural depending on the specific context.

Setting and communicating clear goals and objectives allow all participants to keep decision-makers accountable for those targets (Roach & Worbets, 2012). Assessment against measurable objectives helps ensure that a given initiative can be re-evaluated and improved or replaced if necessary (Meredith, 1997). Clear goals and objectives also help all participants to work with a shared understanding of the management actions. While goals can relate to a common vision, ambiguous objectives lead to misinterpretation, which in turn can generate different and conflicting management actions on the same landscape (Lang, 1986).

Ideally, there is a consensus on general goals among all relevant actors (Sayer *et al.*, 2013). Common goals developed by all participating actors can reveal shared priorities (Margerum, 1997) and an overall vision on how management should proceed. In the absence of shared goals and vision, "decision making is more likely to be influenced by the disjointed array of jurisdictional mandates and their self-generated needs, priorities, and responsibilities" (Halseth *et al.*, 2016). While in some cases there may be conflicts about goals, being clear about which goals have consensus and which do not can support weighing of multiple values, uses, and functions, and assessment of alternatives and trade-offs.

3.2 INRM PLANS, MANAGES, AND MONITORS AT APPROPRIATE GEOGRAPHIC SCALES AND TIMEFRAMES

Geographic and temporal scales are critical when it comes to natural resource management. To date, however, the assessment of natural resource development impacts has measured short timeframes and local scales relating to a specific project. In the absence of a larger scale and longer-term vision, decision-makers often do not have the information needed to make the most effective management decisions. The Panel considers the identification of relevant geographic scales and timeframes to be an INRM characteristic. Reflecting on the broader landscape over longer periods of time can support more informed and effective management decisions.

The impacts of land and natural resource uses can occur at different time scales or have time-dependent impacts. For instance, expanded hunting and trapping opportunities in an area can have immediate economic benefits locally

but may also have longer-term impacts on ecosystem functions over a larger area by altering predator-prey relationships. Geographic impacts associated with a given use of natural resources may vary by scale. For instance, at a local scale, the expansion of agricultural activity may cause habitat loss when a forest is converted to a farm, whereas at a larger scale there could be downstream impacts on water availability and quality. Folke *et al.* (2007) conclude that "environmental and renewable resource issues tend to be neither small-scale nor large-scale but cross-scale in both space and time."

Existing management boundaries create challenges in implementing integrated approaches, since management areas are often not aligned with ecological systems such as watersheds (Slocombe, 1993). These arbitrary boundaries may force multiple disconnected groups to manage the same ecosystem or environmental area. The disparate and often conflicting mandates of these groups can lead to uncoordinated or incompatible management actions that can cause cumulative effects on the landscape (Slocombe, 1993).

Implementing INRM across multiple scales does not mean adopting the widest possible scope. Each planning or management initiative needs to identify its own relevant scales to avoid including too many timeframes or geographic areas. Indeed, it is important to establish realistic boundaries to ensure that the policy, planning, management, and decision-making processes remain manageable (Slocombe & Hanna, 2007). INRM is as comprehensive as it is practicable. Additionally, overarching large-scale INRM processes can support smaller-scale decision-making processes. Higher-order processes upfront (e.g., planning at a regional scale) can allow for more efficient and coordinated project-level decision-making moving forward.

3.3 INRM ENGAGES ALL RELEVANT JURISDICTIONS

Coordination within and across governments is necessary to inform and implement INRM decision-making since, as implied above, the suitable geographic scales for decision-making in INRM often span multiple jurisdictions. In Canada, integration across jurisdictions includes consideration of the multiple orders of governance with distinct and overlapping mandates and responsibilities. Integration within a jurisdiction involves different departments or agencies at the same level of government working together when, for instance, a project triggers several regulatory requirements under the mandate of multiple departments or agencies.

3.4 INRM INVOLVES RIGHTS HOLDERS AND INTERESTED AND AFFECTED PARTIES

Integrated approaches bring together all the relevant rights holders and interested and affected parties. This involves consulting, collaborating, and making decisions with a broad array of relevant people, parties, and groups. These actors may have different, and even competing, interests and priorities. A wide range of groups and individuals may consider themselves to be interested or affected parties when it comes to resource decision-making, particularly when impacts of development are not merely local in scale (e.g., climate change). Integrated approaches consider the priorities of a wide group and make trade-offs to manage the land. Effective engagement and consensus-building has been key to the success of many natural resource projects (Wondolleck, 1985; Schneider *et al.*, 2003).

While many actors may have an interest, rights holders have a specific entitlement relevant to resource management decisions. Governments, industry, Indigenous Peoples, and individuals can all be rights holders. In addition, multiple groups may hold rights over the same land area (e.g., a company may hold surface rights to harvest timber while a province or another company holds subsurface rights to minerals).

Resource management approaches may include a smaller number of actors — typically the proponent of a new land use and a group that oversees land uses in that area. In some cases, governments have been reluctant to engage others, concerned this could compromise their sole decision-making authority (Goetze, 2004; Slocombe & Hanna, 2007). However, INRM is based on careful design to allow the priorities of other actors co-located in the same area and influenced by new land uses to be considered. For example, new exploration for fossil fuels may affect local timber harvest or agricultural growth. Ensuring the meaningful involvement of all actors in INRM is an important part of the governance process; overcoming any challenges can ultimately benefit the INRM process.

3.5 INRM WEIGHS MULTIPLE VALUES, USES, AND FUNCTIONS

Integrated approaches consider and weigh multiple natural resources and land uses in a given geographic area over time. This involves collecting information from all relevant actors on current and potential land uses and weighing all options. INRM recognizes that natural resources and land uses are not limited to extractive industries. Instead, all natural resources and land uses from which humans derive value are important to this process, including social and cultural uses and other ecosystem services.

For Indigenous Peoples in Canada, the use of natural resources, or simply the land itself, is fundamental to way(s) of life beyond their purely economic value or functional use (RCAP, 1996b; Lewis & Sheppard, 2005; Ehrlich, 2010; Mameamskum *et al.*, 2016). Indigenous Peoples have used lands for subsistence as well as for social, cultural, or spiritual purposes for milennia. These values influence their views and reactions to proposed natural resource development projects (Lewis & Sheppard, 2005; Ehrlich, 2010).

Actors may have varying priorities for a given land use. Identifying each actor's priorities facilitates collaborative work and identification of mutually agreeable solutions (Slocombe & Hanna, 2007). Since "value conflicts are at the center of making responsible trade-offs, it is important… to provide an environment in which participants feel they can speak freely and to evoke emotions as well as logical thought" (Gregory *et al.*, 2001). Strictly regulatory or quantitative approaches have typified the past; however, INRM explicitly invites a broad range of values, including those not typically quantified, to the decision-making table and uses those values to inform the entire process.

3.6 INRM ASSESSES ALTERNATIVES AND TRADE-OFFS

Natural resource management almost certainly involves overlapping or conflicting plans for how land uses should be assigned (Brown *et al.*, 2005; Sayer *et al.*, 2013). To reconcile these conflicts, INRM encourages the evaluation of different management alternatives and comparison of the trade-offs inherent in each option. This evaluation forces decision-makers to think through their intended actions, the possible consequences of those actions, and the priorities underpinning their initial choices (Failing *et al.*, 2007). Evaluating the trade-offs of different management scenarios implicitly acknowledges the fact that true win-win scenarios for all actors can rarely, if ever, be achieved (McShane *et al.*, 2011). Judgments about trade-offs are value-laden, with each participant having a different view about their ideal resource management approach. Integrated approaches do not attempt to accommodate each participant's ideal scenario, but instead attempt to find reasonable trade-offs that everybody can live with and understand (Schneider *et al.*, 2003; McShane *et al.*, 2011). In some cases, this may mean that projects may not proceed at all. For instance, the Screech Lake Uranium Exploration Project in the Mackenzie Valley was rejected because "the Upper Thelon area is of high spiritual and cultural importance to the Akaitcho and other aboriginal peoples… The Review Board is of the view that although the proposed development is physically small, the potential cultural impacts are not" (MVEIRB, 2007).

3.7 INRM INCLUDES MULTIPLE WAYS OF KNOWING

A range of knowledge sources and ways of knowing are needed to deal with the changes and shifts in the systems in which natural resource development occurs (Tengö *et al.*, 2014, 2017). Consideration of a combination of knowledge sources can provide a more complete picture of the situation at hand. For example, it can increase the likelihood of including a variety of timeframes and geographic boundaries, leading to better understanding of interactions across temporal and spatial scales (Laidler, 2006; Reid *et al.*, 2006; Gagnon & Berteaux, 2009; Rathwell *et al.*, 2015).

Integrated approaches bring together diverse ways of knowing and a wide range of knowledge sources to make effective environmental decisions (Tengö *et al.*, 2014). In INRM, the political or legal understanding that policy-makers bring to the table is not the only source of knowledge considered. A range of knowledge holders, such as scientists, resource industry representatives, hunters and trappers, and local residents including Indigenous Peoples, may all be able to provide insight on a natural resource management issue, applying both Western scientific knowledge and ILK to decision-making.

3.8 INRM ADDRESSES UNCERTAINTY

Natural systems are non-linear and inherently uncertain, making system interactions and processes hard to predict (Berkes *et al.*, 2003). Uncertainty may be encountered in the inherent nature of data, of forecasts, and of the efficacy of proposed management actions (Failing *et al.*, 2007; York, 2013; Rosa *et al.*, 2014). Uncertainty may increase due to phenomena such as climate change, where both the changes and the response of ecosystems to these changes are uncertain (Dietz, 2017). The lack of stationary natural states resulting from climate change also reduces the ability to project future conditions and thus creates and/or exacerbates uncertainty.

INRM explicitly considers and incorporates uncertainties into decision-making whenever possible. Dealing with uncertainty becomes even more important in INRM as the additional natural resources and scales included in an integrated process can increase the overall complexity and resulting uncertainty (Parkes *et al.*, 2016; DeFries & Nagendra, 2017). Uncertainty is not static, however, and some types may be reduced over time as new knowledge is acquired and integrated into management decisions. Adaptive management that explicitly recognizes uncertainty, seeks to reduce it, and adjusts management strategies in response to monitoring and analysis is an important feature of INRM.

Uncertainty about identifying the best possible management option need not paralyze natural resource management. "In the end," Failing *et al.* (2007) note, "we have to rely on the judgment of concerned and engaged people to evaluate the fact and value-based claims relevant to a decision and make a reasoned and informed choice." Indeed, considering uncertainties allows all participants to be fully aware of potential limitations and risks (Failing *et al.*, 2007).

3.9 CONCLUSION

While the Panel stressed that there is no "one size fits all" approach to INRM, the lack of a shared understanding of INRM acts as a barrier to progress. Therefore, the Panel identified the eight characteristics described above to clarify the concept of INRM and support a shared understanding. The context of each situation is important, and determines the relevance of each of these characteristics. However, in the view of the Panel, any initiative that does not strive to meet these characteristics has not undertaken the most robust efforts to implement INRM. The rest of this report draws on these characteristics to help interpret the state of research and practice of both knowledge and governance.

4

The Role of Knowledge in INRM

- Contextualizing Knowledge for INRM
- Knowledge and Ways of Knowing
- Organizing and Sharing Knowledge
- Application of Knowledge: Planning and Managing for the Future
- Conclusion

4 The Role of Knowledge in INRM

Key Findings

The complexity, uncertainty, and multiscaled nature of natural resources call for a commensurate sophistication in the knowledge used to inform decision-making.

INRM takes advantage of all relevant knowledge and ways of knowing. In Canada, Western science and ILK are particularly relevant for INRM. Successful knowledge bridging respects each way of knowing, while facilitating linkages and communication among different ways of knowing.

Tools exist for sharing knowledge and applying knowledge to decision-making across the INRM continuum. Key tools for applying knowledge across the continuum include regional planning, strategic EA, threshold analysis, trade-off analysis, cumulative effects assessment, adaptive management, and monitoring and baseline studies.

The state of knowledge does not justify delaying INRM implementation. INRM provides the means to make the best use of existing knowledge and expand it over time. Knowledge is fundamental to INRM processes. It helps actors to: understand the state of the environment and social-ecological systems in which natural resources reside; predict the impacts that will occur as a result of management decisions; and monitor those impacts and cumulative effects. Knowledge is therefore the foundation on which actors make informed decisions and implement adaptation measures to react to changing environments and conditions. This chapter begins by highlighting the contextual considerations that influence knowledge requirements in INRM. It goes on to discuss two of the key ways of knowing relevant to INRM in Canada and the importance of bridging knowledge, then describes tools available for organizing and sharing knowledge, and tools that can support the effective application of knowledge to planning and ongoing management efforts.

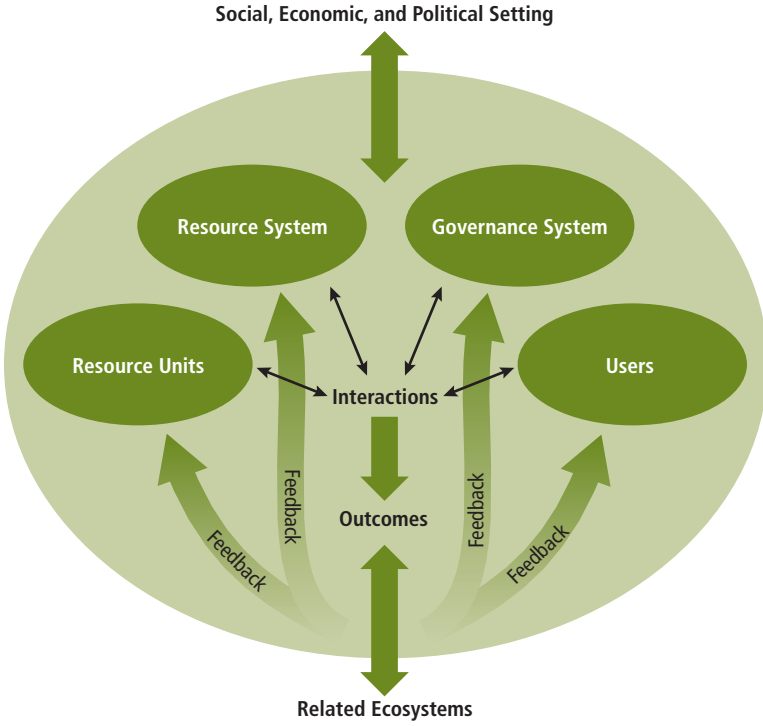
4.1 CONTEXTUALIZING KNOWLEDGE FOR INRM

The context-specific knowledge required to inform INRM presents unique challenges as natural resources: are highly connected to each other and to human actions; exist at many different temporal and spatial scales; and may not be characterized with a high degree of precision.

4.1.1 Understanding the Complexity of Social-Ecological Systems

The complexity of the systems in which individual resources exist — and of the interactions among those systems — influences the knowledge requirements of any effective resource management decision protocol, including INRM. A system-based approach encompasses the social, economic, and environmental dimensions of INRM and their interconnections (Parkes *et al.*, 2016). While the ecological connections among resources (e.g., predator-prey relationships) are well recognized, connections among the social and ecological aspects of an environment (e.g., effects of tourism on wildlife habitat and vice versa) are not always considered. Social-ecological systems, defined as "[i]ntegrated, coupled systems of people and environments" (Armitage *et al.*, 2009), comprise a range of interrelating components whose interactions have an effect on outcomes (Ostrom, 2009). These components are: (i) resource systems (e.g., a forest); (ii) resource units (e.g., trees); (iii) governance systems (e.g., the government agency and other organizations involved in forest management, and the rules related to forest use); and (iv) users of the resource, all of which exist in specific social, economic, and political settings and related ecosystems (Figure 4.1). It is important to recognize how human factors influence social-ecological systems, as these may not be considered in some integrated approaches to resource management. While the Panel chose to use the term *social-ecological system*, it notes that other terms exist to describe systems that include social, economic, and environmental factors.

Managing natural resources within a complex social-ecological system requires many sources of knowledge and the integration of multiple perspectives (Berkes *et al.*, 2003; Dietz, 2013b, 2017). These perspectives can include all actors in the system: experts from different disciplines, a diversity of interest groups (e.g., local citizens, industry associations, NGOs), governments and rights holders, and affected parties. Fundamentally, integrating these perspectives increases the range of knowledge and allows decision-makers to better understand the system to be managed. Ultimately, however, all systems are inherently uncertain, and decision-makers will never have complete knowledge of all components in a social-ecological system.



Source: Adapted from Parrott *et al.* (2012) modified from Ostrom (2009; reprinted with permission from AAAS)

Figure 4.1

A Social-Ecological System

A social-ecological system comprises strongly connected components that interact and mutually affect each other (components illustrated within the oval). This system exists in the context of human factors (their specific social, economic, and political settings), as well as related ecosystems. A social-ecological framework helps to identify relevant variables for studying a given system, and provides a common set of variables for organizing studies of similar systems (Ostrom, 2009).

4.1.2 Data at Multiple and Nested Scales

The importance of broader spatial and temporal scales is a significant characteristic of INRM that separates it from other integrated management approaches. In the experience of the Panel, the larger regions and longer timeframes relevant for INRM are typically underrepresented by existing research and monitoring efforts.

Addressing a process at the wrong scale can lead to incomplete, and in some cases incorrect, representations (Millennium Ecosystem Assessment, 2005a). Considering the appropriate geographic scales recognizes that natural resources and their management occur at widely diverse geographic scales (Lovell *et*

al., 2002; Hein *et al.*, 2006) — from the very local (e.g., an open-pit mine) to the global (e.g., airshed), and from the stationary (e.g., hydroelectric dams) to the distributed (e.g., river system) and dynamic (e.g., migrating caribou). Although the region covered by a management regime will have geographic boundaries, some effects cannot be kept within these boundaries. For instance, poor management of effluents can lead to large-scale contamination downstream from wastewater treatment plants, farms, or manufacturing plants.

Relevant time scales in INRM are often long, as these enable consideration and understanding of long-term effects of land uses. This means a development that changes the landscape and the future reclamation of that land are both considered — something shorter time scales may fail to do (Kennett, 2004). Integrating temporal scales also means finding ways for different planning processes to feed into one another. Although planning for the long-term use of an area is becoming more common, integrating temporal scales goes further. The frequency of events on the landscape is also relevant — these can be episodic, cyclical, recurrent, ephemeral, or continual (Lovell *et al.*, 2002). Human activities similarly occur at diverse time scales; small construction projects occur at shorter, more sporadic time scales, whereas urban sprawl may occur over longer periods at more predictable frequencies.

In the absence of human activity, ecosystems are not static. Over time, any region exhibits natural ecological variability, meaning natural conditions might deviate significantly from the average state of that region and will vary among regions. *Natural variability* can be defined as "the ecological conditions, and the spatial and temporal variation in these conditions, that are relatively unaffected by people, within a period of time and geographical area appropriate to an expressed goal" (Landres *et al.*, 1999). Establishing natural variability requires historical knowledge of the condition of a given area over a set of temporal and geographical scales relevant for the processes of interest. INRM recognizes the importance of considering natural variability rather than a region's average condition, because it can support adaptive management through achievable goal-setting, and provide an understanding of both the conditions needed to maintain ecosystem health and the impact of human activities in a region relative to its unaltered state (Landres *et al.*, 1999; Wong & Iverson, 2004).

Considering multiple geographic scales and timeframes allows integrated approaches to work over larger and longer scales while still maintaining effective action in local areas and over shorter timeframes. Focusing on multiple spatial scales increases the chances that broad-scale, overarching goals are brought to fruition through local management activities. However, this does not mean that INRM always adopts the widest possible scope.

4.1.3 Acknowledging and Dealing with Uncertainty

Uncertainty is an inevitable part of managing natural resource systems and affects the collection, interpretation, and sharing of knowledge among actors. As discussed above, some of the uncertainty derives from the complexity of the social-ecological systems, or from gaps in actors' knowledge. Risk in natural resource management generally refers to the likelihood that some undesirable state will occur, and consists of both the probability of occurrence and the distribution and severity of an impact (Renn, 1992; Stankey *et al.*, 2005). A major problem in current resource management practices is that practitioners, managers, and decision-makers often fail to disclose and adequately deal with uncertainties (Leung *et al.*, 2016). Uncertainty can result in unintended management outcomes, or deter managers from making necessary decisions. Additionally, the failure to acknowledge uncertainty can lead to a discrediting of science when unexpected events lead to outcomes different from those predicted (Stankey *et al.*, 2005).

INRM has a greater need to consider uncertainty compared to single-project resource management because its greater temporal and geographic scales increase both overall complexity and uncertainties (Parkes *et al.*, 2016; DeFries & Nagendra, 2017). The challenge lies in where and how to incorporate uncertainties into the management process, since they are not static and may change over time. Consideration is given to the *location* of uncertainty (i.e., whether it is attributed to assumptions about ecological processes, limited data, or other factors), the *level* of uncertainty (i.e., whether probabilities are known or whether uncertainty is systemic), and the *nature* of uncertainty (i.e., whether it can be sufficiently resolved by more data or information) (Petersen *et al.*, 2013). As explained by Berkes *et al.* (2003), the management of social-ecological systems should be "adaptable and flexible, able to deal with uncertainty and surprise, and [built with] capacity to adapt to change." The Panel notes that these objectives (adaptability, flexibility, ability to deal with uncertainty) are achieved if management systems include the INRM characteristics discussed in Chapter 3. Section 4.3 briefly outlines specific tools that can help meet these important objectives.

4.2 KNOWLEDGE AND WAYS OF KNOWING

Knowledge can come from a broad range of disciplines, data types (e.g., qualitative, quantitative), and ways of knowing (i.e., the process by which information is known). Designers of INRM processes need to be inclusive in identifying a full range of knowledge sources, beyond what is available within their own institution. Although recognition of the relevance of different ways of knowing is not new, wider engagement and legal requirements are currently pushing forward the meaningful practice of using diverse forms of knowledge.

This includes emerging tools and approaches for bridging and sharing different ways of knowing, enabling their integration into decision-making. This section focuses on Western science and ILK in particular because of their relevance to INRM in the Canadian context. The Panel notes, however, that other important knowledges and ways of knowing may inform INRM processes. For example, some local knowledge that informs resource management is not necessarily associated with Indigenous Peoples. This includes the knowledge of commercial fishers, which has allowed for stock assessments and/or mapping of seabeds in many coastal regions around the world, including in Canada (Haggan *et al.*, 2007).

4.2.1 Western Scientific Knowledge

Western scientific knowledge draws on a wide range of disciplines and sources, many of which play important roles in INRM. The natural and physical sciences offer evidence about the current state of an environment and how development is changing it. Social sciences provide insight into how the development of natural resources affects communities and the interactions among communities, governments, and businesses. Similarly, knowledge arising from the fields of health, business, and law informs the multiple values, uses, and functions that support effective INRM.

Several properties of Western science are beneficial for INRM decision-making. For instance, it is communicated using products that are easily transferable (e.g., scientific papers) and can often be applied to more than one case or locale because there is often an emphasis on general rules and principles rather than localized understanding. Western science may also condense and convert information into more easily manageable formats (e.g., converting animal migrations into marked pathways on a map) (Löfmarck & Lidskog, 2017). These traits enable people to gather and combine scientific knowledge from a range of sources. Western scientific knowledge can also be tested, replicated, and revised as needed. INRM actors use different pieces of scientific knowledge from a range of sources to inform policy and adapt decisions, even as new knowledge is created or existing knowledge is changed. Western science is the dominant knowledge source for describing global effects and processes such as climate change (Reid *et al.*, 2006).

The breadth of Western scientific disciplines and sources yields a correspondingly wide range of types of knowledge. Scientific knowledge can be descriptive, qualitative, or quantitative in nature, and based on a variety of methodologies, each with individual strengths and weaknesses. For example, it can stem from experiments, observation of natural phenomenon in the field, interviews with people, or legal proceedings. The questions asked, however, and therefore the people asking the questions, constrain scientific knowledge. For example,

the National Inuit Strategy on Research (NISR) notes that current research investments in Inuit Nunangat "reflect a biological–physical science research bias" to the detriment of other Inuit research priorities (e.g., health), and that funding eligibility criteria tend to preclude Inuit organizations from being principal investigators (ITK, 2018). The NISR seeks to improve the impact and usefulness of research carried out in Inuit Nunangat for the Inuit through actions to support capacity building in Inuit Nunangat; align funding with Inuit priorities; and ensure data are accessible to, owned, and controlled by Inuit (ITK, 2018).

A number of actors and sectors generate scientific knowledge related to natural resources, such as researchers and practitioners working in academia, government, industry, and NGOs. This knowledge is contained in articles, books, reports, or statements from consultants, in company consortia, or in professional societies; data compiled from baseline studies and monitoring activities; and institutional and sector-specific knowledge about what is practical for implementation.

4.2.2 Indigenous and Local Knowledge

Engagement of Indigenous Peoples and local communities for knowledge gathering is important for many reasons, including the practical fact that those who live and/or work in a region have experience with the land in which INRM takes place (Brondizio & Le Tourneau, 2016; Tengö *et al.*, 2017). Indigenous people are the experts of their own land and observers of ongoing changes in the environment. ILK, or traditional ecological knowledge, may be defined as "a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes *et al.*, 2000).[3] Importantly this definition recognizes that ILK exists as a way of life for holders rather than simply a collection of information that can be codified for use elsewhere. Practitioners of ILK may subscribe to protocols (which have been described as caretaking and stewardship) that cannot be separated from how they pursue inquiry (Whyte *et al.*, 2016). ILK informs the decisions, policies, and actions of its holders' communities as they interact with the world around them. Many Indigenous people consider ILK to be an empowering part of their identity as it is unique to their locality and culture (Usher, 2000).

3 Inuit Qaujimajatuqangit (IQ) is a concept unique to Inuit that can be defined as "encompass[ing] all aspects of traditional Inuit culture including values, world-view, language, social organization, knowledge, life skills, perceptions and expectations" (Anonymous, 1998 as cited by Wenzel, 2004). As such, IQ includes social, economic, and cultural issues (Wenzel, 2004; Tester & Irniq, 2008).

ILK often operates at different temporal and geographic scales than Western scientific knowledge: it is generally based on observations of the land, experience, practice, and relationships at a local scale (Cash *et al.*, 2006). ILK is also often temporally deep, in that it takes into consideration long periods of observation of environmental changes (Stevenson, 1996). These forms of knowledge may also be characterized as holistic, oral, qualitative, and intuitive (Nadasdy, 1999).

Even though they are complementary, ILK and Western science are based on different worldviews, assumptions, and rules (Pierotti, 2011; Kimmerer, 2013; Berkes, 2018). Whyte *et al.* (2016) explain that "Indigenous protocols may approach the human condition as not a struggle to know the universe; the condition rather is to know ourselves well enough so we can act morally in the universe." In government and sustainability sciences, many practitioners may follow a protocol of management (e.g., wildlife as a resource to be managed), as opposed to the protocol of caretaking and stewardship of ILK practitioners (Berkes, 2009; Whyte *et al.*, 2016).

Including ILK in environmental decision-making both challenges and reconsiders the assumptions and rules of Western science (Armitage *et al.*, 2011; Whyte, 2013), but also can support and strengthen Western scientific knowledge (Williams & Hardison, 2013; Ban *et al.*, 2018). For example, the understanding of climate change is enhanced through local knowledge from multiple observation points; this extends the geographical coverage of science, ground-truths scientific data, and provides insight into the impacts of change and adaptation options (Savo *et al.*, 2016).

It is important to recognize that ILK is not merely an add-on to Western science. INRM can be supported by the inclusion of ILK-holders from the inception of a study, all the way to its eventual use in decision-making. Different objectives among different actors are not necessarily a problem, as deliberation and negotiation can foster common objectives (Davidson-Hunt & O'Flaherty, 2007). ILK in practice is involved in negotiating research agreements, contracts, or protocols among research partners. Scientists, ILK holders, and others interact to address the research questions and study methods as jointly defined, to deliberate on the relevant evidence and convincing forms of argument, and to decide how to use the co-produced knowledge (Kates *et al.*, 2001; Manseau *et al.*, 2005; Clark *et al.*, 2016).

An added value of ILK comes from the interpretation of this knowledge by Indigenous and local communities (Bowie, 2013). There is an opportunity for knowledge holders to use their understanding to engage in dialogue about how to improve management practices (Bowie, 2013). It is important

that ILK remains in the control of the people who own it, and that ongoing engagement with knowledge holders occurs (Schnarch, 2004). Often, attempts to integrate ILK and Western science have been criticized for divorcing ILK of its context and reducing it purely to data (Huntington, 2013). This ignores the importance of context and cultural identity in Indigenous knowledge, and often represents an underlying distrust of ILK (Manseau *et al.*, 2005). This concern is extended not only to the knowledge as data, but also to the people themselves. As McGregor (2009) notes: "Aboriginal peoples and their knowledge are viewed as objects suitable for study rather than as people for working with." In addition, assumptions that all local and Indigenous people possess the same level or kind of ILK is incorrect. Another caution is that ILK is not uniform across communities, and even within the same community; different ILK experts may hold different (but legitimate) views and knowledge (Idrobo & Berkes, 2012).

Whyte (2013) notes that ILK should be viewed as a "collaborative concept" that can help create bridges across both cultural (e.g., worldview) and situational (e.g., capacity) divides. As the author explains, the use of ILK in environmental governance should acknowledge that these divides exist; therefore, the assumptions of non-Indigenous people may not apply to Indigenous contexts. In this way, ILK should "invite nonindigenous parties to learn more about how particular Indigenous communities approach fundamental questions of the nature of knowledge and how it fits into their visions of environmental governance" despite the fact that this process is not easy (Whyte, 2013).

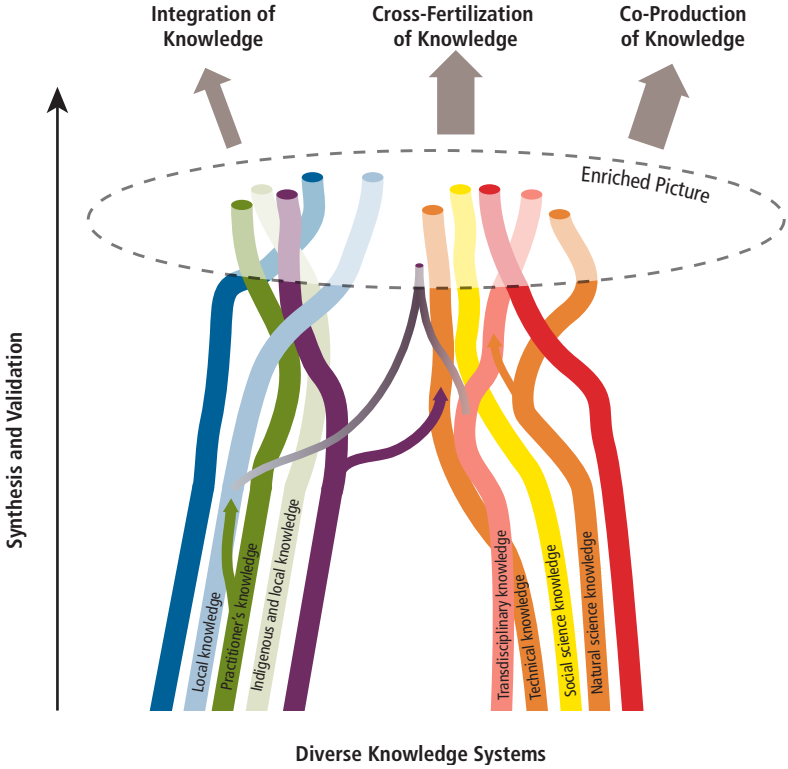
Including ILK in resource management has become more common as management shifts to landscape and ecosystem scales (Menzies & Butler, 2006). ILK has also gained prominence within INRM due to its recognition in addressing Indigenous and Treaty rights, including the Crown's duty to consult, and the current provisions of EA processes (Section 2.1.4). Additionally, the concept of free, prior and informed consent, as described in UNDRIP, relates directly to the "manner in which sharing [of ILK] decisions are made" (Williams & Hardison, 2013). Therefore, any discussion of ILK must include a broader understanding of the role of Indigenous and Treaty rights in the context of environmental decision-making. In this way, the inclusion of ILK is a key mechanism for the inclusion of Indigenous Peoples and Indigenous objectives within INRM processes, although it is only one component of full Indigenous engagement.

4.2.3 Bridging Ways of Knowing

Bridging of ways of knowing can increase the effectiveness of INRM because acknowledgement, engagement, and consideration of multiple forms of knowledge can contribute to better decision-making (Dietz, 2013a, 2017). Each knowledge source can play a valuable role. Scientific knowledge, which is often intended to apply across contexts, is more easily disseminated to different actors than ILK, which is often held by fewer people and may be more context-specific (Huntington, 2013). Nonetheless, when scientific knowledge is applied to resource management, it is usually necessary to "downscale" it to local contexts where data are limited and local dynamics must be interpreted to make the science applicable. Thus, in principle, ILK and science can be strong complements to one another, and INRM can benefit greatly from acknowledging and engaging multiple forms of knowledge.

As mentioned, knowledge sources are often context-specific and may not be validated by each other's systems (Huntington, 2013). The goal of knowledge integration is not to reduce each source of data into one unified collection of information, but rather to consider and weigh each piece of knowledge in the context of its source (Tengö *et al.*, 2014; Berkes, 2018). The information considered and the process used to make these decisions should be conducted in a transparent manner (Roach & Worbets, 2012; Tengö *et al.*, 2014), to help ensure that all actors perceive the process as fair and legitimate.

The consideration of multiple knowledge sources can result in the generation of new knowledge and a better understanding of the social-ecological system under study (Tengö *et al.*, 2014) (Figure 4.2). The new knowledge can help inform the management of natural resources (including ecosystems), and feed back into the decision-making process to support and inform future decisions. This co-production of knowledge can result in improved understanding and management of natural resources. It recognizes and builds on complementary aspects of different types of knowledge, resulting in new insights and innovations and a better understanding of the social-ecological system being studied. Some actors may see the end result as more useful or legitimate due to consideration of multiple knowledge systems (Tengö *et al.*, 2014).



Adapted from Tengö *et al.* (2014)

Figure 4.2

Illustration of a Multiple Evidence Base Approach

Bringing diverse knowledge systems together enables knowledge integration, cross-fertilization, and co-production. Considering an issue from multiple lenses can improve understanding and can ultimately support more effective decision-making.

The sustainability science approach, which overlaps substantially with INRM as defined by the Panel, aims (among other things) to combine different ways of knowing and learning through the processes of co-production (Kates *et al.*, 2001; Clark *et al.*, 2016). Co-production refers to combining different kinds of knowledge as a normative goal: knowledge should be co-produced with the users (Miller & Wyborn, 2018). Co-production does not simply refer to Western science and ILK; it is also about any combination of different kinds of knowledge. Typically, EAs and INRM use natural science knowledge and attempt to integrate physical science data with biologic data. However, as Tengö *et al.* (2014) point out, knowledge co-production must include diverse knowledge systems, such as social science, transdisciplinary science, ILK, and natural science, among others.

Numerous authors have addressed the possibilities for bridging ILK and Western science (e.g., Dei, 1993; Agrawal, 1995; Stevenson, 1996; Nadasdy, 1999; Ingold, 2000; Johnson, 2006; Hill, 2012; Engler, 2013). They agree that, although the differing approaches of the two kinds of knowledge may cause conflict, they may also stimulate a discussion that challenges the status quo and changes how resources are managed. Alternatively, the differing views may remain, with each group learning to respect those of the other (Berkes, 2009). While there are several approaches that can bridge ILK and Western science, there are no well-established methods to bridge the forms of knowledge respectfully, and appropriate approaches will be context-specific (Berkes, 2015; Johnson *et al.*, 2016b). There are instances where it may not be appropriate to bridge knowledge forms at all (e.g., spiritual practices), while in other cases, it could be suitable to go beyond bridging to actually synthesizing different forms of knowledge creatively (e.g., knowledge co-production for conservation) (Berkes, 2015, 2018; Johnson *et al.*, 2016b). For these reasons, it is difficult to establish general protocols for bridging (Berkes, 2015, 2018; Johnson *et al.*, 2016b). Section 6.2 provides a more in-depth discussion of the barriers to bridging ways of knowing and different forms of knowledge, along with examples of how to overcome these barriers.

4.3 ORGANIZING AND SHARING KNOWLEDGE

Regardless of which disciplines or sources of knowledge are used in INRM, they should be transparent and accessible to all actors, along with the decision-making process itself (Roach & Worbets, 2012). Knowledge-sharing is a key concept that underpins INRM: it enhances communication and coordination, supports effective decision-making, increases transparency and accountability, and helps build partnerships (Margerum, 1997; Dale & Newman, 2007; Roach & Worbets, 2012). As Kates *et al.* (2001) note, "[c]ombining different ways of knowing and learning will permit different social actors to work in concert, even with much uncertainty and limited information." Importantly, however, the Panel acknowledges that not all types of knowledge can be shared the same way. The Panel highlights four existing structures and technologies aimed at improving the accessibility of knowledge and facilitating knowledge-sharing: databases, modelling, GIS, and systematic and other reviews. The Panel also notes these structures and technologies have limitations in their ability to be used for sharing ILK, and alternatives may be needed for this purpose (Box 4.1).

Box 4.1
Exchange for Local Observations and Knowledge of the Arctic (ELOKA)

ELOKA recognizes that sharing ILK requires new practices and understanding beyond traditional community and science approaches. ELOKA's goal is to create tools that enable the "collection, preservation, exchange, and use of local observations and Indigenous Knowledge of the Arctic." ELOKA seeks to meet this objective by fostering collaboration between experts residing in the region and visiting researchers, providing support to users and data management, and developing digital tools for ILK. ELOKA strives for projects to be community-driven and for data to be shared ethically with the goal of creating "information and data sovereignty for Arctic residents."

(ELOKA, 2017)

4.3.1 Databases

Databases store large amounts of data that multiple people can access at the same time. Internal databases can facilitate intragovernmental sharing, such as the Data Discovery Portal set up to support data sharing between different ministries in the Government of Alberta (Service Alberta, 2016). Others serve as a conduit for communication with other actors and the public. For instance, the National Forestry Database, as mandated by the Canadian Council of Forest Ministers, shares forest and forest management data among the federal, provincial, and territorial governments (National Forestry Database, 2018). Other relevant examples include Statistics Canada's environmental and resource accounts (StatCan, 2015); the online Canadian Environmental Assessment Registry, which provides information on both potential and current EAs related to projects subject to the federal assessment process (CEAA, 2017); and the Species at Risk Public Registry, an online portal that provides easy access to all information and documents related to the *Species at Risk Act* (GC, 2016b).

Many government departments have developed accessible online data portals that can be used to build maps, such as the Government of Yukon's online map viewer and the Environment and Climate Change Canada Data Catalogue (Geomatics Yukon, n.d.; ECCC, 2018a). While some existing data and mapping tools require GIS knowledge and software, others do not.

4.3.2 Modelling

Modelling allows people to understand and capture the complexity of systems through simulations, and to forecast future states. Multidisciplinary modelling is particularly relevant to INRM because it can process information from multiple scales and calls for the integration of existing models for broader applications. This multiscaled body of knowledge can be used to study systems that are "too large, too slow, or too expensive to experiment with, or when people, unacceptable risks, or irreversible changes preclude real-world experiments" (Vanclay, 2000). Models used in scenario analysis can, for example, combine ecological inputs (e.g., remote sensing) and socio-economic inputs, as well as ILK, and account for the interactions of these components in their outputs (Liu & Taylor, 2002; CILMC, 2005).

INRM applies to multiple outcomes and associated drivers, and thus benefits from integrated assessment models that link across sectors. Sometimes this can be done by using outputs from one model (e.g., a climate model) as input to another model (e.g., a forest or crop model). In other cases, simplified models of processes or sectors are combined into an integrated assessment model that allows consideration of multiple inputs and outcomes (Kling *et al.*, 2017: Weyant, 2017). While all models involve non-trivial uncertainty, they can be useful tools for integrating data and theories and for considering the implications of alternative courses of action across multiple resources of concern (Kling *et al.*, 2017; Weyant, 2017).

To be relevant to INRM, a model must be comprehensive enough to assess cumulative effects, transparent with respect to the underlying assumptions, and able to produce results that are accessible to managers and actors. Transparency is particularly important for identifying bias in relation to the sensitivity of a model to initial conditions or certain key parameter estimates (i.e., being upfront if estimates were selected to minimize the impacts resulting from the model). The use of models, however, with their focus on outputs, can allow for the uncertainly associated with inputs to be lost. Levins (1993) argues that models exist on a multidimensional continuum that includes generality, realism, manageability, and understandability as axes, and that the location of a given model will depend on "the changing contexts in which it is used." Models reflect the current understanding of a system; any estimates produced will be effected by the inherent uncertainty, and no model can be expected to predict exact outcomes.

4.3.3 Geographic Information System

The need to display large amounts of information on physical land attributes, including natural resources at large spatial scales, drove the creation of the GIS in Canada (Tomlinson, 1962). This development enabled the creation of the Canada Land Inventory, which mapped much of rural Canada's land capability for a range of uses, including agriculture, forestry, recreation, and wildlife before it closed in the 1990s (Aronoff, 1989; Pierce & Ward, 2013; GC, 2016a). Since GIS can combine different sets of spatial knowledge, it is used extensively in natural resource management. Originally built to manage and display multiple layers of geographic data, GIS tools have evolved and are pushing spatial and temporal boundaries (Huisman & de By, 2009). Changes over time are particularly important, since one snapshot in time does not effectively represent dynamic elements of geography. GIS tools include methods to connect various sources of information, then model and forecast trends occurring at large scales. As a result, they are increasingly applied in land-use planning.

Participatory GIS (PGIS) is a set of methods that seeks to merge different forms of knowledge within geospatial technologies (Corbett *et al.*, 2006). PGIS represents local people's knowledge spatially, and is focused on community-driven processes. PGIS is therefore tailored to each community, and aims to be both demand-driven and user-friendly (Corbett *et al.*, 2006). In particular, PGIS has emerged as an important approach in documenting ILK within INRM approaches (Candler *et al.*, 2006; Olson *et al.*, 2016). The integration, and interpretation of ILK into geospatial technologies present a number of challenges in terms of accurately representing and communicating ILK, and raise legal and ethical issues for consideration (Chapin, 2006; Scassa *et al.*, 2015). The rise of PGIS, and in particular Indigenous PGIS, however, supports INRM in Canada (Olson *et al.*, 2016). Geothink, the Canadian Geospatial and Open Data Research Partnership, is examining the implications of "increasing two-way exchanges" of location data between governments and their citizens (Geothink, n.d.).

4.3.4 Systematic and Other Reviews

Well established in evidence-based medicine, the use of systematic syntheses of scientific information to support consistency and transparency in decision-making is gaining popularity in natural resource management (Pullin & Knight, 2001; Cooke *et al.*, 2016). Establishing an accepted, clearly defined method to apply systematic reviews in INRM would ensure consistency and transparency of methods, and would facilitate the application of theoretical research results by practitioners. Systematic reviews provide an additional level of certainty and rigour in assembling, critically evaluating, and synthesizing evidence (Cooke *et al.*, 2016). When freely available, they increase the transparency

and accessibility of decision-making processes. Canada is in the early stages of developing the capacity to properly carry out systematic reviews for use in environmental management, and several federal departments have begun to use them in decision-making (e.g., Parks Canada, Environment and Climate Change Canada) (Cooke *et al.*, 2016).

Meta-analyses can also support knowledge-sharing by combining and summarizing the evidence gained from multiple studies (Morgan & Dowlatabadi, 1996). Meta-analyses are statistical approaches for combining data sets from different experiments. In the context of INRM, meta-analyses may allow for the summation of relevant environmental or economic data. For example, a meta-analysis of boreal caribou data from multiple studies across Canada identified critical habitat thresholds and supported recovery planning for the species (EC, 2012).

Large-scale assessments, such as those done by the Intergovernmental Panel on Climate Change (IPCC), also have processes whereby large amounts of research are reviewed and summarized in comprehensive reports. In the case of the IPCC, the literature assessment process is not systematic per se, but is based on expert review of relevant evidence identified from sources considered acceptable (e.g., peer-reviewed articles, government reports) (IPCC, 2013). The IPCC expert review includes a critical appraisal of the quality and validity of each source.

4.4 APPLICATION OF KNOWLEDGE: PLANNING AND MANAGING FOR THE FUTURE

Effective INRM is a function of not only the range of knowledge it can access and share, but also how it uses that knowledge in practice. INRM applies knowledge in a way that supports inclusive, comprehensive, and adaptive resource management (Figure 4.3). The application of knowledge in INRM is an iterative process, where new learning feeds into the cycle and supports adaptation. This section briefly discusses some of the tools that can be used to apply (primarily scientific) knowledge across INRM stages, namely setting objectives, evaluating alternatives, and implementing strategies. The Panel notes that the list of tools discussed in this section is not exhaustive and that there are other tools (e.g., multi-resource analysis) that hold promise for the application of knowledge in INRM (Jenni *et al.*, 2018). In practice, while each tool is linked to a single stage in Figure 4.3, several of these tools can be applied to multiple stages of the cycle. This passage provides only a brief overview of each tool — the reader is directed to the references cited for more detailed descriptions. In some cases, more practical details are provided in textboxes throughout this section and in Chapter 6.

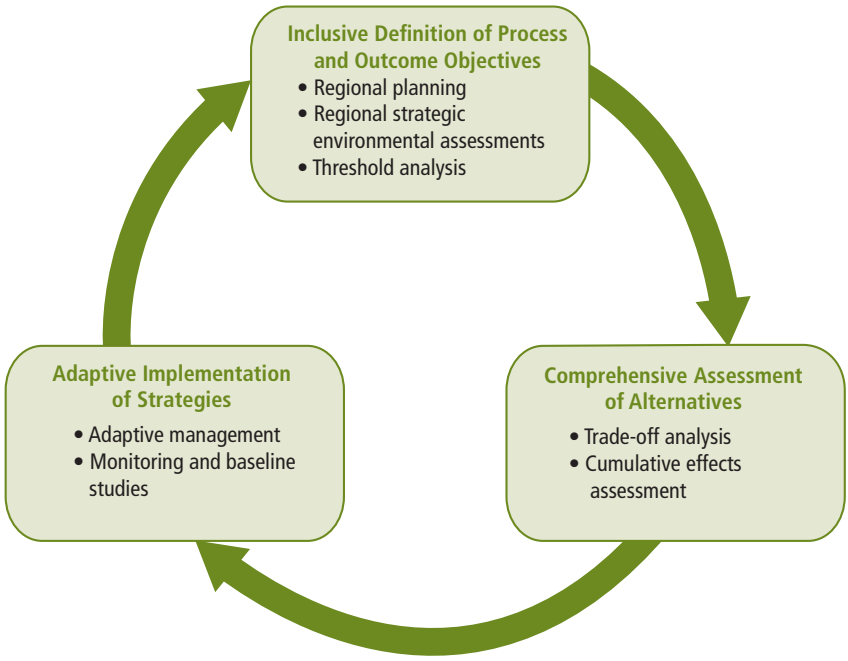


Figure 4.3

Application of Knowledge to INRM

Applying knowledge to INRM entails a cyclical process that includes a wide range of objectives, evaluates alternative approaches, and engages implementation strategies that can evolve as needed. Ongoing learning informs the process, supporting adaptation as new knowledge is obtained.

4.4.1 Inclusive Definition of Process and Outcome Objectives

The scope of INRM encompasses multiple land uses and users, large areas, and long time horizons; it is therefore inclusive with respect to objectives, including those related to both processes and outcomes. Appropriate objectives are established by engaging all relevant jurisdictions, rights holders, and interested and affected parties, and by considering suitable geographic scales and timeframes. Process objectives (or indicators) represent the desired progress in terms of certain elements of the management process, such as collaboration, communication, and rule compliance; outcome objectives represent project goals, such as resource yield, ecosystem health, or employment (Evans *et al.*, 2011). Regional planning, regional strategic EAs, and threshold analysis are examples of related tools that use an inclusive definition of objectives to support resource management.

Regional Planning

Regional planning provides a mechanism to consider sources of cumulative environmental, economic, and social change at an appropriate scale, as they typically extend beyond the project level. The larger areas and longer time horizons involved in regional planning are better suited to address species- and population-level effects and ecological processes, which can operate at scales covering thousands of kilometres (e.g., boreal caribou ranges) and multiple years or decades (e.g., climate change). Regional planning often involves developing a land-use plan to define how to allocate various uses within a region in pursuit of wide-ranging and inclusive objectives. For example, the Lower Athabasca Regional Plan includes objectives related to, among others, the regional economy (e.g., forestry, agriculture, tourism); ecosystem function and biodiversity; air and water quality; population growth; recreation; and the involvement of Indigenous people in land-use planning (Gov. of AB, 2012; LARPRP, 2016). A range of contexts exist for regional land-use planning, including processes driven by land claims, such as those found in Canada's North.

Regional Strategic Environmental Assessment

Regional strategic EA involves systematically evaluating the cumulative effects of alternative development options for a region (CCME, 2009). The focus is on defining desired outcomes and identifying development trajectories that support those outcomes, rather than on mitigating predicted or most likely impacts. Land-use planning and regional strategic EAs are foundational to subsequent local and project-level decision-making because they establish criteria for assessing proposed activities. To effectively provide strategic direction, regional planning and assessment contain environmental, social, and economic objectives that reflect the shared vision of a wide range of actors, including relevant jurisdictions, rights holders, and interested parties (Gunn & Noble, 2009). They also functionally link the objectives to the project level, ideally through legally binding targets or thresholds that guide project-level decision-making (Kennett, 2002).

Threshold Analysis

The setting of thresholds for land use and resource development can guide natural resource management decisions that support environmental objectives at a local level, and ecological well-being at a larger geographic scale (Box 4.2). Thresholds provide a mechanism to estimate a region's capacity to accommodate land-use activities while maintaining a certain level of environmental function (CILMC, 2005). As an important link between planning at a regional level and local decision-making, thresholds provide quantitative criteria for assessing the cumulative effects of multiple proposed projects in the context of regional strategic objectives. These indicator levels represent a theoretical point between acceptable and unacceptable levels of human-caused disturbance (Simpson, 2016).

Box 4.2
Applying Thresholds

Once appropriate geographic boundaries and development thresholds are established, zoning can assign specific land-use intensities to parts of the landscape. The three most common types of zones are intensive-use, mixed-use, and protected. Protected zones and development thresholds in mixed-use zones limit development, which is balanced out with higher production in intensive-use zones. In this way, "land use zoning provides a mechanism to reduce, although not eliminate, the 'economy vs ecology' conflict at a regional scale." Establishing protected zones in areas for which insufficient information exists for setting appropriate development thresholds preserves the ecosystem services and biodiversity of a region, as long as sufficient areas are protected.

(Carlson & Stelfox, 2009)

Statistical analysis can inform thresholds by identifying breakpoints (Carpenter *et al.*, 2011; Toms & Villard, 2015). It can be very challenging to establish precise thresholds that define breakpoints between states (e.g., presence/absence of a community or species) when the transition between states is diffuse and difficult to predict (i.e., there is a large degree of uncertainty). If clear thresholds are not obtainable, however, targets can be set in the context of risk (Box 4.3).

Box 4.3
Defining Environmental Targets

Departure from natural condition can be used to define targets, based on the idea that risk to species and ecological processes increases as the ecosystem departs from its natural state (Landres *et al.*, 1999). The natural disturbance model (Hunter, 1993) is a common example of this approach in forest management, which uses natural disturbance (e.g., fire) and its effect on ecosystems to set management targets (Andison *et al.*, 2016). More generally, the range of natural variation can be used to set targets for ecosystem structure (e.g., landscape composition) and ecological processes (e.g., hydrologic cycle) based on acceptable departure from the natural state (e.g., MacPherson *et al.*, 2014). Defining natural variability requires information on variation of ecosystem attributes over time and space; however, data sufficient in scope are often in short supply. In the absence of suitable site-specific data, other approaches, such as simulations, space-for-time substitutions, and expert opinion, can estimate the range of natural variability (Landres *et al.*, 1999). For species populations, viability analysis can guide targets by using knowledge of population dynamics and threats to estimate risk of extinction (or extirpation) and applying it to set targets that limit extinction risk to within acceptable levels (e.g., EC, 2012).

4.4.2 Comprehensive Assessment of Alternatives

The INRM cycle is comprehensive, evaluating alternatives by applying multiple forms of knowledge to consider the consequences of management decisions for natural resources, values, and uses. Assessment of alternatives takes a complex systems approach by focusing on system-wide response rather than individual components such as projects or indicators. Trade-off analysis and cumulative effects assessment are examples of tools that enable comprehensive assessments of alternatives.

Trade-Off Analysis

Trade-off analysis encourages relevant actors to consider the strengths and weaknesses of different resource management decisions and to establish priorities. This approach acknowledges the rarity of win-win solutions in resource management decisions, with both gains and losses usually incurred (McShane *et al.*, 2011). Scales are important to consider when analyzing trade-offs (Box 4.4). Additionally, trade-offs are most robust when they consider not only the manageable human parameters but also sources of uncertainty, such as natural disturbances and market volatility (Carlson & Stelfox, 2009). By assessing the consequences of multiple scenarios that incorporate both internal and external drivers, scenario analysis offers insight into vulnerabilities and which types of management strategies are consistent with economic and environmental objectives.

Box 4.4
The Importance of Scales in Trade-Off Analysis

Effective consideration of trade-offs occurs within meaningful and appropriate timeframes and geographic boundaries — boundaries larger than the management area and timeframes longer than those of the current land uses (Carlson & Stelfox, 2009). Some researchers suggest a timeframe of at least decades to ensure inclusion of rare events and incremental changes, as well as geographic boundaries that encompass all of the ecosystem components and processes affected by the land use (Carlson & Stelfox, 2009). The inevitable trade-offs that arise from integrating many land uses and actors may be easier to resolve by enlarging the spatial scale of decision-making. For instance, in the Lower Athabasca region of Alberta, where intense oil sands extraction has contributed to the growth and economic prosperity of Alberta for several decades (Gov. of AB, 2012), it may be impractical to try to reconcile other land uses such as agriculture, wildlife habitat, hunting, or recreation within this geographic area itself (Carlson *et al.*, 2010). However, enlarging the scale of analysis across a larger area of northern Alberta may illustrate these other land uses are accommodated elsewhere.

There are a number of approaches to assessing trade-offs, including scenario analysis, sensitivity analysis, cost-benefit and multiple accounts analysis (Box 4.5), statistical approaches, adaptive management, and multicriteria analysis; more detailed descriptions can be found elsewhere (e.g., Bessette, 2016; McDaniels, 2012; Arvai, 2012; Bateman, 2013). Trade-off analysis tools, when used appropriately, make explicit the variables, assumptions, and consequences of each alternative and test or vary them to gauge their robustness in relation to risks or uncertainties. Engagement with relevant actors helps gain an understanding of their priorities, with successful collaboration supported by actors being clear and up-front about their values and preferences (Carpenter *et al.*, 2009). A detailed example of applying trade-off analysis in Alberta is provided in Section 6.1.

Box 4.5
Economic Approaches for Trade-Off Analysis

Economic approaches can be used to carry out a cost-benefit analysis based on a set of principles for estimating the benefits and costs of both natural resources, and ecosystem goods and services. Monetary measures put goods and services into a common currency to support comparisons across various goods and services and locations and, by using discount rates, across time periods. Examples of valuation of different ecosystem goods and services already exist in Canada (e.g., Dias & Belcher, 2015; He *et al.*, 2015). While quantification and valuation provide a method to analyze trade-offs, there will always be challenges in the estimation of goods and services that are not exchanged in markets. Moreover, these challenges do not imply that goods and services require a market price to have value to communities and in sustaining ecosystems, nor that any valued entities should or will be marketed (e.g., McCauley, 2006; Satz, 2010; Sandel, 2012).

Cumulative Effects Assessment

Given the potential magnitude of their impact, inclusion of cumulative effects in the comprehensive assessment of alternatives is important. Cumulative effects assessment is the systematic process that is used to identify, analyze, and evaluate cumulative effects in order to avoid triggers of cumulative environmental change (Noble, 2015b). Cumulative effects assessment is holistic with respect to the selection and analysis of indicators of environmental change (Box 4.6). Cumulative effects assessment is designed to occur at the regional scale to incorporate a comprehensive assessment of drivers, including multiple land-use stressors and ecological processes (Gunn & Noble, 2009; Chetkiewicz & Lintner, 2014). When assessment occurs at the regional scale, regulatory frameworks can link outcomes to project-level decision-making.

Box 4.6
Regional Cumulative Effects Assessment in Practice

Careful selection of indicators and an effects-based approach allow cumulative effects assessments to comprehensively assess regional environmental change and focus on the combined effects of those indicators (Dubé, 2003). The recommended approach for completing a regional cumulative effects assessment in terms of indicators is consistent with the pre-assessment and impact assessment phases of the regional strategic EA framework identified by Gunn and Noble (2009). Effective indicators are meaningful to the public, can detect change and can be used to forecast the consequences of scenarios (Gunn & Noble, 2009). Current and past change of each indicator can help identifying drivers of environmental and socio-economic change and further establish indicator targets.

Strategic alternatives for the region are then identified and analyzed to assess the future consequences of each alternative to the environmental and socio-economic indicators (Quinn *et al.*, 2015). To ensure comprehensive assessment of alternatives, the suite of scenarios can include options that differ substantially so as to illustrate the implications of a wide range of options. The analysis is therefore holistic in scope, assessing the long-term consequences of both ecological processes and multiple land uses (Quinn *et al.*, 2015).

While assessment of the social, legal, and historical cumulative effects stemming from environmental changes is of particular importance in relation to the rights of Indigenous Peoples, these considerations may not be adequately accounted for in some cumulative effects assessment processes (MacDonald, 2014). For example, the evaluation of cumulative environmental effects and their impacts on healthy fish populations in preferred harvesting areas — and subsequent impacts on Indigenous fishing rights and ability to practice traditional ways of life — may not be adequate (MacDonald, 2014).

4.4.3 Adaptive Implementation of Strategies

The INRM cycle reduces uncertainty by being adaptive in how it applies strategies. Adaptive management actions explicitly test management hypotheses and monitor effects to assess ecosystem response at appropriate geographic scales and timeframes. In addition to monitoring ecosystem response to management, baseline studies are needed to define natural ecosystem conditions in the absence of management actions.

Adaptive Management

When implemented fully, adaptive management helps address uncertainty by prioritizing knowledge acquisition (e.g., through monitoring) and enhancing flexibility to respond to new knowledge and changing conditions. Adaptive management goes beyond simple trial and error and includes "setting goals and objectives, evaluating, implementing, and monitoring options as well as performing appropriate adjustments based upon the results" (Thiffault *et al.*, 2007). It regularly collects and analyzes data to capture shifts in baseline conditions, and the resulting information is then used to revise strategies as needed in order to move closer to identified goals (Pavlikakis & Tsihrintzis, 2000; CILMC, 2005; Sayer *et al.*, 2013), and to help manage uncertainty (Folke *et al.*, 2002; Armitage *et al.*, 2009). Full implementation of adaptive management is based on developing management experiments that include testable hypotheses that can be used to adjust management practices (Olszynski, 2017). The main steps in adaptive management are: defining the problem; developing and testing hypotheses; monitoring and evaluating the results; revising the experiment to include the information learned during the experiment; and sharing this new knowledge (Murray & Marmorek, 2004).

While adaptive management plays a central role in INRM, the Panel cautions that the term can be incorrectly applied and used to describe the practice of managing adaptively, but without the goal of reducing uncertainty (a central goal of adaptive management) or of achieving an agreed-upon objective. In the Panel's experience (i) regulatory requirements may hinder, or even preclude, the use of adaptive approaches; (ii) practitioners may lack some of the skills needed for implementation and evaluation, including those related to structured decision-making, actor engagement, and others; and, (iii) in the context of operational practice, the concept of adaptive management can often be seen as a moving target and difficult to enforce. Effective adaptive management is dependent upon implementation of all aspects and stages of the process, and the application of adaptive management often differs from the theory, limiting its utility (Olszynski, 2017). For example, in the United States, "[d]ocumented instances of successful adaptive management are rare, and many touted examples diverge significantly from the theoretical ideal" (Doremus, 2010). A common discrepancy is that management experiments are not included in the design or implementation (Ruhl & Fischman, 2010). In Canada, a study of adaptive management in Alberta's energy resource sector also found significant problems with implementation:

> The results confirm longstanding concerns about the implementation of adaptive management in this context: definitions and conceptions of adaptive management vary, with most proponents erroneously invoking it as a general or routine strategy that will ensure effective mitigation; little or no attention is being paid to experimental design; objectives, indicators, and thresholds for adaptation are generally missing, especially at the environmental assessment stage… [I]mplementation is either non-existent or barely distinguishable from basic compliance monitoring... Not surprisingly, then, none of the projects assessed here had much to show in terms of actual learning.
>
> (Olszynski, 2017)

In situations where adaptive management is not appropriate, either because the risks are too high or there are insufficient resources, resource managers can nevertheless monitor and evaluate their management decisions for effectiveness. While such an approach lacks the experimental rigour of adaptive management, it enables some form of learning from doing.

Monitoring and Baseline Studies

Monitoring is an important component of INRM. It relates to both implementation and effectiveness, and measures both process and outcome (Joseph *et al.*, 2008). Implementation monitoring helps ensure process goals are met (e.g., data transparently released to the public; actors engaged in a timely way) and, if not, provides information to modify processes accordingly. Outcome monitoring in INRM observes multiple drivers and ecological attributes, uses consistent approaches across appropriate geographic and temporal scales, and has sufficient sampling intensity to detect change (Box 4.7).

Including the results of monitoring in the decision-making process supports adaptive management (Douthwaite *et al.*, 2004; Keough & Blahna, 2006). For instance, authorities may use monitoring results to adjust regulatory limits for certain activities (Johnson *et al.*, 2016a). However, for this to be useful, results must then be shared with other actors, including the public, in a way that is accessible (CILMC, 2005; Roach & Worbets, 2012; Sayer *et al.*, 2013). This provides information to people interested in engaging in the decision-making process or in better understanding the decisions made by others (CILMC, 2005). Sharing monitoring results with the public also builds trust that decisions are considered in a way that is both fair and balanced (CILMC, 2005).

Box 4.7
Comprehensive Monitoring

Careful planning of monitoring programs capable of detecting trends at relevant scales supports the development of comprehensive and meaningful data. Selected indicators should link to management goals and be cost-effective to monitor. The identification of an appropriate suite of indicators should include all relevant actors and consider the local context (Prabhu *et al.*, 2001). Large-scale monitoring efforts, such as the Alberta Biodiversity Monitoring Institute and the West Kitikmeot/Slave Study, are well suited to INRM (SENES Consultants Limited, 2008; ABMI, 2014a), and use of consistent indicators and protocols across such programs could aid the sharing and comparing of data between areas and time periods. The large number of samples necessary to detect gradual and regional ecosystem change is such that meaningful information may require many years of data collection. Monitoring therefore requires long-term financial support and a commitment to maintain a consistent methodology over time.

Interpretation of monitoring outcomes requires a baseline understanding of the condition of the system prior to any management action (Mattison *et al.*, 2014). Baseline studies play the crucial role of providing a point of comparison from which to assess land-use impacts, and inform restoration and accommodation actions intended to address degraded ecosystems. The integrity of baselines can be undermined by the "shifting baseline syndrome," whereby ongoing impacts on ecosystems result in the use of degraded ecosystems as the baseline from which to assess the consequences of future management actions (Soga & Gaston, 2018). A combination of project-level decision-making and a shifting baseline system can result in the accumulation of substantial ecosystem degradation over time as a consequence of projects that are each judged to have non-significant impacts. In the presence of cumulative effects, the natural ecosystem condition is used for baseline studies so as to avoid shifting baseline syndrome (Box 4.8).

Box 4.8
Importance of Ecological Benchmarks

Valid baselines can be defined using ecological benchmarks, which are intact ecosystems that are protected from development and monitored to understand natural ecosystem function (Schmiegelow, 2007). In the Panel's view, long-term research and monitoring initiatives are needed in landscapes devoid of natural resource development to improve understanding of ecosystem function, yet few of these pristine ecosystems remain. The development of protected-area networks provides the opportunity to establish a representative network of ecological benchmarks that are large enough to contain extensive ecological processes and wide-ranging species. In essence, monitoring these areas provides data on a control condition that can greatly strengthen the ability to detect changes caused by projects in impacted areas.

4.5 CONCLUSION

In Canada, Western science and ILK are particularly relevant for INRM. The tools described in this chapter provide the means to make the best use of existing knowledge and improve it through time. The state of knowledge does not justify delay in INRM implementation — avoiding action while waiting for complete and definitive knowledge only compounds problems. As explained by Gordon (2008) with respect to using a systems approach to govern forest management in New Brunswick, "problems must usually be dealt with long before definitive science is available. Waiting only reduces options and ultimately increases the costs of solutions."

However, knowledge on its own cannot bring about INRM. The value of INRM comes from applying knowledge to decision-making through a carefully designed and implemented governance process. In Chapter 5, the Panel discusses good governance, including the relevant actors and different approaches to governance that, when combined with knowledge, can promote INRM.

5

The Role of Governance in INRM

- Involvement of Multiple Actors in Governance
- Governance Approaches
- Laws and Regulations Related to Natural Resource Management
- Conclusion

5 The Role of Governance in INRM

Key Findings

Governance that is inclusive of all relevant actors brings legitimacy to INRM. These actors include those with jurisdictional authority over decisions; those who hold rights related to the resources; those who are affected by decisions; and those with relevant specialized knowledge. Governments, rights holders, industry, NGOs, and the public more broadly may therefore all play a role in INRM governance.

Effective INRM governance approaches can be described along a spectrum — from consultative to collaborative to shared decision-making. In Canada, governance processes are trending toward collaborative or shared forms. These approaches promote decisions that are meaningful, supported, and lasting.

Effective governance begins with well-thought-out and participatory design of processes across the INRM lifecycle.

Co-management regimes, including those resulting from modern treaties and land claims agreements, provide useful examples of shared governance.

The laws and policies governing natural resource management in Canada do not prohibit, and in some cases foster, INRM. While the implementation of INRM can face barriers under current legal frameworks, a move towards more collaborative and shared governance is possible.

In the previous chapter, the Panel outlined the foundational role of knowledge in INRM. In this chapter, the Panel explores the governance processes needed to enable the application of knowledge (including uncertainty) in INRM. Although it has long been recognized that the status quo in resource management governance is often not able to address the issues outlined in Chapter 2, change has been slow. That change entails more inclusive forms of governance with a broader set of actors and expanded ways of knowing in order to legitimize and improve the quality of decision-making. In this context, inclusion depends on fair opportunity to participate, procedural fairness, and substantive fairness in outcomes. Effective governance also explicitly incorporates the multilevel legal jurisdiction in which natural resource management occurs. As outlined in Chapter 1, the Panel defines *governance* in the context of INRM as the functions,

institutions, and processes for developing norms, for decision-making and exercise of accountability, and for how relationships among actors proceed. Establishing effective INRM governance requires the careful design of a process that includes key players and considers knowledge generation and incorporation.

The challenges of developing knowledge-based INRM governance may seem significant, but some fields have evolved effective ways to deal with complex problems involving coupled human and natural systems. For example, experience with the governance of the commons started with what seemed an intractable problem when viewed in the abstract. But careful research on various approaches to governance, as well as strong efforts to develop a literature that links across disciplines, have led to a robust literature that guides commons governance (Ostrom *et al.*, 2002). That literature offers both diagnostic questions to help understand the challenges faced in a particular context and also design principles that help guide context-sensitive approaches (Ostrom, 2007; Pottette *et al.*, 2010). Commons work is also marked by regular interaction between researchers and practitioners. The Panel is optimistic that a similar approach drawing on careful analysis of efforts and strong communication across disciplines (and between researchers and practitioners) can carry INRM forward as well.

This chapter identifies and describes actors relevant for the design of INRM governance; consultative, collaborative, and shared governance approaches (along with their strengths and weaknesses); and the laws and regulations in Canada that affect how governance is put into practice.

5.1 INVOLVEMENT OF MULTIPLE ACTORS IN GOVERNANCE

Effective governance in INRM depends on the identification and engagement of a range of actors, including those with jurisdictional authority over decisions; those who hold rights related to the ownership, use, and management of resources; those who are affected by such decisions; and those with specialized knowledge relevant to resource management. Governments, rights holders, industry, NGOs, and the public more broadly may therefore all play a role in INRM governance, helping improve the quality, legitimacy, and ultimately effectiveness of the decisions (Brown *et al.*, 2005; NRC, 2008). Many potential actors can be involved in natural resource management, both across Canada and within a single tier of government. The interdependences among these actors must be managed and embedded into policy, planning, and project decisions. While not every decision requires the collaboration of every actor, having a network of collaboration is important to ensure all decisions can be addressed in an integrated way.

5.1.1 Governments

Governments are responsible for the development and implementation of laws, regulations, policies, and programs related to natural resources. Different governments and orders of government may be involved in making decisions due to the overlap in authorities and responsibilities for natural resources and land use in Canada. While the government employees directly involved in INRM processes are generally public servants, elected government officials do play an essential role in setting legislation and can play a role in driving decision-making that supports INRM. Ultimately, political accountability lies with the elected officials who have the authority to direct change.

Overlap can occur when the boundaries of natural resources do not match the jurisdictional boundaries of the governments responsible for their management. For example, a watershed may cover several jurisdictions, including provinces, territories, municipalities, Indigenous lands and communities, and international territories. Overlapping of authorities also occurs, such as environmental protection falling under federal and provincial/territorial laws. For example, energy production usually falls under provincial/territorial government jurisdiction; transboundary oil and gas transport and electricity transmission are under federal jurisdiction; while Indigenous Peoples hold rights to land in many parts of the country. Most areas also contain multiple natural resources and land uses (e.g., agriculture, mineral production, wildlife and biodiversity conservation), which may fall under the jurisdiction of different government authorities.

Although a sector-specific focus for legislation, governance, and management has tended to be the norm in Canada (Kennett, 2004), changes are occurring that move closer to an INRM framework. For example, in British Columbia, the ministries of Energy, Mines and Petroleum Resources, Environment and Climate Change, and the Environmental Assessment Office coordinate several elements related to governance over the exploration for minerals and development of mines (e.g., policy development, compliance monitoring) (Gov. of BC, n.d.). The situation is similar in many other provinces and territories, but a more integrated approach is not without trade-offs. The involvement of the full set of government and regulatory agencies with jurisdiction in resource development raises coordination and decision-making costs. Having said this, INRM governance that includes better coordination of different governance and planning elements can also yield benefits through greater process efficiency. For example, having coordinated planning in place at a regional level can facilitate faster decision-making at the project level.

5.1.2 Rights Holders

While many actors may have responsibilities or interests in natural resource management, some have particular rights to natural resource uses. The involvement and buy-in of rights holders is vital in INRM, since they can take significant actions to improve the management of natural resources in a given area. In an INRM approach, directly involving rights holders in decision-making helps provide accountability.

Under the Canadian constitution, federal, provincial/territorial, or Indigenous governments own and have jurisdiction over most natural resources (GC, 2012a). Provinces and territories have authority over non-renewable natural resources, forestry resources, and electrical energy within their borders, including the right to make laws related to exploration, development, conservation, and management of resources (GC, 2012a).[4] The federal government has specific authority to make laws related to trade and commerce, navigation and shipping, sea coast and inland fisheries, and anything that is not considered "assigned exclusively to the Legislatures of the Provinces" (GC, 2012a). Private individuals such as farmers, woodlot owners, and (in some cases) owners of mineral-bearing lands have surface rights to their lands (Pearse, 1988). For example, 6.2% of Canada's forests are privately owned (NRCan, 2016b). However, in most parts of Canada, the respective provincial, territorial, or federal government retains the subsurface mineral (including oil and gas) rights, and leases them to organizations for resource use under conditions defined in project approvals and permits (GC, 2016c). In addition, provinces let out tenures to forestry companies, which give the latter the rights to manage these lands over long periods of time (Haley & Nelson, 2007).

As outlined in Chapter 2, broadly speaking, Indigenous Peoples across the country have rights to specific territories recognized in the original (numbered) treaties, negotiated in modern land claims treaties, and in unceded territories where there is no treaty (historic or modern). The federal government has committed to a principle of reconciliation and securing free, prior, and informed consent; this applies to both title and non-title lands (JUS, 2018). In addition, some modern land claims agreements, such as those in Yukon, Northwest Territories, and Nunavut, have recognized the rights of Indigenous governments to subsurface minerals on certain lands (Gwich´in Tribal Council & GC, 1992; Nunavut Tunngavik Inc. & GC, 2010; Gov. of YK, 2017).

4 Under the Nunavut Land Claims Agreement, Nunavut Tunngavik Inc. holds the surface rights on some lands, and surface and mineral rights on other lands, in the territory (the federal government retains these rights for some lands) (Nunavut Tunngavik Inc. & GC, 2010). Devolution talks are currently in progress.

5.1.3 Industry

Private companies are usually the main proponents of new natural resource developments. They lead new projects, making long-term investments that entail a host of risks emanating from the market, regulatory structure, and their own actions that affect social licence. Companies can hold extensive natural resource rights provided by governments through lease or tenure, or in some cases through ownership (e.g., private forest lands); both are subject to government-set policies. Industry may also self-regulate resource development through voluntary standards and private governance (see Section 6.5 for details). Accordingly, industry has a strong voice in natural resource management.

5.1.4 Non-Governmental Organizations

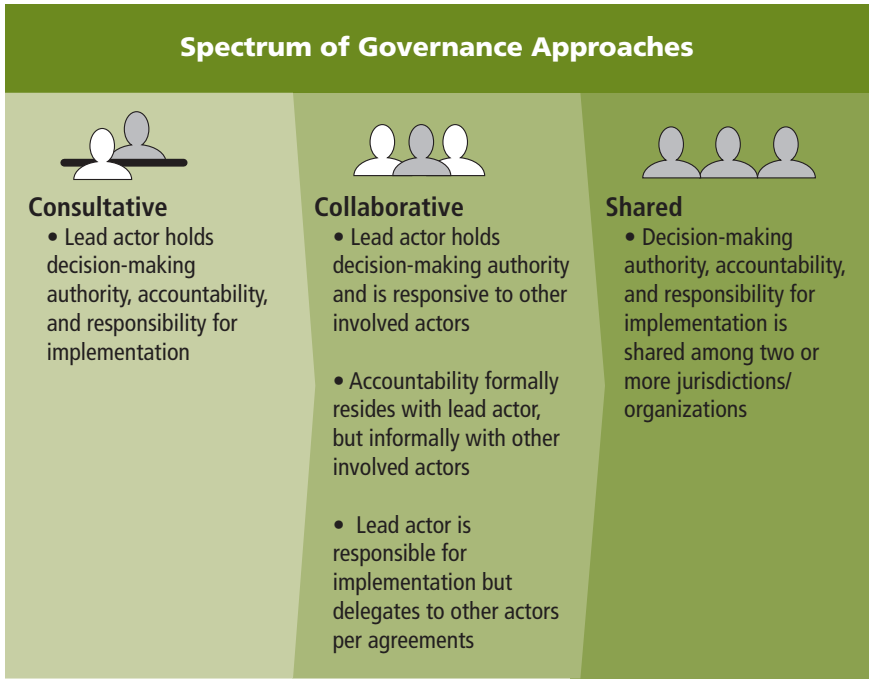
NGOs can participate in natural resources governance as part of certification bodies and schemes; through advocacy for particular views that influence the public, industry, and government decision-making; by becoming directly involved in regulatory and project reviews; and in limited examples of NGO-owned nature conservancy lands. NGOs are also involved in active management of wetlands, other critical habitats, and larger regions (e.g., HBC, 2018). Some NGOs conduct research on natural resources, support research through grants, and/or partner with researchers in academia or government (NCC, 2018a, 2018b). Indigenous environmental NGOs can play an important role in supporting Indigenous Peoples in building capacity and using ILK to tackle environmental issues related to their lands and resources (CIER, 2017). These organizations can also help facilitate collaboration between Indigenous and non-Indigenous governments and groups (CIER, 2017). Actions outside of government jurisdiction or beyond the reach of industrial partners may be accomplished best by NGOs (Breckenridge, 1999).

5.1.5 The Public

Individuals, households, community groups, and communities routinely have an interest in, or stand to be affected by, the operations of a proposed or existing natural resource project. Involving the public in natural resource management can result in better-informed decisions (NRC, 2008) and increased likelihood that the natural resources will be protected in the long term (Nagendra & Ostrom, 2012). Public involvement brings a unique perspective and knowledge to the management process (Burby, 2003; Brown *et al.*, 2005; Lockwood *et al.*, 2010); when people live in an area for some time, they gain insights about the ways that components of the social-ecological system interact with each other. The public may also ask questions and raise issues that experts may not have considered (NRC, 2008). On the other hand, the Panel notes that the public's focus on local issues and interests may lead to situations where landowners and other groups object to all nearby resource use schemes.

5.2 GOVERNANCE APPROACHES

For INRM, research and practical experience have shown that effective governance involves a range of approaches that correspond with the nature and complexity of the resource management issues and processes under consideration. The governance approaches that have evolved in Canada over recent decades can be viewed as existing along a spectrum, from consultative to collaborative to shared (Figure 5.1). While this spectrum is only one method of categorizing governance approaches in Canada and may not be universally accepted, the Panel believes it is useful for understanding the key differences among various approaches. Moving along the consultative-collaborative-shared spectrum, each approach represents an increasing and more substantive involvement of more than one actor in decision-making and accountability. Although progression along this spectrum is often desirable, there may be one or more aspects of INRM (from legislation to policy to planning to project review to monitoring) for a given circumstance that dictate a more consultative approach.



Adapted with permission from Stratos Inc. (2015)

Figure 5.1

A Spectrum of Natural Resource Governance Approaches in Canada

Governance approaches can exist along a spectrum, from consultative to collaborative through to shared governance.

Regardless of the approach, INRM governance extends beyond the government with authority over the resource to include all relevant actors in order to bring legitimacy to the process. Outcomes are more likely to be accepted if actors are provided with the opportunity to participate in decision-making (Lockwood *et al.*, 2010). Meaningful inclusion entails both procedural and substantive fairness. Procedural fairness requires that decisions be made by impartial and independent parties, but also that any individual "must have an adequate opportunity to be heard" prior to a decision being made if said decision has a "sufficiently direct impact on their interest" (NEB, n.d.). Ensuring such fairness may not be a fast process, depending on the level of consensus and the number of people or groups who have a direct interest. Substantive fairness ensures that the outcomes of regulatory decisions "are considered fair in their distribution of costs, benefits, and risks" (Stratos Inc., 2017). Procedural and substantive fairness are especially important in cases where there is public mistrust (NRC, 2008).

5.2.1 Designing the Process

In the Panel's experience, effective design is co-design — that is, the relevant actors collaboratively design the governance system from the outset. As Rodela (2012) states, "while the involvement of stakeholders has the potential to improve the quality and durability of a decision, this is very often influenced by the quality of the very process that leads to it." For this reason, involvement in designing the decision-making process itself is a fundamental aspect of successful governance in INRM.

The first step is identifying relevant actors and bringing them together to collaboratively set objectives and design the process in which they will participate (Astofooroff, 2008). Co-design is an inherently deliberative process where actors share their priorities and goals, and agree on the best structure to accomplish them. Actors need to agree on what natural resource management challenges must be addressed, even if they may not yet agree on how to address them. They should also be aware of the different types of knowledge available and select mechanisms for identifying, collecting, and bridging this knowledge (e.g., giving Indigenous or local communities the time or resources to collect or document their knowledge). Collaboratively designing an INRM process can address the power imbalances among actors by identifying and setting up mechanisms to address them at the outset.

A consensus-driven governance approach may prove to be more efficient in the long term than standard decision-making processes, which are often assumed to progress in a positive and linear fashion (sometimes referred to

as *constant-returns decision-making*) (Nesbitt, 2016). Conversely, in consensus decision-making, the progress may be slow at first as actors discuss the issues, but agreement often quickly emerges at the end, with stronger outcomes than those of conventional decision-making (Nesbitt, 2016). Indeed, the process for unilateral decision-making may ultimately take longer because many of the decisions are later challenged in court or delayed by political actions such as protests. This can make the final approval process longer, as well as more controversial and confrontational, than approval processes for collaborative or shared governance approaches (Staples & Askew, 2016; Noble, 2017).

5.2.2 Consultative Governance

In the experience of the Panel, consultative governance is currently the most-used form of natural resource governance in Canada, particularly in areas of provincial and federal jurisdiction. In consultative governance, a government makes the decisions and is responsible and accountable for their implementation, using varying degrees of consultation to gain the input of rights holders and interested and affected parties. In the view of the Panel, consultative decision-making may be appropriate when there is broad societal consensus on objectives and their trade-offs, and where the knowledge that informs the decisions is relatively certain.

Successful public engagement in INRM is based on a clear purpose, adequate resources, implementation focus, self-assessment, appropriate timing, learning from experience, inclusivity, and procedural and substantive fairness (NRC, 2008; Stratos Inc., 2017). Interested actors and the public are engaged early, often, and on a regular basis throughout the lifecycle of the INRM process, including during policy-making, regional or strategic planning, project review, and monitoring (Stratos Inc., 2017). To demonstrate the responsiveness of decision-makers, feedback mechanisms ensure the incorporation of outcomes of participatory processes into decision-making (Brown *et al.*, 2005). This helps build trust and transparency in the process, and provides a number of opportunities for interested actors and the public to inform decisions. It is important to emphasize that consultation with the public, however effective, should not be conflated with participation of Indigenous Peoples and other rights holders in INRM.

The lead actor's mandate may limit the scope of consultative governance in terms of natural resources considered. As the mandates of individual government departments (or agencies) encompass a limited number of natural resources, there tends to be a focus on a particular resource or ecosystem service rather than the full spectrum of services provided by a managed landscape.

Deliberative Consultation as a Specific Mechanism in Consultative Governance

Deliberative consultation involves actors more significantly in consultative governance by actively seeking mutual understanding and agreement in management goals rather than one actor listening passively to the concerns of others (Rodela, 2012). Clear communication through dialogue with actors early in the process, and repeatedly, allows them to see their input at work and fosters trust in the process (NAS, 2016b). Although decision-making power, accountability, and responsibility for implementation remain with the lead actor (government), other actors are more likely buy into the decisions. Deliberative consultation through a multi-actor process has supported BC Hydro's water use planning efforts for the past decade (Box 5.1).

Box 5.1
BC Hydro Water Use Planning

BC Hydro has designed a consultative water use planning (WUP) process to seek consensus decisions on a broad suite of environmental and social uses and outcomes for its hydroelectric generation facilities. These interests include, for example, domestic water supply, fish and wildlife, recreation, heritage, flood control, and power generation needs (Mattison *et al.*, 2014).

All but one of BC Hydro's generating facilities have undergone the WUP process (Fraser Basin Council, n.d.). Consultations provide a venue for actors — government agencies, First Nations, local residents, resource users, environmental groups, and other interest groups — to address environmental, social, economic, and cultural values, and to inform decisions on how to balance these different needs (Gregory *et al.*, 2006; Failing *et al.*, 2007). Nearly all WUPs reached consensus on their water use recommendations (Mattison *et al.*, 2014). This success has been attributed to participants' willingness to work together through the WUP process. In the one WUP where consensus was not reached, it was because the participants could not agree on a final operating regime (J. Benson, personal communication, 2017).

continued on next page

The design of the WUP process has been invaluable to its eventual success. After years of conflict among users of the Alouette River, BC Hydro brought together a diverse group of participants and interested parties to collectively set management guidelines with third-party facilitators using a structured decision-making process (McDaniels & Gregory, 2004). This process proved so effective in creating consensus and resolving conflicts that BC Hydro used it across all but one of its facilities (Mattison *et al.*, 2014; J. Benson, personal communication, 2017). Gregory (2002) attributes the success of the WUP process to "defining value-driven attributes…; the use of expert judgement elicitations in cases where data quality is low; and providing a framework for adaptive management that allows for monitoring and learning."

5.2.3 Collaborative Governance

Although a single actor may hold complete decision-making authority, accountability, and responsibility for implementation, they may involve other parties substantively in the carrying out of these responsibilities (Stratos Inc., 2015). In collaborative governance, the decision-making body is willing to be influenced by deliberations with other actors, and to work with those making related decisions (NRC, 2008). Such arrangements can be set out in terms of reference for standing bodies that involve the various actors or in the processes designed for policy-making, planning at a regional level, and project review. For example, the development of regulations for air quality in Alberta benefited from a consensus approach between governments, industries and NGOs, working together under the Clean Air Strategic Alliance (CASA, n.d.).

A key aspect of collaborative governance is building effective relationships, which involves a commitment of time and effort from all actors (Roach & Worbets, 2012). Stronger forms of collaborative governance involve a greater say or louder voice for rights holders and other actors in influencing decisions, and clear demonstration of government responsiveness to their inputs. Box 5.2 describes a collaborative initiative involving different orders of government and other actors in implementing an air quality management system.

Box 5.2
Air Quality Management System

Federal, provincial, and territorial governments, Indigenous organizations, industry actors, and NGOs all worked together to implement the Canada-wide Air Quality Management System (AQMS), and continue to cooperate on its development (CCME, 2014b, n.d.-b). Its purpose is to reduce air pollution in airsheds across Canada by implementing stronger air quality standards for several pollutants. The governments involved adopted a new approach, drawing on respective federal and provincial/territorial authorities over the air (e.g., federal authority to set national standards, provincial/territorial authority over air pollution sources) (CCME, 2012). The approach recognized the need for managing air quality at the regional airshed level. A range of non-governmental actors continue to be involved through the Stakeholder Advisory Group, which includes both industry and NGO members (CCME, n.d.-a). This group provides advice to governments related to the "ongoing implementation, improvement, and operation of AQMS" (CCME, 2014c).

The process's success is attributed to the incorporation of principles such as collaboration and transparency (CCME, 2014c). Because the AQMS is implemented via monitoring and public reporting, as well as continued collaboration among actors, its outcomes are dependent on a variety of factors (e.g., resourcing).

One way to facilitate collaborative governance involving multiple government agencies is through the creation of nested (or linked) arrangements. In these structures, an overarching plan or set of goals is agreed upon at a larger scale (e.g., regional), which then helps guide decisions made in smaller-scale institutions (e.g., cities) or the local community level (Odum, 1982; Folke *et al.*, 2007). Nested arrangements address jurisdictional overlap by sharing decision-making among the appropriate government agencies (Folke *et al.*, 2007). In Australia, natural resource management has been governed in a nested arrangement where federal and state/territory goals are collaboratively established for natural resources (e.g., reduction in water salinity), which enables regional boards to implement local strategies to achieve their aims (Pannell & Roberts, 2010). Larger jurisdictions can use their greater area of oversight to direct broad strategies and provide resources to small jurisdictions in developing their own tailored and local solutions (Paton *et al.*, 2004). The Australian arrangement devolves its practical management work to local orders of government, which creates more effective and efficient solutions with greater buy-in from all actors (Paton *et al.*, 2004).

5.2.4 Shared Governance

In shared governance, decision-making explicitly involves more than one government to varying extents (Cash *et al.*, 2006). A number of shared governance arrangements for natural resources exist in the Mackenzie Valley. Examples include Gwich'in, Sahtu, and Wek'èezhìi Land and Water Boards involving First Nations and the federal and territorial governments (MVLWB, 2018); and the Inuvialuit, territorial, and federal government joint councils for wildlife and fisheries management and environmental screening in the Mackenzie Delta and Beaufort Sea (IRC, 2018). These are often complex relationships due, in part, to the large number of government agencies, branches, and political groups, as well as the variety of interests, perspectives, and political actors at the community level (Carlsson & Berkes, 2005). Understanding the power imbalances among different governments can help mediate conflicts and identify ways to structure the approach for increased flexibility and "sharing of governing authority" (Armitage *et al.*, 2009). Trust among governments is needed to build functional relationships and networks (Henry & Dietz, 2011). Open communication and multiple interactions are key to building trust, but may take a number of years to establish (Armitage *et al.*, 2009).

Co-Management as a Form of Shared Governance

The main form of shared governance used in natural resource management in Canada is co-management. Co-management occurs when the government and local resource users share power and responsibility (Berkes, 2009). Nearly all co-management agreements in Canada have arisen through land claims negotiations (Natcher, 2001; Goetze, 2004) since the 1975 signing of the first modern land claims agreement: the James Bay and Northern Quebec Agreement between the Cree and Inuit Peoples of northern Quebec and the governments of Canada and Quebec (Natcher, 2001). Since then, co-management has been included in almost all comprehensive claims agreements (Berger *et al.*, 2010). The resource management regime established by the Haida Nation in Haida Gwaii is a leading example of effective co-management built on long-term relationships (Box 5.3). In some cases, co-management involves revenue sharing (Fontaine *et al.*, 2015). For example, the Government of Ontario, Grand Council Treaty #3, Wabun Tribal Council, and Mushkegowuk Council recently reached an agreement to share revenues from forestry and mining in parts of the province (The Canadian Press, 2018).

Box 5.3
Co-Management in Haida Gwaii as a Form of Shared Governance

The Council of the Haida Nation and the Governments of Canada and British Columbia lack a signed treaty that clarifies rights and title to the lands and resources of Haida Gwaii. In the absence of a treaty, co-management of those lands and resources has been evolving as an effective tool to protect and respect all parties' interests.

In the 1980s, the Council of the Haida Nation declared a Haida Heritage Site over Gwaii Haanas, an area in the south of the archipelago scheduled to be logged. High-profile conflict ensued and in 1986, the Governments of Canada and British Columbia agreed to federal park establishment. However, the Council of the Haida Nation asserted the Haida interest and consequently the Government of Canada agreed with the Council of the Haida Nation in 1987 to establish the Gwaii Haanas National Park Reserve pending resolution of title (Hawkes, 1996; Sadler, 2005). They later negotiated the Gwaii Haanas Agreement (1993), which set up the Archipelago Management Board (AMB) — a co-management board made of half Haida and half Government of Canada members — to manage Gwaii Haanas (CHN & GC, 1993; AMB, 2003).

The agreement to set aside the unresolved issue of title to Haida Gwaii was critical for success (CHN & GC, 1993; Sadler, 2005). Instead, they focused on the development of a co-equal management board to oversee not only the natural resources, but also the cultural and heritage values of the area and its people (AMB, 2003). Building trust through mutual respect for each other's ceremonies and processes was a major component of successful co-management in Gwaii Haanas. Local participants pointed to an occasion when non-Haida management staff held a potlatch in the community as a turning point in developing trust between Parks Canada staff and the Haida community (Wheatley, 2006). Ultimately, equity in decision-making power and the inclusion of ILK in co-management drove the AMB's success (Wheatley, 2006). The AMB has rarely failed to reach consensus in decisions (Langdon *et al.*, 2010; NCFNG, n.d.); it (and the Gwaii Haanas Agreement more generally) is widely regarded as a model of successful co-management (Hawkes, 1996; Astofooroff, 2008; Langdon *et al.*, 2010; Thomlinson & Crouch, 2012; Nesbitt, 2016; NCFNG, n.d.).

This experience led to the Kunst'aa guu - Kunst'aayah Reconciliation Protocol 2009 between the Council of the Haida Nation and the Government of British Columbia and establishment of the Haida Gwaii Management Council with delegated co-management responsibility for the annual allowable forest harvest, all strategic land use and park management plans, and heritage site policies throughout Haida Gwaii (Haida Nation & BC, 2009).

Although its implementation can vary, co-management includes some common elements. All governing parties create and sign co-management agreements, which are put into action by co-management boards composed of an equal mix of representatives from each government (Natcher, 2001; Goetze, 2004). The boards collaboratively make recommendations to their respective governments for decision-making on implementing their agreement (Goetze, 2004; Berger *et al.*, 2010).

Co-management helps alleviate resource management problems by engaging the governments in joint problem-solving (Carlsson & Berkes, 2005). The focus on problem-solving helps resolve or reduce conflicts through discussions during the process of setting up the system or through the roundtable format of decision-making (i.e., via the board itself) (Carlsson & Berkes, 2005). By gathering knowledge and perspectives from different orders of government, co-management addresses natural resource management issues that cross multiple geographic areas and jurisdictions (Berkes, 2002). Although knowledge such as biological monitoring data is important, a broad suite of information, such as economic forecasts, ILK, and traditional relationships with the land is also needed to build a coherent understanding of the natural resources and land in question (Carlsson & Berkes, 2005; White *et al.*, 2007).

One challenge hindering co-management, as highlighted by the Assembly of First Nations, is the lack of information on how to implement this approach (AFN, 2012). As a result, some First Nations members disapprove of the term *co-management*, because it reflects the rights-holding status of First Nations, and implies that the Government of Canada and First Nations are equal partners. The partnership is equal in that each group has valid knowledge of natural resources and management skills, and they will work together to make and implement decisions (AFN, 2012).

Sharing of power presents another challenge. Goetze (2004) notes that the "main failing of… most co-management systems is their attempt to involve local stakeholders in resource management without sharing power." The multi-party basis of co-management agreements excludes other local actors, such as members of industry or conservation groups, from sharing power (Goetze, 2004). In addition, the Panel notes that, even in co-management systems, a government official is the final decision-maker in terms of accepting, rejecting, or modifying board recommendations and sometimes has the authority to overrule all decisions. It can also be difficult to meet the requirement for non-Indigenous governments to value ILK alongside science in co-managing resources (Usher, 2000; Huntington, 2013).

One form of co-management is adaptive co-management (ACM), which originated in the late 1990s and has expanded in use since then (Plummer *et al.*, 2012). In its simplest form, ACM is the merging of co-management and adaptive management (Plummer *et al.*, 2012). Armitage (2009) describes ACM as a process that "draws explicit attention to the learning (experiential and experimental) and collaboration (vertical and horizontal) functions necessary to improve our understanding of, and ability to respond to, complex social-ecological systems." While related to co-management, ACM places a different emphasis on linkages, timeframes, organizational level, and focus on capacity. Like other aspects of INRM, no one-size-fits-all approach exists for ACM (Armitage *et al.*, 2009; Plummer *et al.*, 2012).

In general, governance processes that include adaptive management do have some limitations. Some argue that adaptive approaches allow for agencies and industry to exert too much discretion in how specific requirements are implemented (Doremus, 2001; Houck, 2009). Furthermore, as discussed in Chapter 4, there appears to be a disconnect between adaptive management in policy and adaptive management in practice (Plummer *et al.*, 2013), and evidence suggests practitioners may not appreciate what adaptive management means from a regulatory perspective (Allen *et al.*, 2011). Adaptive management has been identified as most appropriate when there are high levels of uncertainty and where situations are controllable, with other approaches being more suited to situations where there is certainty about outcomes (Peterson *et al.*, 2003; Williams, 2011). Additionally, Williams (2011) notes that adaptive management is not the ideal method when fundamental components (e.g., effective monitoring) are unlikely to be realized.

5.3 LAWS AND REGULATIONS RELATED TO NATURAL RESOURCE MANAGEMENT

Laws and regulations establish the boundaries of and conditions for resource-based decision-making in Canada, and can create a space in which INRM can thrive. For example, having a solid legislative basis has been identified as at least somewhat important for implementation with respect to strategic land-use planning in British Columbia (Joseph *et al.*, 2008). In the view of the Panel, laws or policies that require monitoring and integrating information into a collaborative decision-making process are more likely to support INRM than those that vest broad discretionary powers in separate governmental entities.

The Expert Panel for the Review of Environmental Assessment Processes came to a similar conclusion, noting that the "discretionary approach to carrying out regional studies under CEAA 2012" has resulted in no such studies being conducted, and recommended that future federal impact assessment legislation require regional impact assessments to be carried out wherever cumulative impacts already (or may) occur on federal lands or marine areas (Gélinas *et al.*, 2017).

With a few notable exceptions (Box 5.4), most environmental and natural resource laws in Canada were passed before INRM had garnered significant interest, and with limited recognition of Indigenous governments. Many of these laws vest decision-making authority in a single government entity — often a Minister and delegates in a department — in a highly discretionary manner (Boyd, 2003). A classic example of single-government power at the federal level is the original (1977 to 2012) fish habitat authorization regime under Section 35 of the *Fisheries Act*. The Act gave the Minister of Fisheries and Oceans broad discretionary authority to approve impacts to fish habitat, subject to whatever terms and conditions the Minister deemed appropriate. Furthermore, the fragmentation of legal authority at the federal level, as is often dictated by legislation, makes collaboration challenging (NRC, 2013). A similar single-government approach is used across most provincial resource management laws. For example, pursuant to Sections 50 and 51 of Saskatchewan's *Water Security Agency Act*, the Water Security Agency has sole and seemingly unlimited discretion to issue a water licence (Gov. of SK, 2017).

Unless the relevant legislation requires collaboration with other actors at various stages of INRM, regulators faced with adversity may readily revert to unilateral, sectoral decision-making. For example, based on the experience of the Panel, a sound attempt to establish an INRM regime post-devolution in Yukon failed partially because it lacked a clear and meaningful government-wide commitment, did not have an effective institutional champion, and did not grant authority to overcome structural and behavioural obstacles. More recent laws requiring collaboration, however, nevertheless suffer from many of the weaknesses identified in earlier environmental legislation, including excessive discretionary executive powers (Bankes *et al.*, 2014); their impact will be reduced if they are not accompanied with the necessary resourcing.

Box 5.4
Statutes and Collaboration: The Alberta Land Stewardship Act

The *Alberta Land Stewardship Act* (ALSA) is perhaps the most ambitious current provincial/territorial example of a statute on collaboration. When it was brought into force, the Government of Alberta promoted ASLA as "the most comprehensive land-use policy in Canada and, indeed, in North America" (Gov. of AB, 2009). The Act "provides for landscape level land-use planning as a means to integrate decision-making and respond to the cumulative effects of development activity" (Bankes *et al.*, 2014). In this way, ALSA seeks to provide a mechanism to enable sustainable development (Bankes *et al.*, 2014). It does so by setting out a process for the development of regional plans, each of which must establish a vision and objectives for a given region (Gov. of AB, 2013).

Although ALSA is a positive step, it has some deficiencies and has not yet achieved all of its goals. Regional planning may include more detailed elements such as policies, thresholds, indicators, or monitoring requirements, but these are not mandatory (Gov. of AB, 2013) and are at the discretion of the Cabinet (Bankes *et al.*, 2014). Furthermore, while approved plans are considered binding for the Crown, decision-makers, local government bodies, and all other persons, ALSA also permits the exemption of an entity from the definition of *local government body* or *decision-making body* (Gov. of AB, 2013). As of January 2019, only two regional plans have been completed, with a third in progress (and four not yet started) (AEP, 2016). In addition, an independent review panel concluded that the Lower Athabasca Regional Plan suffers from numerous deficiencies with respect to First Nations participation and concerns, including the absence of any Traditional Land-Use Management Framework (Lower Athabasca Regional Plan Review Panel, 2016).

As noted in Chapter 2, Indigenous Peoples in Canada have their own set of legal traditions that are distinct from the European legal traditions that form Canadian law. Elements of these traditions are compatible with and supportive of INRM goals. For example, some of the guiding principles that form the Laws of Haida Nation (e.g., seeking wise counsel) align with INRM characteristics (e.g., adaptive management or ongoing learning) (CHN & GC, 2018). Additionally, modern land claims agreements between Indigenous Peoples and the Government of Canada can provide a mechanism to implement shared governance and new EA processes, as well as participate in knowledge-sharing. For example, Torngat

Mountains National Park in northern Labrador (part of Nunatsiavut) was established as a result of the Labrador Inuit Land Claims Agreement (The Inuit of Labrador & GC, 2005). The park's co-management board includes members of the Nunatsiavut Government, Makivik Corporation, and Parks Canada, as well as an independent Chairperson. The co-management board provides "advice to the Federal Minister responsible for the Parks Canada Agency on matters related to park management" as well as other co-management boards (e.g., Torngat Joint Fisheries Board), the Nunatsiavut Government, and the Makivik Corporation (Parks Canada, 2010). The co-management board provides a mechanism to develop a management plan for the park that is "collaborative and meaningful" for Parks Canada, and the Inuit of Nunavik and Nunatsiavut (Parks Canada, 2010).

Although the majority of Canadian laws governing resource management do not formally support INRM, none explicitly prohibit INRM processes. Implementing INRM characteristics can face barriers related to the current legal framework, but the Panel believes a move towards more collaborative and shared governance is both necessary and possible.

5.4 CONCLUSION

Governance approaches for INRM in Canada exist along a spectrum from singular to shared decision-making authority. Broadly speaking, more shared and collaborative governance helps all actors to participate fully and respectfully in the process, and to view it as legitimate. The appropriate choice is based on the specific context, and careful participatory design of governance processes is an essential first step. Appropriate laws and regulations ultimately enable the participation of actors in the various governance approaches. INRM is more likely to succeed when laws and regulations "have teeth" — ensuring that decision-making and management actions are completed in an integrated, inclusive way. Nevertheless, it is possible to take positive action to advance more consultative and collaborative forms of governance within current legal structures. In the next chapter, the Panel addresses five key barriers to INRM — connected to both knowledge and governance — and presents potential solutions emerging from Canadian experiences to date.

6

Implementing INRM in Canada: Barriers and Potential Solutions

- Data Gaps and Accessibility
- Bridging Multiple Sources of Knowledge: Western Science and ILK
- Project-Level Versus Integrated Decision-Making
- Governance Structures
- Industry Incentives: From Conflict to Alignment
- Conclusion

6 Implementing INRM in Canada: Barriers and Potential Solutions

Key Findings

Knowledge-sharing networks and better coordination of research and monitoring efforts are needed to foster interdisciplinary knowledge creation and exchange at scales relevant to INRM. Informed decision-making is impeded by fundamental data gaps, and by research and monitoring efforts that are incomplete, narrow in scope, and poorly disseminated.

Bridging multiple forms of knowledge calls for the co-design of bridging processes that are acceptable to all knowledge holders and respectful of their differences.

Effective INRM is supported by regional-level planning and strong links among regional-level plans and targets, and project-level decisions.

Lack of a defined lead, organizational silos, and conflicting goals all raise challenges for INRM governance and call for enhanced leadership, coordination, and institutional arrangements.

Industry can achieve multiple objectives by advancing INRM approaches through company-level initiatives, participation in certification programs, adoption of voluntary standards, and cooperation with and implementation of government-led INRM.

INRM has the potential to address many of the natural resource challenges facing Canada, but its implementation is hindered by a number of factors. This chapter identifies five critical barriers to effectively implementing INRM in Canada (in no particular order). Panel members drew on their own expertise and knowledge of INRM to identify potential solutions and leading practices that address these challenges. In the Panel's view, another important barrier to progress is the lack of a shared understanding of INRM among practitioners and policy-makers; the eight INRM characteristics established by the Panel (Chapter 3) are intended to support and elevate this understanding.

6.1 DATA GAPS AND ACCESSIBILITY

6.1.1 Barriers

Knowledge integration across multiple ways of knowing is a crucial feature of integrated approaches. However, much of the data that could help inform Western scientific knowledge of INRM are either absent, incomplete, or inaccessible. Speaking on Canada-wide data, *Canadian Biodiversity: Ecosystem Status and Trends 2010*, a report overseen by federal, provincial, and territorial government representatives, states:

> Piecing together information from disparate sources is currently the only way to assess status and trends of Canada's ecosystems. In some cases, there are good data sets backed by long-term monitoring programs. Information is sometimes available for status but not trends, or trend information is limited to a small geographic area over a short time interval. Often, information critical to the assessment of ecosystem health is missing.
>
> (FPTGC, 2010)

A review of Environment and Climate Change Canada's environmental indicators highlights some of these challenges, especially the lack of recent and comprehensive data. For example, some of the most recent indicators date back several years (e.g., migratory bird populations as of 2013 (ECCC, 2016b), municipal wastewater treatment as of 2009 (ECCC, 2017b)). Data on the extent of Canada's wetlands are pieced together from over a dozen different sources because there is no national wetland monitoring system (ECCC, 2016a). Economic, political, technical, and structural barriers all contribute to difficulties accessing data. Not all actors are enthusiastic about sharing their data due to concerns about the potential misuse or misinterpretation. For instance, resistance in sharing data and information exists among Indigenous Peoples as a result of the lack of consultation with respect to information's collection, maintenance, and access (RCAP, 1996a). In addition, governments may have concerns about sharing data, associated with loss of control, privacy concerns, technical issues, or the resources required to share and maintain open data (NRC, 2013). When data are made available through requirements of an EA process or otherwise, proponent data are often in inaccessible formats (Dowdeswell *et al.*, 2010; Wong, 2018). The siloed structure that exists within large institutions and organizations (e.g., universities, governments, industries) may also limit data sharing. Scientists are often incentivized to specialize in narrower topics rather than generalize or work across disciplines (Klein & Falk-Krzesinski, 2017). When disciplines do not work together, it becomes common for different actors to collect and maintain data using different spatial and temporal scales and sometimes even different definitions of key concepts (NRC, 2013).

Overall, the lack of understanding about what information exists, coupled with the inability to readily access the data, undermines government- and proponent-based monitoring and data sharing. Under current practices, few mechanisms ensure data sharing and accessibility (Wong, 2018); this is illustrated by the Panel's challenges in creating an accurate map of natural resource development in Canada (Section 2.1.2). In addition, in the experience of Panel members, combining datasets is further challenged by the fact that representation, recording, and nomenclature of data can be significantly different among jurisdictions in terms of what is characterized as a land disturbance (e.g., trails, roads, seismic lines). In short, a standard methodology does not exist in Canada for the creation of a disturbance database. This issue was recognized by Environment Canada, which noted that, on the subject of mapping disturbances as they relate to the identification of critical habitat for woodland caribou, "analyses undertaken using different data sources may yield different total disturbance results" (EC, 2011).

In the experience of the Panel, the majority of monitoring programs have deficiencies in terms of meeting the needs of INRM due to limited scopes and/or poor data harmonization dictated by individual development projects or narrow regulatory requirements and limited budgets. This observation is consistent with the conclusions of expert panels and auditors who have found deficiencies in Canada's monitoring programs for natural resource development (e.g., Bellringer, 2015; EPJOSM, 2016; Gélinas *et al.*, 2017). For example, although the Expert Panel on Assessing the Scientific Integrity of the Canada-Alberta Joint Oil Sands Monitoring found that the Joint Oil Sands Monitoring had made "good progress" since its launch in 2012, it still had several problems preventing it from being a "fully integrated and harmoniously functioning long-term monitoring system" (EPJOSM, 2016). Reasons for this include "limited comprehensive analysis" of the data collected, which makes it challenging to determine if the level of monitoring is sufficient to assess impacts; the absence of analysis, resulting in little progress in "harmonizing and rationalizing pre-existing disparate monitoring approaches and activities;" and the four monitoring pieces (air, water, wildlife contaminants and toxicology, and biodiversity and land disturbance) remaining separate (EPJOSM, 2016).

6.1.2 Potential Solutions

In the absence of comprehensive data inventories and knowledge management systems, it is still possible to improve decision-making with existing information via knowledge-sharing networks, independent organizations, and tools to manage uncertainty, while at the same time making new strategic investments to improve information availability and accessibility.

When different actors, orders of government, and government agencies collaborate and exchange knowledge, the understanding of natural resources and the consequences of management strategies in a region is strengthened. Knowledge-sharing networks can provide mechanisms for clear and effective communication, management, and exchange of knowledge. This allows all actors to have access to knowledge and data beyond their formal jurisdiction or specific areas of concern, and, when jurisdictions overlap, actors can combine and assess each other's data to ensure a common understanding. Such knowledge-sharing networks can include governing bodies at various orders, interested parties, and rights holders working together as a learning community (Armitage *et al.*, 2009). Engaging all relevant jurisdictions is important to overcome problems associated with silos and fragmentations (e.g., data access, or boundary, jurisdictional, and legal conflicts) (Slocombe & Hanna, 2007). When organizations develop trust in the system, its goals, and in each other, many of their concerns can be better addressed. Here the scholarship on networks in natural resource management and especially on bridging organizations can be helpful (e.g., Frank, 2011; Henry & Vollan, 2014; Tindall, 2015; Henry, 2018; Masuda *et al.*, 2018).

Cronmiller and Noble (2018) have noted that independent organizations, perhaps affiliated with a consortium of universities, could house the resources and intellectual capacity for knowledge/data management, quality control, and distribution. Operating independently and overseen by a board of directors, such an organization could ensure that data and knowledge generated are applicable to the needs of the various actors and decision-makers — and of value to regulatory processes, such as impact assessments (Cronmiller & Noble, 2018). Although initiating these centres requires government financial support in one form or another, longer-term funding may be collaborative, including expertise and financial commitments from all orders of government, industry, and various granting agencies (Lockwood *et al.*, 2009; Cronmiller & Noble, 2018). Created in 1992, the International Forestry Resources and Institutions research network establishes shared data collection methods across its 14 collaborating research centres, and houses a database covering themes such as biodiversity and forest carbon across 250 sites in 15 countries (IFRI, n.d.).

When information is limited, it is essential to manage the corresponding uncertainty using tools such as predictive models or risk assessment combined with expert judgment. Guidance established by the IPCC can be instructive for INRM. It suggests assessing uncertainty in the following ways: describing the overall state of knowledge, identifying key factors that contribute to uncertainty in overall conclusions, and quantitatively or qualitatively characterizing available ranges and distributions (Moss & Schneider, 2000). BC Hydro's WUP process illustrates how decision-making can proceed despite incomplete information.

Water use plans are required to consider trade-offs in their planning process, with the goal of finding compromises across water uses (Gov. of BC, 1998). Assessing uncertainty and risk is a key component of trade-off analysis. Uncertainty may call for greater reliance on expert judgement, or additional research including modelling and data collection, to help evaluate alternatives (Failing *et al.*, 2007). As such, there is an adaptive management aspect to this approach, which uses learning to address and reduce uncertainty (Gregory *et al.*, 2006). Adaptive management is formalized within the WUP process through the commitment to funding for long-term ecological monitoring. Furthermore, the decision-making framework allows for iterative improvement, with lessons from the initial review potentially leading to a preferred set of trade-offs (Failing *et al.*, 2007). The Alberta Watershed Resiliency and Restoration Program demonstrates how trade-off analysis can be used to present data in a way that is accessible to decision-makers and reduce some of the uncertainty around the potential impacts of their decisions (Box 6.1).

Box 6.1
The Watershed Resiliency and Restoration Program (WRRP) Simulation Project in the Bow River Basin

The goal of the WRRP's Bow River Basin Simulation Project was "to demonstrate reduction of environmental and socioeconomic risk obtainable through conservation and restoration strategies aimed at building resilience." The ALCES Online land-use simulation model is a tool used to help achieve this goal and support the integrated decision-making process in the Bow River Basin.

All of the major land uses in the basin (agriculture, oil and gas extraction, aggregate extraction, forestry, and urban and rural residential development) were included in the scenarios, along with forest fire. A working group that included representatives from conservation organizations, government agencies, and natural resource sectors identified land-use scenario assumptions, watershed indicators, and conservation and restoration strategies.

The 50-year land-use simulation found that the footprint of all human activities (with the exception of agriculture) went from 1,837 to 2,831 km^2. The largest contributor to this growth was found to be urban and rural residential development. The model determined that increased land use would be associated with a higher risk to watershed function. The effectiveness of conservation and restoration strategies was also assessed in the model, enabling the identification of those with the greatest

continued on next page

possible benefits. For example, reclamation of the energy sector's footprint had the greatest potential for reducing risk to the fish population.

Web-based dashboards were used to communicate the assessment of trade-offs among mitigation options to managers and other actors. These dashboards included dynamic figures such as maps that demonstrate both the risks to watershed integrity and the potential effectiveness of mitigation strategies.

(Carlson *et al.*, 2018)

Beyond enhancing public data-gathering efforts, governments can improve other groups' data gathering and sharing. Regulatory EA processes can motivate data sharing, or require it through clearly articulated data management and access plans. Standards and protocols for data collection and information management can ensure consistency and comparability (CILMC, 2005). Supported by funds from government, industry, and granting agencies, the Alberta Biodiversity Monitoring Institute tracks over 2,500 species within a grid of 1,656 locations across the province and makes the data freely available alongside its monitoring protocols and quality management plan (ABMI, 2014a, 2014b, 2014c, 2014d).

6.2 BRIDGING MULTIPLE SOURCES OF KNOWLEDGE: WESTERN SCIENCE AND ILK

6.2.1 Barriers

INRM bridges available and relevant knowledge. In Canada, the importance of ILK in particular is increasingly recognized, but bridging ILK with Western science can be challenging. By bringing together multiple sources of knowledge, more information is available to understand the system in question and to make informed management decisions (Tengö *et al.*, 2014). There has been limited success in the consideration of multiple knowledge systems in international practice (Tengö *et al.*, 2014; Ford *et al.*, 2016). Different disciplines often use different timeframes and geographic boundaries, and the challenge of integrating these can deter and limit the success of efforts to bridge knowledge. If information is measured and presented in timeframes and geographic boundaries that are not compatible, natural resource managers may not be able to include all relevant and available information when making decisions (Vogt *et al.*, 2002). It may be necessary to develop frameworks that can build connections among different sources of knowledge (Tengö *et al.*, 2014). Overall, respecting the integrity and context of different sources of knowledge is essential to successfully working with the information and its holders (Berkes, 2015).

Lack of well-developed and generally accepted methodologies may also be a barrier to the consideration of multiple knowledge systems. Some have noted a dearth of tools and processes to help increase the successful use of multiple sources of knowledge. This includes an absence of frameworks that connect knowledge systems across different timeframes and geographic boundaries. Ideally, these frameworks would help to "promote and enable equal and transparent connections between knowledge systems, to level the power dynamics involved, to empower communities, and also fulfill the potential of knowledge synergies for ecosystem governance" (Tengö *et al.*, 2014). Tengö *et al.* (2017) further noted that "[c]ollaboration will require moving from studies 'into' and 'about' indigenous and local knowledge systems, to equitable engagement *with* and *among* these knowledge systems."

A major impediment to integrating ILK and Western science is the power differential between the two (Stevenson, 1996; Nadasdy, 1999; Battiste & Youngblood Henderson, 2000; Hill *et al.*, 2012). Berkes has explored these power dynamics in some detail (Berkes, 2015, 2018; Johnson *et al.*, 2016b). According to Johnson *et al.* (2016b), "[i]f and when integration occurs, such integration often works to the disadvantage of Indigenous people and Indigenous knowledge systems due to differences in power." Differences in power often result in the disadvantaging of Indigenous people and Indigenous knowledge systems. Thus, scientists and resource managers might apply ILK in ways that suit their purposes, often "mining" ILK as "data," and applying ILK out of its cultural context (Berkes, 2015). An additional power imbalance stems from the fact that collaboration (or consultation) is often based on meetings among natural resource professionals (e.g., scientists, resource managers) and ILK holders who are volunteers or only employed on an *ad hoc* basis (e.g., for the duration of a meeting). Therefore, on one hand are staff whose jobs consist of planning and carrying out resource management, and on the other are those with little (or no) paid time to prepare. Furthermore, there is a situational divide created by the fact that Indigenous people may have limited control over the region in which they live compared to other orders of government (Whyte, 2013). These imbalances are also applicable to non-Indigenous local populations, as citizen groups are also generally represented by volunteers and have fewer financial and technical resources compared to government and industry (NRC, 2008).

6.2.2 Potential Solutions

Barriers to effectively using different knowledge systems together can be overcome by applying internationally accepted principles and learning from existing good practices. Proper process is very important in finding ways to

bridge ILK, Western science, and other forms of knowledge and should be informed by the duty to consult and commitments to adhere to the principle of free, prior, and informed consent in UNDRIP. Often a bridging organization can serve as a trusted knowledge broker among various interested and affected parties and their forms of knowledge. Bridging organizations have been used to manage data and knowledge-sharing networks, which help facilitate knowledge-sharing and learning from both Western science and ILK (Olsson *et al.*, 2007). Bridging organizations can also help build social capital, deal with conflicts, generate trust, develop shared goals and vision, and provide a means for horizontal and vertical collaboration (Hahn *et al.*, 2006). Miller and Wyborn (2018) note that institutions that engage in the co-production of knowledge can consider existing power dynamics, then introduce new governance approaches and redistribute power. Bridging organizations are often a key component of successful co-management, where they have existed as a group of scientists or as the co-management board itself (e.g., Beverly Qamanirjuaq Caribou Management Board) (Berkes, 2009). In a different model, the Independent Environmental Monitoring Agency for the Ekati Diamond Mine (Northwest Territories) serves a range of functions that include ensuring ILK is applied in environmental planning and programing, and that information is shared with Indigenous Peoples (IEMA, n.d.). Bridging organizations can also be valuable to other INRM initiatives, since collaboration is a pre-requisite for success. They can help develop processes to link forms of knowledge and build networks of communications and trust among those who should have a voice in developing the knowledge necessary for INRM (Bidwell *et al.*, 2013), as described below in the case of the Arctic Borderlands Ecological Knowledge Society.

Berkes (2015) has explored a number of methods to bridge the two kinds of knowledge in ways that are respectful, and that foster equal collaboration and two-way learning (Figure 6.1). Some of these methods, such as participatory rural appraisal,[5] have a relatively long history; others, such as community-based monitoring, are still being developed. In general, the approaches draw on the substantial literature on public participation in EA and decision-making and deliberative processes (e.g., NRC, 2008), but place special emphasis on the challenges and opportunities in bridging different forms of knowledge.

5 *Participatory rural appraisal* refers to a set of approaches to engage with and give ownership to local people in their own planning, recognizing they are best-placed to analyze and improve their own conditions (Chambers, 1994).

Some approaches that foster equal partnerships between two kinds of knowledge	Some techniques to elicit and understand local and Indigenous views and knowledge	Cooperating around a particular task at which local and Indigenous communities may have specific expertise
Participatory rural appraisal: adapted for use with ILK	**Participatory mapping:** most popular technique	**Participatory conservation planning:** uses complementary knowledge from science and local/ Indigenous communities
Participatory action research: emphasizes collective inquiry and social change; seeks to change the world collaboratively and reflectively	**Participatory workshops and modelling:** used successfully with Indigenous and non-Indigenous rural knowledge holders	**Participatory environmental restoration:** uses ILK and science; local knowledge can provide essential information not otherwise available to science
Participatory education (critical pedagogy): from a tradition of empowering learners to become co-creators of knowledge	**Participatory scenario planning:** part of a toolkit of participatory workshops and modelling approaches	**Community-based monitoring:** involves reading signs and signals of environmental change based on the ways of knowing of a given group
Learning communities: groups of people with a shared interest, learning in partnership through regular interactions based in practice		

Adapted with permission from Berkes (2015)

Figure 6.1

Bridging Knowledge: Collaboration and Two-Way Learning Between ILK and Western Science

Various approaches and techniques exist to support collaboration and two-way learning between ILK and Western science, including approaches that foster partnerships, improve understanding, and enhance cooperation.

Bridging Western science and ILK is an ongoing area of practice and research where INRM efforts can learn from multiple experiences and develop a process suitable for the context in which they are applied. The Panel chose to highlight three examples that combine ILK and Western science to serve INRM in a way that is acceptable to both kinds of knowledge holders, and respectful of their differences. Perhaps the earliest case in Canada is detailed in the 1994 Report of the Scientific Panel for Sustainable Forest Practices in Clayoquot Sound (Clayoquot Sound Scientific Panel, 1994). That panel was set up to resolve disputes over logging old-growth forest on Vancouver Island. In his analysis, Lertzman (2010) notes that, "[w]ith its unprecedented mandate to develop sustainable forest practice standards drawing equally on Western science and Nuu-Chah-Nulth traditional ecological knowledge, the Clayoquot Scientific

Panel achieved a full consensus on all recommendations where previous land use planning attempts had failed." The consensus was particularly noteworthy given that this was a high-profile environmental conflict and that earlier efforts to resolve the conflict had failed. Lertzman (2010) identified the following features of the Clayoquot Scientific Panel's approach that contributed to its success in achieving consensus:

- use of the Nuu-Chah-Nulth inclusive process, which supports cross-cultural communication and calls for participants to listen and seek to understand the views of one another, and to respect data emerging from both science and traditional knowledge;
- respect for cultural teachings and spiritual philosophy that recognizes the sacredness of the Clayoquot Valley;
- recognition of the traditional land, water, and resource stewardship system in the proposed framework for co-managing Clayoquot Sound; and
- reliance on and enhancement of cultural literacy to communicate effectively between cultures.

The Arctic Borderlands Ecological Knowledge Society (ABEKS) provides an example of how bridged knowledge from different sources and actors can support better management of wildlife. The society supports the work of the Porcupine Caribou Management Board, a joint Canada/U.S. co-management body that oversees the porcupine caribou population in Yukon, Northwest Territories, and eastern Alaska (ABEKS, 2014a). ABEKS includes local and Indigenous governments and councils as well as representatives from territorial, state, and national governments on both sides of the Canada-U.S. border (Gordon *et al.*, 2008; ABEKS, 2014b). Gordon *et al.* (2008) write that, "since its beginning, the Co-op has encouraged and supported the use of both science-based studies and studies based on local and traditional knowledge in the monitoring and management of ecosystems." As Eamer (2004) describes, "[t]he program's focus is on strengthening the role of local aboriginal knowledge in environmental assessment, and in exploring ways to bring local and science-based knowledge together to improve understanding of ecological status and trends." This initiative gathers a variety of information and knowledge, including ILK in the form of local observations and traditional ecological knowledge as well as science in the form of monitoring, records, statistical analysis, and research (Eamer, 2004). Observations are gathered through interviews conducted by community researchers, and results are made available online and through community meetings (ABEKS, 2014a). Russell (2011) writes that these community-based interviews are valuable and recommends that this initiative be seen as "a model of integrating community based monitoring data into resource management decision making throughout the north." Participants have also identified over 70 indicators to monitor ecosystem change, including physical, ecological, and

socio-economic variables (ABEKS, 2014c), with the goal of understanding the linkages among climate drivers and the information derived from interviews (Svoboda *et al.*, n.d.).

EAs in the Mackenzie Valley, Northwest Territories are administered by a dedicated board, the Mackenzie Valley Environmental Impact Review Board (MVEIRB) (White *et al.*, 2007). Regional land and water boards conduct preliminary screenings of development projects, but the MVEIRB holds the responsibility for reviewing environmental impacts for potential developments in the Mackenzie Valley, and functionally replaces the federal assessment process within its boundaries (INAC, 2007). Although the *Canadian Environmental Assessment Act* (2012) identifies ILK as a source of knowledge that may be taken into account during an assessment, there is no formal requirement to include ILK in federal EAs (GC, 2012b).[6] In contrast, the co-managed MVEIRB strongly encourages the use of ILK, not only through recommendations, but also by coordinating community meetings to consider the implementation of ILK into their EAs (White *et al.*, 2007). In exercising its power, the *Mackenzie Valley Resource Management Act* (MVRMA) stipulates that the MVEIRB "shall consider any traditional knowledge and scientific information that is made available to it" (GC, 2016d). The MVEIRB has been lauded for its transparency, Indigenous representation, incorporation of ILK, and larger solicitation of Indigenous perspectives (White *et al.*, 2007).

The examples of the Clayoquot Panel, the ABEKS, and the MVEIRB show the various ways in which science and ILK can be brought together. They illustrate several elements of effective practices for considering both ILK and Western science established by Johnson *et al.* (2016b):

- "[R]especting the integrity of each knowledge system produces healthy results. The operative word, therefore, should be 'bridging' knowledge systems (Reid *et al.*, 2006). Such an approach is preferable to 'synthesizing' or 'combining' or 'integrating' knowledge systems."
- "The two paradigms can best be considered together by combining knowledge in a collaborative way around a particular topic." There have been attempts to combine the two kinds of knowledge around species biology and ecology (e.g., Gagnon & Berteaux, 2009), and around ecosystems such as forest ecosystems (Trosper & Parrotta, 2012) and biocultural landscapes (Kimmerer & Lake, 2001).

6 The Impact Assessment Act (Bill C-69) strengthens the Government of Canada's commitment to ILK, at least in principle (House of Commons, 2018c).

- "Combining the two kinds of knowledge is especially important in situations of insufficient information. Using the two paradigms together can improve problem solving." Notably, this has been used to better understand climate change because it takes advantage of the complementarity of ILK and Western science (Tyler *et al.*, 2007; Nakashima *et al.*, 2012).

In reflecting on the theory and practice set out above, the Panel drew several conclusions on strategies to support effective knowledge-bridging. First, just as in the development of governance processes, the details of any process to bring together ILK, Western science, and other forms of knowledge should be co-designed by the interested and affected parties. Second, knowledge-bridging is complex, and involving individuals and organizations with expertise in the practice of bridging can improve the process and the outcomes. Third, each body of knowledge should be considered in the context of its source and in a way that is satisfactory to the knowledge holders. In addition, the Panel underscored that, while bridging may be challenging, this is not an excuse for inaction; furthermore, real action requires dedicating resources to ILK studies and sharing power and influence with knowledge holders.

6.3 PROJECT-LEVEL VERSUS INTEGRATED DECISION-MAKING

6.3.1 Barriers

The current approach to managing the development of natural resources in Canada has been through project-by-project reviews, using conventional, regulatory-based EA processes. The system of project-based management is constrained in its ability to address cumulative effects, which are often unaccounted for either because small projects do not trigger their own assessment or because the narrowness of the project's assessment scale limits consideration of some impacts (Seitz *et al.*, 2011; Nielsen *et al.*, 2012). As a result, regional environmental degradation can occur by default (as opposed to by design) through what has been referred to as the "tyranny of small decisions" (Kahn, 1966; Odum, 1982; Noble, 2010). Impacts that appear insignificant at the project level can accumulate across multiple projects and sectors to cause substantial change. As well, the spatial and temporal extent of project-based planning is frequently insufficient to incorporate the broad scales at which ecological processes operate. The home range size of species such as grizzly bear and boreal caribou can span thousands of square kilometres, and ecological processes such as fire and hydrological function can operate at even larger spatial scales. Project-based planning on its own will fail to identify impacts of such large-scale phenomena (Parkes *et al.*, 2016).

Even when planning at a regional scale exists, if regional targets are not functionally linked to project-level decisions (e.g., through law or defined policies), INRM capacity is inhibited (Kennett, 2002). For example, on its own, establishing thresholds does not guarantee that projects will not be approved if they expect to contribute to exceeded thresholds. This is illustrated by the approval of the Jackpine Mine Expansion Project in Alberta, which occurred despite Shell's models projecting that thresholds for certain air pollutants (as defined in the regional plan) may be exceeded due to the cumulative effects of industrial projects (JRP, 2013). Shell's models suggested that the nitrogen dioxide threshold would be exceeded even if the expansion did not go forward; approval of the expansion was therefore predicted to further elevate levels beyond the threshold (JRP, 2013).

6.3.2 Potential Solutions

In contrast to project-based planning, regional planning processes and regional strategic assessments can assess the combined threats and consequences of multiple natural resource sectors operating over large landscapes and long timeframes. Planning at a regional level addresses the spatial allocation of activities across a landscape in pursuit of regional objectives, thereby providing direction to decision-making at the local scale. For instance, regional strategic EAs conducted early in land-use and development planning tend to be more expedient and effective (Staples & Askew, 2016; Noble, 2017). Further, global experience can be useful in designing such assessments. The Panel suggests that the knowledge (science, tools, methodology) to carry out these regional strategic assessments already exists (e.g., CCME, 2009), but there has been limited uptake across the country as decision-making has been devolved to governments (and government agencies) that lack the authority or motivation for pursuing a broader perspective. The isolated attempts at planning at the regional level identified by the Panel provide valuable learning opportunities for INRM.

The Great Sandhills, an ecologically rich environment of approximately 1,900 km^2 in the southwest region of Saskatchewan (GSHSAC, 2007), is a good example of planning at a regional level. In 2004, the provincial government commissioned a regional assessment of human-induced disturbances in the area. It did so in response to decades of concern over two key issues: the cumulative effects of land use, including natural gas development, cattle ranching, road development, and recreation; and municipal landowner frustration about the failure of previous planning initiatives to provide adequate, science-based strategic direction for land-use management and protection of biodiversity. The regional assessment's terms of reference stipulated a strategic assessment framework, with the overall aim to identify a preferred, integrated land-use

strategy to protect the long-term ecological integrity of the region and realize its economic benefits, specifically from natural gas development (GSHSAC, 2007). The Government of Saskatchewan appointed an independent scientific committee to carry out the assessment, which resulted in the identification of a preferred land-use strategy and over 60 recommendations concerning land-use designations, industry best management practices, biodiversity conservation, and economic and social policy to manage cumulative effects in the region (GSHSAC, 2007).

The main difference between the Great Sandhills assessment and past planning and assessment initiatives in the region was its integrated, strategic approach to assessing the effects and risks associated with multiple land uses (Noble, 2008). A strategic approach, focused on future scenarios, enabled the assessment "to occur beyond the constraints of individual project-based initiatives, many of which are not subject to any form of regulatory assessment, in order to address the nature and underlying sources of cumulative change and to identify desirable futures and outcomes" (Noble, 2008).

That said, the Great Sandhills case also exposed several challenges to regional and integrated approaches. First, like many attempts at regional assessment (e.g., Parkins, 2011), it was a one-off initiative with "no real mechanism to sustain it as an integral part of regional planning and downstream project assessment" (Noble, 2008). Second, the original intent was for the assessment to "inform and guide future development activities, land use zoning, and decision-making." However, as in most jurisdictions in Canada, a formal tiered system does not exist to effectively carry the results of a strategic assessment forward from the regional scale to the project scale, or to integrate the results into ongoing planning and policy-making processes. Third, although a provincial government ministry commissioned the assessment, it lacked the capacity and the authority to fully implement many of the recommendations emerging to effectively manage land use and cumulative effects, particularly those related to oil and gas regulation and social policy. Noble (2008) stresses that these undertakings necessitate "a collaboration that requires joint commitment and crosses agency boundaries and responsibilities to achieve a common goal." Any of these challenges could be exacerbated when regional assessments span multiple jurisdictions (e.g., a watershed that crosses a provincial boundary).

A promising initiative is emerging in British Columbia, under the umbrella of a province-wide Cumulative Effects Framework (Gov. of BC, 2016). This example highlights the importance of coordination and leadership. Like most provinces, British Columbia has managed its natural resources using several stewardship tools and regulatory processes, typically applied on a sector-by-sector or project-

by-project basis. In 2010, the province embarked on a process to develop and implement a Cumulative Effects Framework across the natural resource sector in recognition of its growth and the unintended consequences of sector- and project-based resource management and development decision-making (Gov. of BC, 2014). The Framework outlines a stepwise process for cumulative effects assessment that includes the following components:

- selecting values for assessment;
- defining standard assessment protocols;
- assessing the current condition of values, including identification of key drivers of change, and management tools and responses; and
- reporting on current and potential future conditions of values and management responses.

(Gov. of BC, 2016)

The Framework does not replace existing policy and regulatory processes; it is intended to strengthen and add to the suite of tools used for integrated resource management within the natural resource sector. The Government of British Columbia envisions a two-way exchange in which the Cumulative Effects Framework can learn from and inform other natural resource initiatives (e.g., species at risk recovery, implementation planning) (Gov. of BC, 2016).

Once fully implemented, the Cumulative Effects Framework is intended to inform and support:

- strategic decisions, such as land-use planning, objective setting, and other forms of management and direction;
- tactical decisions, such as defining priorities for research, monitoring, and development planning; and
- operational decisions, such as informing authorizations for natural resource activities and project-specific impact assessments.

(Gov. of BC, 2016)

The Panel concluded that INRM can be successful when regional planning processes, including regional strategic assessments, are linked to project-based reviews and decision-making in a meaningful way to realize multiple — and often competing — environmental, economic, and social objectives. Indicator targets are an important mechanism in this regard. Establishing economic and environmental targets for different types of resource management zones provides guidance for project-level decision-making, thereby ensuring that projects are consistent with regional and strategic objectives. A feedback link from project outcomes to regional-level planning is also needed in order for

INRM to be successful. Project impacts are monitored to determine whether regional objectives and targets are being achieved, and alternative strategies are identified and pursued as needed. Coordination of monitoring across projects (e.g., through monitoring agencies or monitoring requirements) allows for the assessment of outcomes across projects so as to understand change and address issues relevant to regional objectives. The organization accountable for achieving regional objectives needs to have the authority and mechanisms to impose changes to management actions where necessary, in order to achieve the objectives.

6.4 GOVERNANCE STRUCTURES

6.4.1 Barriers

Existing governance structures often pose barriers to moving forward with INRM; silos, conflicting goals across governments, and lack of a defined lead (due to constitutional division of powers in Canada) all contribute to the challenge. Different orders of government have jurisdiction over different aspects of natural resource management and operate at different scales. Further, within any government, natural resource management responsibilities are often distributed across multiple departments. As a result, the ability of any one actor to implement INRM on its own is limited.

Government departments or agencies often make decisions about the use and allocation of natural resources in isolation from other departments and agencies, and other governments, resource users, and interests. Multi-party planning processes, where they do exist, are generally *ad hoc* and governments sometimes struggle to coordinate decision-making, particularly when working with Indigenous governments (Eyford, 2013). Although working collaboratively may be part of ministers' mandates, the lack of human, financial, and knowledge resources to carry out joint activities often hampers collaboration among government agencies (NRC, 2013). This can occur when budgets assigned to specific activities cannot be shared among agencies, or agencies — through self-interest, mandate, or limited funding — choose not to share resources.

Conflicting mandates or objectives also lead to disagreements among governments over natural resource issues, and these conflicts are exacerbated when the division of powers is unclear. For instance, in the 1990s, BC Hydro, a provincial crown corporation, found itself in conflict with the federal Department of Fisheries and Oceans over a minimum flow order to protect fish, which affected its electricity generation activities. This situation arose from the overlap of federal fish habitat jurisdiction and provincial jurisdiction over electricity generation (Federal Court of Canada Trial Division, 1998).

6.4.2 Potential Solutions

Enhanced coordination, changes to institutional rules, and leadership across governments can all help overcome these barriers. Several approaches have been used in Canada to coordinate the environmental statutes and regulations that exist within several jurisdictions. One approach is to create an institution that brings together different jurisdictions (e.g., Committee on the Status of Endangered Wildlife in Canada, Canadian Council of Ministers of the Environment). Bilateral agreements between the federal and provinces/territories, and the Canada-wide Accord on Environmental Harmonization (excluding Quebec), have also been established to coordinate statutes and regulations (Benidickson, 2013). The *Canada Water Act* enables the federal government to form boards to oversee transboundary issues (ECCC, 2017a). Domestic inter-jurisdictional boards contribute to the management of the water in the Ottawa River, Lake of the Woods, the Prairie provinces, and the Mackenzie River Basin (ECCC, 2017a). The Mackenzie River Basin Board brings together representatives from the federal government and five provincial/territorial governments, as well as five Indigenous representatives, to address water use and ecology and to issue recommendations for water quality and quantity objectives; the Minister then makes the final decision (Hill *et al.*, 2008; MRBB, 2015).

One of the longest-standing examples of multijurisdictional coordination in North America is the International Joint Commission (IJC), which was established by the Boundary Waters Treaty of 1909 to prevent and settle disputes over the boundary of waters between Canada and the United States (Legault, 2000). The mandate of the IJC was expanded in 1972 to implement the Great Lakes Water Quality Agreement (GLWQA), a bilateral agreement between Canada and the United States aimed at protecting and improving the quality of the Great Lakes' water (IJC, n.d.). The members of the Great Lakes Water Quality Board include representatives of federal, state, provincial, municipal, and Indigenous governments, environmental NGOs, business, and agricultural organizations (GLWQB, n.d.). The Panel believes that this diversity in participants and decision-makers has encouraged accountable management of the Great Lakes. The extent to which the GLWQA bridges multiple jurisdictional scales is unique and has served as a model for other nations attempting to solve similar transboundary challenges (Johns, 2017). By managing the entire Great Lakes basin on such a large scale through one coordinated effort, the GLWQA provides a governance framework for achieving joint goals collaboratively. That said,

as the GLWQA is solely between the governments of Canada and the United States, efforts at the local level may not be fully coordinated (Benevides *et al.*, 2007). In recognition of the agreement's lack of clarity on the responsibility of subnational governments and other interested parties, a subsequent Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health was developed to outline responsibilities of the respective jurisdictions implementing the GLWQA and ensure communication among governments (Benevides *et al.*, 2007; GC & Gov. of ON, 2014).

In some situations, the collaboration of different jurisdictions to support INRM initiatives may require more substantive change in institutional rules and organizational culture (Margerum, 1997). The concept of collaborative consent (Box 6.2), which first emerged through the development of the Mackenzie River Basin Bilateral Water Management Agreement, offers some strategies for pursuing such changes (Fontaine *et al.*, 2015; Phare *et al.*, 2017). The Mackenzie Valley co-management system offers one example of the institutional and cultural changes in resource management that have occurred through the implementation of co-management regimes in Canada's North as a result of land claims. When the federal government passed the 1998 MVRMA following the land claims negotiations in the Mackenzie Valley, it effectively devolved environmental decision-making to regional co-management boards (MVEIRB, 2004). The MVRMA created a network of co-management boards responsible for land-use planning, land and water regulation, preliminary environmental screenings for development applications, and EA. The co-management boards represent a partnership between governments and Indigenous people, whereby First Nations nominate one-half of the members of each co-management board, and territorial and federal governments the other half (MVEIRB, 2004). The Gwich'in and Sahtu Regional Land Use Planning Boards, for example, are responsible for creating and implementing land-use plans for their respective settlement areas (MVEIRB, 2004). The Mackenzie Valley Land and Water Board (MVLWB) is responsible for land-use planning, permitting, licensing, and overseeing inspection and compliance for resource use, while a separate board, the MVEIRB, manages the EA process (MVEIRB, 2004). This structure is intended to incorporate mechanisms for Indigenous ownership and regional self-governance, while ensuring linked land-use planning, regulation, and assessment across the Mackenzie Valley (Armitage, 2005; MVEIRB, 2004).

Box 6.2
Hallmarks of Collaborative Consent

Collaborative consent is based on hallmarks that "are not prescriptive or exhaustive but are conditions that facilitate meaningful mutual consent-based decision-making" (Phare *et al.*, 2017):

- Collaborative consent is fundamentally based on respect, trust, and the art of diplomacy between governments.
- All governments recognize each other as legitimate authorities.
- Collaborative consent tables are decision-making tables, which means that representatives must have the authority to participate fully and make decisions at the table.
- The scope of issues considered through the process can be extensive and ultimately must be satisfactory to all parties.
- Collaborative consent starts at the front-end and all governments commit to remaining at the table for the "long haul."
- Each government's interests must be dealt with in a satisfactory manner from their own point of view.
- The process generates real outcomes.

Excerpts from Phare *et al.* (2017)

Adaptive co-management (ACM), as introduced in Chapter 5, can have the benefits of co-management and adaptive management. The collaborative nature of ACM may increase adaptive capacity (Whitney *et al.*, 2017), which may help address uncertainty (Armitage *et al.*, 2009) and resiliency (Olsson *et al.*, 2004). The social learning networks formed during the process can build trust and enable medium- to long-term learning (Armitage *et al.*, 2009). ACM has the potential to better match the scales between governance systems and social-ecological systems (Folke *et al.*, 2005; Olsson *et al.*, 2007) by identifying the geographic areas covered by the natural resources and involving the actors who are responsible for them (Plummer *et al.*, 2012). In practice, ACM is most often used with common pool resources — that is, resources managed as common property and subject to overuse (e.g., forestry, fisheries, water) (Plummer *et al.*, 2012).

In the Panel's view, improving coordination and changing rules and organizational cultures require governments to establish new regimes or realign institutions, but it does *not* mean that one level of government is expected to lead INRM

for Canada as a whole. Instead, leadership is needed across jurisdictions, to coordinate efforts, champion integrative solutions, and provide support to regional and sub-regional initiatives.

6.5 INDUSTRY INCENTIVES: FROM CONFLICT TO ALIGNMENT

6.5.1 Barriers

Actors in the resource management system each have their own set of priorities and incentives, and these do not always align to support INRM. Company balance sheets may not capture many of the environmental impacts of their operations, and thus improved environmental management may not always be seen as a priority. Additionally, the scope of work for projects may not incorporate full lifecycle considerations. The literature is relatively silent on the role(s) that the private sector, including individual landowners (e.g., agricultural landowners, ranchers, woodlot owners) and resource industries (e.g., mining or oil and gas rights holders) can and should play in INRM — and on articulating the benefits and opportunities to facilitate their engagement. However, in the Panel's view, companies are increasingly recognizing the benefits of using INRM approaches for improving project efficiencies and enhancing corporate reputations.

6.5.2 Potential Solutions

As explained above, overlapping rights and jurisdictions create an obligation to take a more integrated, longer-term approach to project management. Hydro-Québec's Eastmain-1-A-Sarcelle-Rupert Hydroelectric Project is one such example where the crown corporation fostered collaborative approaches with Indigenous governments in the early stages of the project. This project aimed to build a partial diversion on the Rupert River to increase the utility's generating capacity (CHA, n.d.). Before initiating the EA process, the Grand Council of the Crees (Eeyou Istchee), Cree Regional Authority, Eastmain Band, Cree Nation of Mistissini, Nemaska Band, Waskaganish Band, Hydro-Québec, and Société d'énergie de la Baie James signed the Boumhounan Agreement. The agreement ensured active Cree participation in the impact studies and project work, and provided funds to be managed by the Cree for addressing project impacts (PRC, 2006; Hydro-Québec, 2007). The agreement also included provisions to share the economic benefits of the $5-billion project with the Cree through employment and minimum thresholds for awarding of contracts (GCC *et al.*, 2002).

The use of industry-led standards has been growing rapidly in importance, as demonstrated by the proliferation of certification schemes for wood products, fish, and coffee (Auld, 2014). As of 2014, for example, 33% of the world's production forests in more than 80 countries were certified to meet sustainability standards established by the Forest Stewardship Council or the Pan European Forest Certification Program (Auld, 2014); 17% of coffee production was certified sustainable as of 2010; and sustainable-certified fish capture was almost 7% as of 2011 (Steering Committee, 2012).

Companies and industry sectors choose to be leaders and exceed legal requirements for a range of reasons. These include satisfying consumer demand, gaining social licence to operate, increasing brand visibility, lowering costs, meeting requirements within supply chains, increasing the efficiency of operations, responding to investor pressure, or for altruistic reasons (Carroll & Shabana, 2010; Vandenbergh, 2014; Vandenbergh & Gilligan, 2017; Graedel, 2018). The Mining Association of Canada (MAC) established Towards Sustainable Mining (TSM) in 2004 with the goal of improving community engagement, environmental practices, and health and safety practices among its member companies (MAC, 2017b). For Canada's mining companies, characterizing TSM as voluntary is somewhat misleading; participation is mandatory at the facility-level for all MAC members. External verification of performance over time shows major improvements in Indigenous and community outreach, tailings management, and biodiversity conservation. Internationally, this program is gaining traction with other mining associations and has been adopted by associations in Finland, Argentina, and Botswana (MAC, 2017b).

Voluntary standards that exceed government regulations may develop with support and assistance from environmental NGOs. The Marine Stewardship Council, Rainforest Alliance, and Forest Stewardship Council are three examples of organizations that have defined sustainable practices for resource harvesting, namely seafood, coffee, and timber (Vandenbergh & Gilligan, 2017). In some parts of the world, construction, mining, and oil and gas companies are voluntarily implementing biodiversity offsets to strengthen their relationship with communities and regulators, and to gain access to capital through the Business and Biodiversity Offsets Programme (BBOP) (BBOP, 2018). Established to advise companies on ecologically effective development while achieving economic goals, the BBOP is an international collaboration among private companies, financial institutions, civil society, and government agencies (e.g., New Zealand, Australia, France, Netherlands); Canada is not a member as of January 2019 (BBOP, 2018).

Governments may facilitate the adoption of elements of private governance by industry (e.g., corporate social responsibility in extractive industries (Global Affairs Canada, 2014)). In some cases, governments may also later adopt private governance initiatives in public regulations (e.g., green building codes) (Steering Committee, 2012). Many of the environmental and social requirements that corporations and households face are the result of private governance (Vandenbergh, 2013). Ultimately, there is still a role for governments to play in bringing about INRM — when the incentives are not there for industry leadership, legal requirements can motivate action or ensure compliance. Responding to deteriorating water quality in the Elk Valley, British Columbia's Ministry of Environment and Climate Change required the company Teck to develop a water quality plan for its five mining operations in the valley (Teck, 2014). Teck's plan was developed through consultation with its stakeholders, the public, governments, and First Nations, and includes provisions for ongoing monitoring and adaptive management in response to monitoring results. The plan establishes management goals and corresponding targets in relation to calcite formation and concentrations of selenium, nitrate, sulphate, and cadmium (Teck, 2014). The plan was accepted by the provincial ministry in 2014, and a subsequent permit was issued, turning many of the plan's commitments into legal requirements (EMC, 2018).

6.6 CONCLUSION

Progress in overcoming the five barriers laid out above could enable significant advances in INRM implementation in Canada. Throughout the chapter, the Panel identified both effective and promising practices at work across Canada to overcome these barriers. The Panel observes that leadership is critical in enabling or impeding progress towards INRM. Governments have the opportunity to take a leadership role in fostering interdisciplinary knowledge acquisition, bridging different ways of knowing, linking regional-level planning to project-level decision-making, and encouraging industry engagement in INRM. Moving forward, leadership is needed at all orders to go beyond one-off INRM initiatives to effect lasting changes in the governance of resources.

While the practices outlined in this chapter provide valuable lessons for researchers and practitioners, the availability of knowledge on these cases is limited. There remains a need for enhanced documentation and communication of the challenges and promising practices that are emerging as INRM is implemented. This review of the state of practice of INRM in Canada (in relation to five key challenges) played a key role in informing the Panel's conclusions set out in the next chapter.

7

Key Findings and Final Reflections

- Current Context and the Integration Imperative
- A Framework for INRM
- Knowledge for INRM
- Governance for INRM
- Final Reflections

7 Key Findings and Final Reflections

This report represents the analysis of a 13-member multidisciplinary expert panel assembled to consider the following question:

> *What is the state of knowledge and practice of integrated approaches to natural resource management in Canada?*

The Panel considered evidence in the literature and in practice as it explored the knowledge and governance processes supporting INRM, barriers to understanding and implementing INRM, and promising INRM practices.

In this chapter, the Panel reflects on the current context motivating INRM, sets out a framework for understanding INRM, and offers key findings on the state of knowledge and governance in relation to INRM. Finally, the Panel shares some parting reflections on the nature of the challenge ahead.

7.1 CURRENT CONTEXT AND THE INTEGRATION IMPERATIVE

Integration is needed to address current realities, and overcome the limitations of conventional approaches which focus on managing individual activities and resources.

Natural resources are profoundly important to people in Canada in a myriad of ways, contributing to economic, health, social, cultural, environmental, and spiritual aspects of life. Changing resource demands, environmental conditions, and legal and social contexts, including commitments to reconciliation, are all driving decision-makers to re-examine natural resource management practices in Canada. Current resource management challenges include cumulative effects, competition pressures, industry uncertainty, lack of public trust, and jurisdictional complexity. Informed decision-making is impeded by research and monitoring efforts that are incomplete, narrow in scope, and poorly disseminated.

In the face of these challenges, INRM has much to offer, including:

- an effective framework for reconciling the views of multiple governments with resource-related responsibilities;
- a regional focus that enables a strategic approach to resource management in which large-scale decisions are integrated with and able to simplify more local decisions;
- a process that recognizes and seeks to include multiple ways of knowing;
- an explicit assessment and weighing of trade-offs;
- adaptive management practices that enable ongoing learning and course corrections as new information becomes available; and
- a comprehensive approach to engaging all relevant jurisdictions and all rights holders.

7.2 A FRAMEWORK FOR INRM

In considering its charge, one of the Panel's early observations was that INRM is a concept subject to many interpretations and, as such, is difficult to define. Based on their collective expertise and their review of the evidence, Panel members have articulated eight defining characteristics of INRM.

An integrated approach to natural resource management is one that:

- *pursues clear and comprehensive goals and objectives;*
- *plans, manages, and monitors at appropriate geographic scales and timeframes;*
- *engages all relevant jurisdictions;*
- *involves rights holders and interested and affected parties;*
- *weighs multiple values, uses, and functions;*
- *assesses alternatives and trade-offs;*
- *includes multiple ways of knowing; and*
- *addresses uncertainty.*

Every natural resource management system is unique so some of these characteristics may be more relevant than others. However, robust efforts to implement INRM are likely to encompass all eight of these characteristics to some degree.

INRM calls for higher-order decision-making that embraces land-use planning and strategic assessment at regional scales, enabling better and more efficient decision-making at project-specific stages.

INRM emphasizes scale-appropriate planning and assessment in order to assess the cumulative effects of resource use, to weigh and consider multiple values, uses, and functions of an ecosystem, and to identify trade-offs in resource management. Current project-based approval processes often exclude small projects, impose artificially narrow temporal and spatial scales on the assessment, and ignore cumulative effects. The effectiveness of project-level approvals would be enhanced if they were implemented within the context of a regional plan or more strategically focused regional EA initiatives. Likewise, effective INRM establishes strong links among regional-level plans and targets, and project-level decisions.

Change will require further leadership and policies to bring about greater reliance on INRM. Legislative changes are one option, though the Panel notes that, given the complex legal framework for natural resource management in Canada, there is no one generic approach that would encourage INRM across the country. Government policies can be adjusted or established in order to develop and implement regional planning processes. These processes connect

to other decision-making processes and consider additional institutions to allow for continued INRM implementation. Strong policy frameworks, and sharing power across decision-makers, will be needed to advance INRM nationally.

INRM takes place across the continuum of decision-making, as summarized in Figure 7.1. INRM is underpinned at the outset by legislation, treaties, and policies (which are themselves a function of societal rights, values, and norms). These then lay the foundation for regional land-use planning that is inclusive, comprehensive, and informed by multiple ways of knowing. Land-use plans in turn inform the development of regional and strategic EAs that consider cumulative effects, then shape and simplify project-level EAs. Licensing and permitting decisions flow from these assessments. Monitoring, evaluation, and learning by doing are relevant across the continuum.

The Panel notes that INRM is not an all-or-nothing proposition. Incremental progress is being made to implement resource management approaches that increasingly satisfy the eight characteristics established in this report. In the Panel's view, rather than calling for an entirely new approach to decision-making, INRM calls for a greater focus on regional planning processes at the outset.

7.3 KNOWLEDGE FOR INRM

We know enough to act.

There is growing recognition that the dynamics of complex systems demand an inclusive approach to knowledge-gathering to increase the range of knowledge brought to bear on a question. The foundation of knowledge and supporting tools are sufficiently developed to support inclusive, adaptive, and comprehensive INRM processes. Multiple temporal and geographical scales are important features of INRM, as is the need to recognize and account for multifunctional landscapes. Reliance on emerging data-sharing tools and networks, and use of new strategies for applying this knowledge to decision-making, are all contributing to actors' ability to practice INRM.

Although the theory behind INRM is well described in the literature, much less empirical evidence exists on how to implement integrated approaches and, when implemented, on the successes and challenges of these approaches in practice. Initiatives across Canada — such as British Columbia's Cumulative Effects Framework, the *Alberta Land Stewardship Act*, and the *Mackenzie Valley Resource Management Act* — show the growing inclusion and importance of practitioner insights that supplement theoretical and academic knowledge.

Despite considerable experience in implementing INRM in Canada, undertakings have not generally been comprehensive and are often ultimately scaled back. Documentation of ongoing efforts by the provincial governments in British Columbia and Alberta to manage cumulative effects will help demonstrate learnings that can be applied to future initiatives.

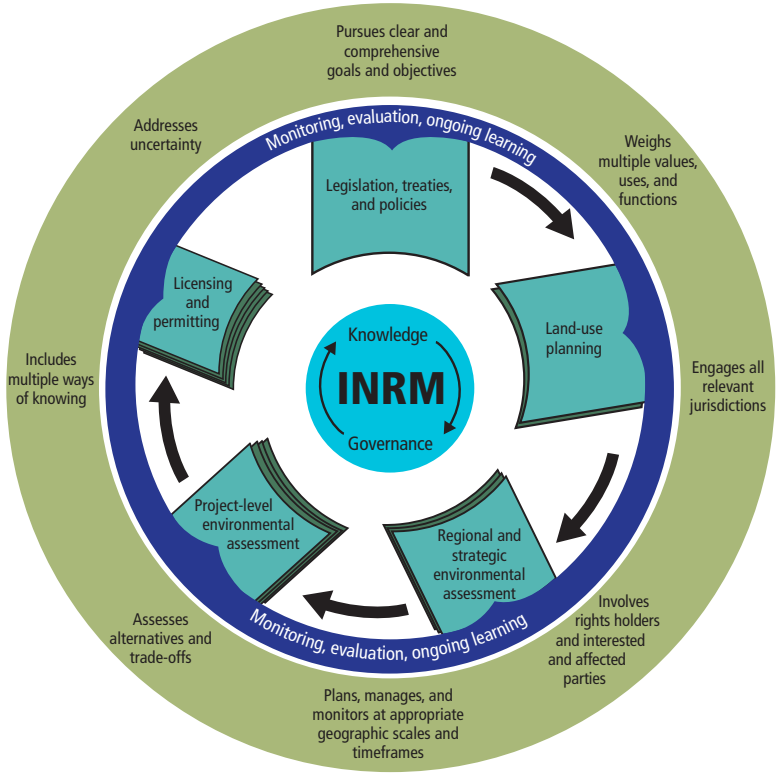


Figure 7.1

Continuum of Integrated Natural Resource Management Decision-Making

INRM applies across the continuum of natural resource management decision-making, originating from legislation, treaties, and policies that lay the foundation for regional land-use planning, which in turn informs regional and strategic environmental assessments and subsequent project-level environmental assessments, which themselves can then lead to licensing and permitting decisions. Process and outcome monitoring and evaluation can apply across the continuum to support ongoing learning. The eight characteristics of INRM are relevant throughout.

Knowledge-sharing networks, a tolerance for decision-making under uncertainty, and better coordination of research and monitoring efforts can foster interdisciplinary knowledge creation and exchange at scales relevant to INRM. Actors can start to make better-informed decisions with existing knowledge while continuing to strengthen the creation and systematic distribution of information to inform INRM and fill knowledge gaps.

INRM is built on a foundation of knowledge that effectively bridges Western science and Indigenous and local knowledge (ILK).

The complexity, uncertainty, and multiscaled nature of natural resources calls for a commensurate sophistication in the knowledge used to inform decision-making. INRM takes advantage of all relevant knowledge and ways of knowing. In Canada, Western science and ILK are particularly relevant for INRM. By reviewing and incorporating both science and ILK into decision-making in a way acceptable to knowledge holders, the integrity and legitimacy of the knowledge system can be maintained.

The Panel believes that co-design of a bridging process encourages the incorporation of ILK. The goal of bridging is to consider and weigh each piece of knowledge in the context of its source; it is not to reduce each source of data into one unified collection of information. Early examples of success in bridging Western science with ILK offer a foundation for incorporating different ways of knowing. However, considerable work remains to ensure that practitioners are comfortable in co-designing processes for ensuring knowledge integrity. Since there is a lack of well-established methodologies for bridging, knowledge is often based in different scales, and there are often significant inequities in power among knowledge holders, with deference often given to Western science. These challenges may serve to deter resource managers from even attempting to incorporate ILK in decision-making, but making good-faith efforts to bridge ways of knowing is an essential first step. The Government of Canada's commitment to UNDRIP and reconciliation requires further efforts to elevate our collective capacity and mainstream methods for incorporating ILK into resource decision-making.

7.4 GOVERNANCE FOR INRM

Careful and inclusive design of INRM governance is essential to its success.

INRM applies knowledge to decision-making through carefully designed and implemented governance processes. Effective governance begins with well-thought-out and participatory design of processes across the INRM lifecycle. Governance that is inclusive brings legitimacy and improves outcomes. Effective

governance in INRM identifies and engages a range of actors, including those with jurisdictional authority over decisions; those who hold rights related to the resources; those who are affected by such decisions; and those with relevant specialized knowledge. Governments, rights holders, industry, NGOs, and the public more broadly may therefore all play a role in INRM governance. Appropriate management scales often span multiple governments and decision-makers. As a comprehensive management approach, INRM is supported and enabled by the commitment of all orders of government.

The Panel sees effective INRM governance approaches falling along a spectrum — from consultative to collaborative to shared decision-making. In Canada, governance processes are increasingly tending toward more collaborative and shared forms, which can be further strengthened by applying experience and lessons from successful regimes and practices. These lead to more widely supported decisions that are meaningful to many rights holders and actors, and which tend to endure. The laws applicable to governing natural resource management in Canada do not prohibit and, in some cases, foster INRM. Co-management regimes, including those resulting from modern treaties and land claims agreements, provide useful examples of shared governance. Elements of Indigenous legal traditions are also compatible with and supportive of INRM goals. While implementing INRM characteristics can be challenging under current legal frameworks, a move towards more collaborative and shared governance is possible.

7.5 FINAL REFLECTIONS

INRM is a timely and important topic for all orders of government, and of relevance to many decision-makers and actors across Canada. The Panel developed this report for leaders seeking to strengthen the legitimacy of Canada's systems of resource management, and for practitioners and actors who want to understand the changes needed to implement INRM. Canada is in a state of transition in resource management: from exclusively project-level planning to planning on a regional level that incorporates cumulative effects; from consultative to collaborative or shared governance; and from recognition of single to multiple ways of knowing. This report describes the potential contribution of INRM within Canada's complex natural resource management landscape. The eight defining characteristics of INRM outlined by the Panel do not call for a complete overhaul of current resource management practices, but can act as guides for INRM. The Panel found many promising, emerging resource management regimes that are applied at regional scales, that bridge multiple ways of knowing, that pursue consensus-based decision-making, and that include a wider range of actors in the governance system.

If fully implemented, INRM will support reconciliation efforts; it is a management system better equipped to respect the rights of Indigenous Peoples and meet the Government of Canada's commitment to obtaining free, prior, and informed consent prior to project approval, and to consider multiple ways of knowing in natural resource decision-making. In fact, existing co-management boards that share decision-making authority among Indigenous, provincial/territorial, and federal governments are often at the leading edge of INRM, with many lessons learned that could be applied to other resource management regimes in Canada.

The Panel believes that, if INRM were successfully implemented on a wide scale, Canada could expect reduced conflict, enhanced sustainability, and increased investor certainty over the long term. Whereas many existing decision-making systems are challenged by the messiness and complexity inherent in natural resource management, INRM is a roadmap designed with this complexity in mind and readily adjusts based on local context. It is a work in progress that will take time and resources to implement. Capacity-building efforts to train practitioners, foster a community of expertise, and reflect on and publish lessons can all support learning by doing and effective INRM deployment. Clarifying and strengthening INRM through implementation in Canada can also provide practices that may be useful for Canadian companies and governments in their international resource-related activities.

INRM needs to be both carefully designed and thoroughly implemented. It requires ongoing *resourcing* to support its operations; regional and long-term monitoring efforts; the collection and sharing of information; and research. An INRM regime has the *authority* to carry out decisions. It requires *leadership* to bring about a change in culture within government, industry, and communities, and *accountability* to ensure objectives are met on a sustained basis.

Ultimately, effective INRM calls for a greater level of commitment on the part of governments to enhance knowledge and governance beyond the consideration of individual resource projects. However, in the Panel's view, widespread INRM implementation is crucial for addressing the scale and complexity of 21st century problems, and to allow for the continued prosperity that natural resources have delivered to Canada.

References

References

ABEKS (Arctic Borderlands Ecological Knowledge Society). (2014a). About Us. Retrieved May 2017, from https://www.arcticborderlands.org/about-us.

ABEKS (Arctic Borderlands Ecological Knowledge Society). (2014b). Partners. Retrieved June 2018, from https://www.arcticborderlands.org/partners.

ABEKS (Arctic Borderlands Ecological Knowledge Society). (2014c). Scientific Indicators. Retrieved May 2017, from https://www.arcticborderlands.org/scientific-indicators.

ABMI (Alberta Biodiversity Monitoring Institute). (2014a). Overview. Retrieved December 2018, from http://www.abmi.ca/home/what-we-do/overview.html.

ABMI (Alberta Biodiversity Monitoring Institute). (2014b). About ABMI Data. Retrieved November 2018, from http://www.abmi.ca/home/data-analytics/DA-top-about-data/About-ABMI-Data.html.

ABMI (Alberta Biodiversity Monitoring Institute). (2014c). Communications, Access & Data Management. Retrieved November 2018, from http://www.abmi.ca/home/what-we-do/communications-access-data-management.html.

ABMI (Alberta Biodiversity Monitoring Institute). (2014d). Governance & Funding. Retrieved December 2018, from http://www.abmi.ca/home/about-us/governance-funding.html.

AEP (Alberta Environment and Parks). (2016). Regional Plans. Retrieved March 2018, from https://landuse.alberta.ca/REGIONALPLANS/Pages/default.aspx.

AFN (Assembly of First Nations). (2012). *Co-Management Discussion Paper*. Ottawa (ON): AFN.

Agrawal, A. (1995). Dismantling the divide between Indigenous and scientific knowledge. *Development and Change, 26*(3), 413-439.

Ali, S. H., Giurco, D., Arndt, N., Nickless, E., Brown, G., Demetriades, A., . . . Yakovleva, N. (2017). Mineral supply for sustainable development requires resource governance. *Nature, 543*(7645), 367-372.

Allen, C. R., Fontaine, J. J., Pope, K. L., & Garmestani, A. S. (2011). Adaptive management for a turbulent future. *Journal of Environmental Management, 92*(5), 1339-1345.

AMB (Archipelago Management Board). (2003). *Gwaii Haanas National Park Reserve and Haida Heritage Site. Management Plan for the Terrestrial Area*. Haida Gwaii (BC): AMB.

Andison, D., Belisle, A. C., Bergeron, Y., & MacLean, D. (2016). *Towards a Natural Range of Variation (NRV) Strategy for the CBFA*. Vancouver (BC): Canadian Boreal Forest Agreement.

Anonymous. (1998). *Policy for Nanavut: A Discussion Paper*.

Armitage, D., Berkes, F., Dale, A., Kocho-Schellenberg, E., & Patton, E. (2011). Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic. *Global Environmental Change, 21*(3), 995-1004.

Armitage, D. R. (2005). Collaborative environmental assessment in the Northwest Territories, Canada. *Environmental Impact Assessment Review, 25*(3), 239-258.

Armitage, D. R., Plummer, R., Berkes, F., Arthur, R. I., Charles, A. T., Davidson-Hunt, I. J., . . . Wollenberg, E. K. (2009). Adaptive co-management for social-ecological complexity. *Frontiers in Ecology and the Environment, 7*(2), 95-102.

Aronoff, S. (1989). Geographic information systems: A management perspective. *Geocarto International, 4*(4), 58.

Arvai, J., Gregory, R., Bessette, D., & Campbell-Arvai, V. (2012). Decision support for developing energy strategies. *Issues in Science and Technology, 28*(4), 43-52.

Astofooroff, N. (2008). *Evaluating Collaborative Planning: A Case Study of the Haida Gwaii Land and Resource Management Plan. MRM Thesis.* Burnaby (BC): Simon Fraser University.

Auld, G. (2014). *Constructing Private Governance: The Rise and Evolution of Forest, Coffee, and Fisheries Certification.* New Haven (CT): Yale University Press.

Ban, N. C., Frid, A., Reid, M., Edgar, B., Shaw, D., & Siwallace, P. (2018). Incorporate Indigenous perspectives for impactful research and effective management. *Nature Ecology & Evolution, 2*(11), 1680-1683.

Bankes, N., Mascher, S., & Olszynski, M. (2014). Can environmental laws fulfill their promise? Stories from Canada. *Sustainability, 6*(9), 6024-6048.

Bateman, I. J., Harwood, A. R., Mace, G. M., Watson, R. T., Abson, D. J., Andrews, B., . . . Termansen, M. (2013). Bringing ecosystem services into economic decision-making: Land use in the United Kingdom. *Science, 341*(6141), 45-50.

Battiste, M. & Youngblood Henderson, J. S. (2000). *Protecting Indigenous Knowledge and Heritage.* Saskatoon (SK): Purich Press.

BBOP (Business and Biodiversity Offsets Program). (2018). Who We Are: About BBOP. Retrieved June 2018, from http://bbop.forest-trends.org/pages/about_bbop.

BCC (Business Council of Canada). (2017). *The Investment Environment in Canada: Survey of Business Leaders.* Ottawa (ON): BCC.

Bellringer, C. (2015). *Managing the Cumulative Effects of Natural Resource Develoment in B.C.* Victoria (BC): Auditor General of British Columbia.

Benevides, H., Davis, C., de Leon, F., Gilbert, R., Jackson, J., Nalbone, J., . . . Wilder, P. (2007). *The Great Lakes Water Quality Agreement: Promises to Keep; Challenges to Meet.* Chicago (IL): Alliance for the Great Lakes, Biodiversity Project, Canadian Environmental Law Association, Great Lakes United.

Benidickson, J. (2013). *Environmental Law* (4th ed.). Toronto (ON): Irwin Law Inc.

Berger, T., Kennett, S. A., & King, H. (2010). *Canada's North: What's the Plan?* Ottawa (ON): The Conference Board of Canada.

Berkes, F., Colding, J., & Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications, 10*(5), 1251-1262.

Berkes, F. (2002). Cross-Scale Institutional Linkages: Perspectives from the Bottom-Up. In E. Ostrom, T. Dietz, N. Dolsak, P. C. Stern, S. Stonich & E. U. Weber (Eds.), *The Drama of the Commons*. Washington (DC): The National Academies Press.

Berkes, F. (2009). Evolution of co-management: Role of knowledge generation, bridging organizations and social learning. *Journal of Environmental Management, 90*(5), 1692-1702.

Berkes, F. (2015). *Coasts for People: Interdisciplinary Approaches to Coastal and Marine Resource Management*. New York (NY): Routledge.

Berkes, F. (2018). *Sacred Ecology* (4th ed.). New York (NY): Routledge.

Berkes, F., Colding, J., & Folke, C. (Eds.). (2003). *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. New York (NY): Cambridge University Press.

Bessette, D. L., Campbell-Arvai, V., & Arvai, J. (2016). Expanding the reach of participatory risk management: Testing an online decision-aiding framework for informing internally consistent choices. *Risk Analysis, 36*(5), 992-1005.

Bidwell, D., Dietz, T., & Scavia, D. (2013). Fostering knowledge networks for climate adaptation. *Nature Climate Change, 3*, 610-611.

Bohnert, N., Chagnon, J., & Dion, P. (2015). *Population Projections for Canada (2013 to 2063), Provinces and Territories (2013 to 2038)*. Ottawa (ON): Statistics Canada.

Booth, A. & Halseth, G. (2011). Why the public thinks natural resources public participation processes fail: A case study of British Columbia communities. *Land Use Policy, 28*(4), 898-906.

Borrows, J. (2005). Indigenous legal traditions in Canada. *Washington University Journal of Law & Policy, 19*, 167-220.

Bowie, R. (2013). Indigenous self-governance and the deployment of knowledge in collaborative environmental management in Canada. *Journal of Canadian Studies, 47*(1), 91-121.

Boyd, D. R. (2003). *Unnatural Law: Rethinking Canadian Environmental Law and Policy*. Vancouver (BC): UBC Press.

Breckenridge, L. P. (1999). Nonprofit environmental organizations and the restructuring of institutions for ecosystem management. *Ecology Law Quarterly, 25*(4), 692-706.

Brend, Y. (2017). Collision Between Indigenous Hunting and Oil Development Rights Set for Legal Showdown in B.C. Court. Retrieved January 2019, from https://www.cbc.ca/news/canada/british-columbia/bc-treaty-rights-law-blueberry-river-first-nation-oil-and-gas-development-court-1.4151779.

Bringezu, S., Ramaswami, A., Schandl, H., O'Brien, M., Pelton, R., Acquatella, J., . . . Zivy, R. (2017). *Assessing Global Resource Use: A Systems Approach to Resource Efficiency and Pollution Reduction.* Nairobi, Kenya: International Resource Panel. United Nations Environment Programme.

Brondizio, E. S. & Le Tourneau, F.-M. (2016). Environmental governance for all. *Science, 352*(6291), 1272-1273.

Brown, K., Mackensen, J., Rosendo, S., Viswanathan, K., Cimarrusti, L., Fernando, K., . . . Susilowati, I. (2005). Chapter 15. Integrated Responses. In K. Chopra, R. Leemans, P. Kumar & H. Simons (Eds.), *Ecosystems and Human Well-Being: Policy Responses* (Vol. 1). Washington (DC): Island Press.

Burby, R. J. (2003). Making plans that matter: Citizen involvement and government action. *Journal of the American Planning Association, 69*(1), 33-49.

Candler, C., Olson, R., Deroy, S., & Broderick, K. (2006). PGIS as a sustained (and sustainable?) practice: First Nation experiences in Treaty 8 BC, Canada. *Participatory Learning and Action, 54*, 51-57.

CanLII (Canadian Legal Information Institute). (2018). Canadian Legal Information Institute (CanLII), Canada (All Jurisdictions) Database, Federal, Provincial, and Territorial Courts. Retrieved October 2018, from https://www.canlii.org/en/.

CAPP (Canadian Association of Petroleum Producers). (2018). *Update: A Competitive Policy and Regulatory Framework for Alberta's Upstream Oil and Natural Gas Industry.* Calgary (AB): CAPP.

Carlson, M. & Stelfox, B. (2009). Integrated Resource Management and Planning. In R. J. Hudson (Ed.), *Encyclopedia of Life Support Systems (EOLSS).* Oxford, United Kingdom: EOLSS Publishers.

Carlson, M., Antoniuk, T., Farr, D., Francis, S., Manuel, K., Nishi, J., . . . Pan, D. (2010). *Informing Regional Planning in Alberta's Oilsands Region with a Land-Use Simulation Model.* Paper presented at International Congress on Environmental Modelling and Software Modelling, Ottawa (ON).

Carlson, M., MacDonald, R. J., & Chernos, M. (2018). *Watershed Simulation Tool – Methods and Outcomes for the Bow River Basin.* Calgary (AB): Bow River Basin Council.

Carlsson, L. & Berkes, F. (2005). Co-management: Concepts and methodological implications. *Journal of Environmental Management, 75*(1), 65-76.

Carpenter, S. R., Mooney, H. A., Agard, J., Capistrano, D., DeFries, R. S., Diaz, S., . . . Whyte, A. (2009). Science for managing ecosystem services: Beyond the Millennium Ecosystem Assessment. *Proceedings of the National Academy of Sciences, 106*(5), 1305-1312.

Carpenter, S. R., Cole, J. J., Pace, M. L., Batt, R., Brock, W. A., Cline, T., . . . Weidel, B. (2011). Early warnings of regime shifts: A whole-ecosystem experiment. *Science, 332*(6033), 1079-1082.

Carroll, A. B. & Shabana, K. M. (2010). The business case for corporate social responsibility: A review of concepts, research and practice. *International Journal of Management Reviews, 12*(1), 85-105.

CASA (Clean Air Strategic Alliance). (n.d.). Consensus Process. Retrieved January, 2019, from http://www.casahome.org/consensus-process/.

Cash, D. W., Adger, W. N., Berkes, F., Garden, P., Lebel, L., Olsson, P., . . . Young, O. (2006). Scale and cross-scale dynamics: Governance and information in a multilevel world. *Ecology and Society, 11*(2), 8.

CCME (Canadian Council of Ministers of the Environment). (2009). *Regional Strategic Environmental Assessment in Canada: Principles and Guidance*. Winnipeg (MB): CCME.

CCME (Canadian Council of Ministers of the Environment). (2012). *Guidance Document on Air Zone Managemnet*. Winnipeg (MB): CCME.

CCME (Canadian Council of Ministers of the Environment). (2014a). *Canada-Wide Definitions and Principles for Cumulative Effects*. Winnipeg (MB): CCME.

CCME (Canadian Council of Ministers of the Environment). (2014b). Stakeholder Engagement. Retrieved June 2018, from https://www.ccme.ca/en/current_priorities/air/aqms_sh_engagement/index.html.

CCME (Canadian Council of Ministers of the Environment). (2014c). Resources: AQMS. Retrieved January 2018, from https://www.ccme.ca/en/resources/air/aqms.html.

CCME (Canadian Council of Ministers of the Environment). (n.d.-a). *Call for Nominations*. Winnipeg (MB): CCME.

CCME (Canadian Council of Ministers of the Environment). (n.d.-b). Air Quality Management System. Retrieved December 2018, from http://airquality-qualitedelair.ccme.ca/en/.

CEA (Canadian Electricity Association). (2018). Statement by the Canadian Electricity Association on Resources Table Report. Retrieved October 2018, from https://electricity.ca/news-events/news/statement-by-the-canadian-electricity-association-on-resources-table-report/.

CEAA (Canadian Environmental Assessment Agency). (2017). Canadian Environmental Assessment Registry. Retrieved August 2018, from https://www.ceaa-acee.gc.ca/050/evaluations/Index?culture=en-CA.

CEPA (Canadian Energy Pipeline Association). (2018). *Media Statement: CEPA Concerned by Uncertainties in Proposed Regulatory Reform Legislation*. Calgary (AB): CEPA.

CEST (Canada's Economic Strategy Tables). (2018). *Resources of the Future*. Ottawa (ON): CEST.

CHA (Canadian Hydropower Association). (n.d.). *Paths Forward: Hydropower and Aboriginal Relationships Across Canada*. Ottawa (ON): CHA.

Chambers, R. (1994). The origins and practice of participatory rural appraisal. *World Development, 22*(7), 953-969.

Chapin, M. (2006). Mapping projects: Identifying obstacles, finding solutions. *Participatory Learning and Action, 54*, 93-97.

Cherneski, P. (2018). *The Impacts and Costs of Drought to the Canadian Agriculture Sector*. Paper presented at North American Drought Monitor Forum, Calgary (AB).

Chetkiewicz, C. & Lintner, A. M. (2014). *Getting it Right in Ontario's Far North: The Need for a Regional Strategic Environmental Assessment in the Ring of Fire (Wawangajing)*. Thunder Bay (ON): Wildlife Conservation Society Canada and Ecojustice.

CHN & GC (Council of the Haida Nation and Government of Canada). (1993). *Gwaii Haanas Agreement*. CHN and GC.

CHN & GC (Council of the Haida Nation and Government of Canada). (2018). *Gwaii Haanas. Gina 'Waadluxan KilGuhlGa. Land-Sea-People. Management Plan*. Queen Charlotte (BC): Council of the Haida Nation and GC.

Chu, C., Minns, C. K., Lester, N. P., & Mandrak, N. E. (2015). An updated assessment of human activities, the environment, and freshwater fish biodiversity in Canada. *Canadian Journal of Fisheries and Aquatic Sciences, 72*(1), 135-148.

CIER (Centre for Indigenous Environmental Resources). (2017). *Centre for Indigenous Environmental Resources Biennial Report 2014-2016*. Winnipeg (MB): CIER.

CILMC (Canadian Integrated Landscape Management Coalition). (2005). *Integrated Landscape Mangement: Applying Sustainable Development to Land Use*. CILMC.

CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). (2018a). Self-Government. Retrieved December 2018, from https://www.aadnc-aandc.gc.ca/eng/1100100032275/1100100032276.

CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). (2018b). Treaties and Agreements. Retrieved December 2018, from https://www.rcaanc-cirnac.gc.ca/eng/1100100028574/1529354437231#chp4.

Clark, W. C., van Kerkhoff, L., Lebel, L., & Gallopin, G. C. (2016). Crafting usable knowledge for sustainable development. *Proceedings of the National Academy of Science, 113*(17), 4570-4578.

Clayoquot Sound Scientific Panel. (1994). *Report of the Scientific Panel for Sustainable Forest Practices in Clayoquot Sound*. Victoria (BC): Government of BC.

Cleland, M., Nourallah, L., & Fast, S. (2016). *Fair Enough: Assessing Community Confidence in Energy Authorities. Interim Report*. Ottawa (ON): University of Ottawa and Canada West Foundation.

Cooke, S. J., Rice, J. C., Prior, K. A., Bloom, R., Jensen, O., Browne, D. R., . . . Auld, G. (2016). The Canadian context for evidence-based conservation and environmental management. *Environmental Evidence, 5*, 14.

Corbett, J., Rambaldi, G., Kyem, P., Weiner, D., Olson, R., Muchemi, J., . . . Chambers, R. (2006). Overview: Mapping for change – the emergence of a new practice. *Participatory Learning and Action, 54*, 13-19.

Costanza, R., de Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., . . . Grasso, M. (2017). Twenty years of ecosystem services: How far have we come and how far do we still need to go? *Ecosystem Services, 28*(A), 1-16.

Craik, N. (2015). Process and reconciliation: Integrating the duty to consult with environmental assessment. *Osgoode Hall Law Journal, 53*(2), 632-680.

Cronmiller, J. G. & Noble, B. F. (2018). Integrating environmental monitoring with cumulative effects management and decision making. *Integrated Environmental Assessment and Management, 14*(3), 407-417.

Dale, A. & Newman, L. (2007). Governance for Integrated Resource Management. In D. S. Slocombe & K. S. Hanna (Eds.), *Integrated Resource and Environmental Management*. Don Mills (ON): Oxford University Press.

Data Basin. (2017). Human Access of Canada's Landscapes. Retrieved December 2018, from https://databasin.org/datasets/0c54d369b225471ea7e9f7999ce94cc0.

Davidson-Hunt, I. J. & O'Flaherty, R. M. (2007). Researchers, Indigenous Peoples, and place-based learning communities. *Society and Natural Resources, 20*(4), 291-305.

DeFries, R. & Nagendra, H. (2017). Ecosystem management as a wicked problem. *Science, 356*(6335), 265-270.

Dei, G. J. S. (1993). Sustainable development in the African context: Revisiting some theoretical and methodological issues. *Africa Development / Afrique et Développement, 18*(2), 97-110.

Dias, V. & Belcher, K. (2015). Value and provision of ecosystem services from prairie wetlands: A choice experiment approach. *Ecosystem Services, 15*, 35-44.

Díaz, S., Pascual, U., Stenseke, M., Martín-López, B., Watson, R. T., Molnár, Z., . . . Shirayama, Y. (2018). Assessing nature's contributions to people. *Science, 359*(6373), 270-272.

Dietz, T. (2013a). Bringing values and deliberation to science communication. *Proceedings of the National Academy of Sciences, 110*(Supplement 3), 14081-14087.

Dietz, T. (2013b). Epistemology, Ontology, and the Practice of Structural Human Ecology. In T. Dietz & A. Jorgenson (Eds.), *Structural Human Ecology: Essays in Risk, Energy, and Sustainability*. Pullman (WA): WSU Press.

Dietz, T. (2017). Science, Values, and Conflict in the National Parks. In S. R. Beissinger, D. D. Ackerly, H. Doremus & G. E. Machlis (Eds.), *Science, Conservation, and National Parks*. Chicago (IL): The University of Chicago Press.

Doelle, M. & Tollefson, C. (2013). Jurisdiction Over the Environment. In *Environmental Law: Cases and Materials* (2nd ed.). Toronto (ON): Carswell.

Donihee, J., Gilmour, J., & Burch, D. (2000). *Resource Development and the Mackenzie Valley Resource Management Act: The New Regime*. Calgary (AB): Canadian Institute for Resources Law.

Doremus, H. (2001). Adaptive management, the Endangered Species Act, and the institutional challenges of new age environmental protection. *Washburn Law Journal, 41*(1), 50-89.

Doremus, H. (2010). Adaptive management as an information problem. *North Carolina Law Review, 89*, 1455-1498.

Douthwaite, B., Ekboir, J. M., Twomlow, S. J., & Keatinge, J. D. H. (2004). The Concept of Integrated Natural Resource Management (INRM) and Its Implications for Developing Evaluation Methods. In B. Shiferaw, H. A. Freeman & S. M. Swinton (Eds.), *Natural Resources Management in Agriculture: Methods for Assessing Economic and Environmental Impacts*. Cambridge, United Kingdom: Cabi Publishing.

Dowdeswell, L., Dillon, P., Ghoshal, S., Miall, A., Rasmussen, J., & Smol, J. P. (2010). *A Foundation for the Future: Building an Environmental Monitoring System for the Oil Sands*. Gatineau (QC): Environment Canada.

Dubé, M. (2003). Cumulative effect assessment in Canada: A regional framework for aquatic ecosystems. *Environmental Impact Assessment Review, 23*(6), 723-745.

Duinker, P. N. & Greig, L. A. (2006). The impotence of cumulative effects assessment in Canada: Ailments and ideas for redeployment. *Environmental Management, 37*(2), 153-161.

Eamer, J. (2004). *Keep it Simple and Be Relevant: The First Nine Years of the Arctic Borderlands Ecological Knowledge Co-op*. Whitehorse (YK): Environment Canada.

EC (Environment Canada). (2011). *Scientific Assessment to Inform the Identification of Critical Habitat for Woodland Caribou (Rangifer tarandus caribou), Boreal Population, in Canada: 2011 Update*. Ottawa (ON): EC.

EC (Environment Canada). (2012). *Recovery Strategy for the Woodland Caribou (Rangifer tarandus caribou), Boreal Population in Canada*. Ottawa (ON): EC.

ECCC (Environment and Climate Change Canada). (2016a). Extent of Canada's Wetlands Indicator: Data Sources and Methods. Retrieved November 2018, from https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/publications/extent-wetlands-data-methods.html.

ECCC (Environment and Climate Change Canada). (2016b). Population Status of Canada's Migratory Birds. Retrieved November 2018, from https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/population-status-migratory-birds.html.

ECCC (Environment and Climate Change Canada). (2017a). *Canada Water Act: Annual Report for April 2015 to March 2016*. Gatineau (QC): ECCC.

ECCC (Environment and Climate Change Canada). (2017b). Municipal Wastewater Treatment. Retrieved November 2018, from https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/municipal-wastewater-treatment.html.

ECCC (Environment and Climate Change Canada). (2018a). Environment and Climate Change Canada Data. Retrieved December 2018, from http://donnees.ec.gc.ca/data/.

ECCC (Environment and Climate Change Canada). (2018b). *Canadian Environmental Sustainability Indicators: Water Quality in Canadian Rivers*. Gatineau (QC): ECCC.

ECCC (Environment and Climate Change Canada). (2018c). *Canadian Environmental Sustainability Indicators: Water Quantity in Canadian Rivers*. Gatineau (QC): ECCC.

Ehrlich, A. (2010). Cumulative cultural effects and reasonably foreseeable future developments in the Upper Thelon Basin, Canada. *Impact Assessment and Project Appraisal, 28*(4), 279-286.

ELOKA (Exchange for Local Observations and Knowledge of the Arctic). (2017). ELOKA In-Depth. Retrieved January 2019, from http://eloka-arctic.org/about-in-depth.

EMC (Environmental Monitoring Committee). (2018). *Permit 107517. Environmental Monitoring Committee 2018 Public Report*. Vancouver (BC): Teck.

EMMC (Energy and Mines Ministers' Conference). (2014). *Our Resources, New Frontiers: Overview of Competitiveness in Canada's Natural Resources Sector*. Sudbury (ON): EMMC.

Engler, N. J., Scassa, T., & Taylor, D. R. F. (2013). Mapping traditional knowledge: Digital cartography in the Canadian North. *Cartographica: The International Journal for Geographic Information and Geovisualization, 48*(3), 189-199.

EPJOSM (Expert Panel on Assessing the Scientific Integrity of the Canada-Alberta Joint Oil Sands Monitoring). (2016). *Assessing The Scientific Integrity of the Canada-Alberta Joint Oil Sands Monitoring (2012-2015)*. Edmonton (AB): Government of Canada and the Government of Alberta.

Evans, L., Cherrett, N., & Pemsl, D. (2011). Assessing the impact of fisheries co-management interventions in developing countries: A meta-analysis. *Journal of Environmental Management, 92*(8), 1938-1949.

Eyford, D. R. (2013). *Forging Partnerships, Building Relationships: Aboriginal Canadians and Energy Development*. Ottawa (ON): Government of Canada.

Failing, L., Gregory, R., & Harstone, M. (2007). Integrating science and local knowledge in environmental risk management: A decision-focused approach. *Ecological Economics, 64*(1), 47-60.

Federal Court of Canada Trial Division. (1998). *British Columbia Hydro and Power Authority v. Canada (Attorney General), 1998*. Ottawa (ON): Federal Court of Canada Trial Division.

Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C. S., & Walker, B. (2002). Resilience and sustainable development: Building adaptive capacity in a world of transformations. *Ambio: A Journal of the Human Environment, 31*(5), 437-440.

Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources, 30*, 441-473.

Folke, C., Pritchard Jr, L., Berkes, F., Colding, J., & Svedin, U. (2007). The problem of fit between ecosystems and institutions: Ten years later. *Ecology and Society, 12*(1), 30.

Fontaine, P., Phare, M.-A., & Miltenberger, M. (2015). *Collaborative Consent: A Nation-to-Nation Path to Partnership with Indigenous Governments*. Akwesasne (ON): Prepared for the Minister of Natural Resources.

Ford, J. D., Cameron, L., Rubis, J., Maillet, M., Nakashima, D., Willox, A. C., & Pearce, T. (2016). Including indigenous knowledge and experience in IPCC assessment reports. *Nature Climate Change, 6*, 349-353.

FPAC (Forest Products Association of Canada). (2018). Forest Sector Seeks Federal Partnership to Improve Competitiveness, Accelerate Innovation and Ensure a Healthy Forest of the Future. Retrieved October 2018, from file://cca-ad1/Public/Assessments/Assessments%20-%20Active/044%20Integrated%20Natural%20Resource%20Management/Research%20and%20references/PDFs/FPAC%20(2018)%20Forest%20sector%20Seeks%20Federal%20Partnership.html.

FPTGC (Federal, Provincial and Territorial Governments of Canada). (2010). *Canadian Biodiversity: Ecosystem Status and Trends 2010*. Ottawa (ON): Canadian Councils of Resource Ministers.

FPTGC (Federal, Provincial, and Territorial Governments of Canada). (2014). *2012 Canadian Nature Survey: Awareness, Participation and Expenditures in Nature-Based Recreation, Conservation, and Subsistence Activities*. Ottawa (ON): Canadian Councils of Resource Ministers.

Frank, K. A. (2011). Social Network Models for Natural Resource Use and Extraction. In Ö. Bodin & C. Prell (Eds.), *Social Networks and Natural Resource Management: Uncovering the Social Fabric of Environmental Governance*. Cambridge, United Kingdom: Cambridge University Press.

Fraser Basin Council. (n.d.). Water Use Plans. Retrieved August 2017, from http://www.rethinkingwater.ca/water_use_plans.html.

Gagnon, C. A. & Berteaux, D. (2009). Integrating traditional ecological knowledge and ecological science: A question of scale. *Ecology and Society, 14*(2), 19.

GC (Government of Canada). (2012a). *A Consolidation of the Constitution Acts 1867 to 1982*. Ottawa (ON): GC.

GC (Government of Canada). (2012b). *Canadian Environmental Assessment Act*. Ottawa (ON): GC.

GC (Government of Canada). (2014). *Canada's Sixth National Report on Climate Change*. Gatineau (QC): GC.

GC (Government of Canada). (2016a). Canada Land Inventory (CLI). Retrieved June 2018, from http://sis.agr.gc.ca/cansis/nsdb/cli/index.html.

GC (Government of Canada). (2016b). About the Public Registry. Retrieved September 2018, from https://www.registrelep-sararegistry.gc.ca/default.asp?lang=En&n=BEDADDA3-1.

GC (Government of Canada). (2016c). *Exploration and Mining in Canada: An Investor's Brief*. Ottawa (ON): GC.

GC (Government of Canada). (2016d). Mackenzie Valley Resource Management Act. Ottawa (ON): GC.

GC (Government of Canada). (2017a). *Yukon Environmental and Socio-economic Assessment Act*. Ottawa (ON): GC.

GC (Government of Canada). (2017b). *Species at Risk Act*. Ottawa (ON): GC.

GC (Government of Canada). (2018a). Post-1975 Treaties (Modern Treaties). Retrieved November 2018, from https://open.canada.ca/data/en/dataset/be54680b-ea62-46f3-aaa9-7644ed970aef.

GC (Government of Canada). (2018b). Pre-1975 Treaties (Historic Treaties). Retrieved November 2018, from https://open.canada.ca/data/en/dataset/f281b150-0645-48e4-9c30-01f55f93f78e.

GC (Government of Canada). (2018c). *Equality and Growth: A Strong Middle Class. Budget 2018*. Ottawa (ON): GC.

GC & Gov. of ON (Government of Canada and Government of Ontario). (2014). *Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health*. Ottawa (ON): Environment Canada and the Ontario Ministry of the Environment.

GCC, CRA, EB, CNM, NB, WB, . . . SEBJ (Grand Council of the Crees (Eeyou Istchee), Cree Regional Authority, Eastmain Band, Cree Nation of Mistissini, Nemaska Band, Waskaganish Band, Hydro-Québec, and Société d'énergie de la Baie James). (2002). *Boumhounan Agreement*. Waskaganish (QC): GCC, CRA, EB, CNM, NB, WB, HQ, SEBJ.

Gélinas, J., Horswill, D., Northey, R., & Pelletier, R. (2017). *Building Common Ground: A New Vision for Impact Assessment in Canada: The Final Report of the Expert Panel for the Review of Environmental Assessment Processes*. Ottawa (ON): Canadian Environmental Assessment Agency.

Geomatics Yukon. (n.d.). GeoYukon. Retrieved December 2018, from http://mapservices.gov.yk.ca/GeoYukon/.

Geothink. (n.d.). Project Description. Retrieved December 2018, from http://geothink.ca/project-description/.

Gillett, N., Weaver, A., Zwiers, F., & Flannigan, M. (2004). Detecting the effect of climate change on Canadian forest fires. *Geophysical Research Letters, 31*(18), 1-4.

Gillingham, M. P., Halseth, G., Johnson, C. J., & Parkes, M. W. (Eds.). (2016). *The Integration Imperative: Cumulative Environmental, Community and Health Effects of Multiple Natural Resource Developments*. New York (NY): Springer.

Global Affairs Canada. (2014). *Doing Business the Canadian Way: A Strategy to Advance Corporate Social Responsibility in Canada's Extractive Sector Abroad*. Ottawa (ON): Global Affairs Canada.

Global Forest Watch Canada. (2014). *Fragmentation of Canada's Landscape*. Available from https://databasin.org/datasets/0c54d369b225471ea7e9f7999ce94cc0.

GLWQB (Great Lakes Water Quality Board). (n.d.). Members. Retrieved December 2018, from https://ijc.org/en/wqb/who/members.

Goetze, T. C. (2004). *Sharing the Canadian Experience with Co-Management: Ideas, Examples, and Lessons for Communities in Developing Areas*. Ottawa (ON): International Development Research Centre.

Gordon, A. B., Andre, M., Kaglik, B., Cockney, S., Allen, M., Tetlichi, R., . . . Rexford, F. (2008). *Arctic Borderlands Ecological Knowledge Co-op Community Reports 2006-2007*. Whitehorse (YK): Arctic Borderlands Ecological Knowledge Society.

Gordon, S. (2008). New Brunswick's Systems Approach to Natural Resources Management Planning. In B. McAfee & C. Malouin (Eds.), *Implementing Ecosystem-Based Management Approaches in Canada's Forests*. Ottawa (ON): Natural Resource Canada.

Gov. of AB (Government of Alberta). (2008). *Land-Use Framework*. Edmonton (AB): Gov. of AB.

Gov. of AB (Government of Alberta). (2009). Alberta Hansard: Tuesday afternoon, June 2, 2009. Retrieved November 2017, from www.assembly.ab.ca/ISYS/LADDAR_files/docs/hansards/han/legislature_27/session_2/20090602_1330_01_han.pdf#page=25.

Gov. of AB (Government of Alberta). (2012). *Lower Athabasca Regional Plan 2012-2022*. Edmonton (AB): Gov. of AB.

Gov. of AB (Government of Alberta). (2013). *Alberta Land Stewardship Act, Statutes of Alberta, 2009, Chapter A-26.8*. Edmonton (AB): Gov. of AB.

Gov. of BC (Government of British Columbia). (1998). *Water Use Plan Guidelines*. Victoria (BC): Gov. of BC.

Gov. of BC (Government of British Columbia). (2014). *Addressing Cumulative Effects in Natural Resource Decision-Making: A Framework for Success*. Victoria (BC): Gov. of BC.

Gov. of BC (Government of British Columbia). (2016). *Cumulative Effects Framework: Interim Policy*. Victoria (BC): Gov. of BC.

Gov. of BC (Government of British Columbia). (n.d.). Compliance Oversight. Retrieved September 2018, from http://mines.nrs.gov.bc.ca/compliance-oversight.

Gov. of QC (Government of Quebec). (2017). *Act Establishing the Eeyou Istchee James Bay Regional Government*. Québec (QC): Gov. of QC.

Gov. of SK (Government of Saskatchewan).(2017). *W-8.1 The Water Security Act*. Regina (SK): Gov. of SK.

Gov. of YK (Government of Yukon). (2017). Yukon and First Nation Land Claims. Retrieved December 2018, from http://www.emr.gov.yk.ca/mining/yukon_first_nations_land_claims.html.

Government of Canada, Inuit Tapiriit Kanatami, Inuvialuit Regional Corporation, Makivik Corporation, Nunatsiavut Government, & Nunavut Tunngavik Incorporated. (2017). *Inuit Nunangat Declaration on Inuit-Crown Partnership*. Iqaluit (NU): Government of Canada, Inuit Tapiriit Kanatami, Inuvialuit Regional Corporation, Makivik Corporation, Nunatsiavut Government, and Nunavut Tunngavik Incorporated.

Graedel, T. E. (2018). Grand challenges in metal life cycles. *Natural Resources Research, 27*(2), 181-190.

Gregory, R., McDaniels, T., & Fields, D. (2001). Decision aiding, not dispute resolution: Creating insights through structured environmental decisions. *Journal of Policy Analysis and Management, 20*(3), 415-432.

Gregory, R. & Failing, L. (2002). Using decision analysis to encourage sound deliberations: Water use planning in British Columbia, Canada. *Journal of Policy Analysis and Management, 21*(3), 492-499.

Gregory, R., Failing, L., & Higgins, P. (2006). Adaptive management and environmental decision making: A case study application to water use planning. *Ecological Economics, 58*, 434-447.

GSHSAC (Great Sand Hills Scientific Advisory Committee). (2007). *Great Sand Hills Regional Environmental Study*. Regina (SK): Government of Saskatchewan.

Gunn, J. & Noble, B. (2009). Integrating cumulative effects in regional strategic environmental assessment frameworks: Lessons from practice. *Journal of Environmental Assessment Policy and Management, 11*(3), 267-290.

Gwich'in Tribal Council & GC (Gwich'in Tribal Council and Government of Canada). (1992). *Gwich´in Comprehensive Land Claim Agreement*. Ottawa (ON): Gwich´in Tribal Council and GC.

Haggan, N., Neis, B., & Baird, I. G. (Eds.). (2007). *Fishers' Knowledge in Fisheries Science and Management*. Paris, France: UNESCO Publishing.

Hahn, T., Olsson, P., Folke, C., & Johansson, K. (2006). Trust-building, knowledge generation and organizational innovations: The role of a bridging organization for adaptive comanagement of a wetland landscape around Kristianstad, Sweden. *Human Ecology, 34*(4), 573-592.

Haida Nation & Gov. of BC (Haida Nation and Government of British Columbia). (2009). *Kunst'aa guu - Kunst'aayah Reconciliation Protocol* Haida Gwaii (BC): Haida Nation and Gov. of BC.

Haley, D. & Nelson, H. (2007). Has the time come to rethink Canada's Crown forest tenure systems? *The Forestry Chronicle, 83*(5), 630-641.

Halseth, G. R., Gillingham, M. P., Johnson, C. J., & Parkes, M. W. (2016). Cumulative Effects and Impacts: The Need for a More Inclusive, Integrative, Regional Approach. In M. P. Gillingham, G. R. Halseth, C. J. Johnson & M. W. Parkes (Eds.), *The Integration Imperative: Cumulative Environmental, Community, and Health Effects of Multiple Natural Resource Developments*. New York (NY): Springer International Publishing.

Hanesiak, J. M., Stewart, R. E., Bonsal, B. R., Harder, P., Lawford, R., Aider, R., . . . Zha, T. (2011). Characterization and summary of the 1999–2005 Canadian Prairie drought. *Atmosphere-Ocean, 49*(4), 421-452.

Hawkes, S. (1996). The Gwaii Haanas Agreement: From conflict to cooperation. *Environments, 23*(2), 87-100.

HBC (Hudson Bay Consortium). (2018). Background. Retrieved March 2018, from https://hudsonbayconsortium.com/en.

He, J., Moffette, F., Fournier, R., Revéret, J.-P., Théau, J., Dupras, J., . . . Varin, M. (2015). Meta-analysis for the transfer of economic benefits of ecosystem services provided by wetlands within two watersheds in Quebec, Canada. *Wetlands Ecology and Management, 23*(4), 707-725.

Hein, L., van Koppen, K., de Groot, R. S., & van Ierland, E. C. (2006). Spatial scales, stakeholders and the valuation of ecosystem services. *Ecological Economics, 57*(2), 209-228.

Henry, A. D. & Dietz, T. (2011). Information, networks, and the complexity of trust in commons governance. *International Journal of the Commons, 5*(2), 188-212.

Henry, A. D. & Vollan, B. (2014). Networks and the challenge of sustainable development. *Annual Review of Environment and Resources, 39*, 583-610.

Henry, A. D. (2018). Learning sustainability innovations. *Nature Sustainability, 1*(4), 164-165.

Hill, C., Furlong, K., Bakker, K., & Cohen, A. (2008). Harmonization versus subsidiarity in water governance: A review of water governance and legislation in the Canadian provinces and territories. *Canadian Water Resources Journal, 33*(4), 315-332.

Hill, R., Grant, C., George, M., Robinson, C. J., Jackson, S., & Abel, N. (2012). A typology of Indigenous engagement in Australian environmental management: Implications for knowledge integration and social-ecological system sustainability. *Ecology and Society, 17*(1), 23.

Houck, O. A. (2009). Nature or nurture: What's wrong and what's right with adaptive management. *Environmental Law Reporter, 39*(10), 10923.

House of Commons (Government of Canada). (2018a). *Bill C-262: An Act to Ensure That the Laws of Canada Are in Harmony with the United Nations Declaration on the Rights of Indigenous Peoples*. Ottawa (ON): House of Commons, Government of Canada.

House of Commons (Government of Canada). (2018b). *Bill C-68: An Act to Amend the Fisheries Act and Other Acts in Consequence*. Ottawa (ON): House of Commons, Government of Canada.

House of Commons (Government of Canada). (2018c). *Bill C-69: An Act to Enact the Impact Assessment Act and the Canadian Energy Regulator Act, to Amend the Navigation Protection Act and to Make Consequential Amendments to Other Acts*. Ottawa (ON): House of Commons, Government of Canada.

Huisman, O. & de By, R. A. (Eds.). (2009). *Principles of Geographic Information Systems*. Enschede, The Netherlands: The International Institute for Geo-Information Science and Earth Observation.

Hunter, M. L. (1993). Natural fire regimes as spatial models for managing boreal forests. *Biological Conservation, 65*, 115-120.

Huntington, H. P. (2013). *Traditional Knowledge and Resource Development*. Whitehorse (YK): Resources and Sustainable Development in the Arctic.

Hydro-Québec. (2007). *Projet de l'Eastmain-1-A–Sarcelle–Rupert*. Montréal (QC): Hydro-Québec.

Idrobo, C. J. & Berkes, F. (2012). Pangnirtung Inuit and the Greenland shark: Co-producing knowledge of a little discussed species. *Human Ecology, 40*(3), 405-414.

IEMA (Independent Environmental Monitoring Agency). (n.d.). The Agency. Retrieved November 2018, from https://monitoringagency.net/about/#the-agency.

IFRI (International Forestry Resources and Institutions). (n.d.). About Us. Retrieved November 2018, from http://www.ifriresearch.net/about-us/.

IJC (International Joint Commission). (n.d.). The IJC and the Great Lakes Water Quality Agreement. Retrieved December 2018, from https://www.ijc.org/en/what/glwqa-ijc.

INAC (Indian and Northern Affairs Canada). (2007). *The Mackenzie Valley Resource Management Act: A Citizen's Guide*. Ottawa (ON): INAC.

INAC (Indigenous and Northern Affairs Canada). (2014a). Comprehensive Land Claim and Self-Government Negotiation Tables. Retrieved July 2017, from http://www.aadnc-aandc.gc.ca/eng/1346782327802/1346782485058.

INAC (Indigenous and Northern Affairs Canada). (2014b). FAQs (Frequently Asked Questions) - Nunavut Devolution. Retrieved July 2018, from https://www.aadnc-aandc.gc.ca/eng/1352471950067/1352472030084.

INAC (Indigenous and Northern Affairs Canada). (2015). *Evaluation of Consultation and Accommodation*. Gatineau (QC): INAC.

INAC (Indigenous and Northern Affairs Canada). (2016a). General Briefing Note on Canada's Self-Government and Comprehensive Land Claims Policies and the Status of Negotiations. Retrieved January 2017, from https://www.aadnc-aandc.gc.ca/eng/1373385502190/1373385561540.

INAC (Indigenous and Northern Affairs Canada). (2016b). Nunavut Devolution. Retrieved July 2018, from https://www.aadnc-aandc.gc.ca/eng/1352471770723/1352471861365.

INAC (Indigenous and Northern Affairs Canada). (2017a). United Nations Declaration on the Rights of Indigenous Peoples. Retrieved August 2017, from https://www.aadnc-aandc.gc.ca/eng/1309374407406/1309374458958.

INAC (Indigenous and Northern Affairs Canada). (2017b). Speech for the Honourable Carolyn Bennett, Minister of Indigenous and Northern Affairs at the United Nations Permanent Forum on Indigenous Issues 16th Session. Retrieved November 2017, from www.canada.ca/en/indigenous-northern-affairs/news/2017/05/speaking_notes_forthehonourablecarolynbennettministerofindigenou.html.

Ingold, T. (2000). *The Perception of the Environment: Essays on Livelihood, Dwelling and Skill*. New York (NY): Routledge.

IPCC (Intergovernmental Panel of Climate Change). (2013). *Appendix A to the Principles Governing IPCC Work. Procedures for the Preparation, Review, Acceptance, Adoption, Approval and Publication of IPCC Reports*. Geneva, Switzerland: IPCC.

IRC (Inuvialuit Regional Corporation). (2018). Co-Management. Retrieved August, 2018, from http://www.irc.inuvialuit.com/co-management.

ITK (Inuit Tapiriit Kanatami). (2018). *National Inuit Strategy on Research*. Ottawa (ON): ITK.

Jenni, K. E., Pindilli, E., Bernknopf, R., Nieman, T. L., & Shapiro, C. (2018). *Multi-Resource Analysis—Methodology and Synthesis*. Reston (VA): U.S. Geological Survey.

Johns, C. M. (2017). The Great Lakes, Water Quality and Water Policy in Canada. In S. Renzetti & D. P. Dupont (Eds.), *Water Policy and Governance in Canada*. Switzerland: Springer International Publishing.

Johnson, C. J., Gillingham, M. P., Halseth, G. R., & Parkes, M. W. (2016a). A Revolution in Strategy, Not Evolution of Practice: Towards an Integrative Regional Cumulative Impacts Framework. In M. P. Gillingham, G. R. Halseth, C. J. Johnson & M. W. Parkes (Eds.), *The Integration Imperative: Cumulative Environmental, Community, and Health Effects of Multiple Natural Resource Developments*. New York (NY): Springer International Publishing.

Johnson, J. T., Louis, R. P., & Pramono, A. H. (2006). Facing the Future: Encouraging critical cartographic literacies in Indigenous communities. *ACME: An International E-Journal for Critical Geographies, 4*(1), 80-98.

Johnson, J. T., Howitt, R., Cajete, G., Berkes, F., Louis, R. P., & Kliskey, A. (2016b). Weaving Indigenous and sustainability sciences to diversify our methods. *Sustainability Science, 11*(1), 1-11.

Joseph, C., Gunton, T. I., & Day, J. C. (2008). Implementation of resource management plans: Identifying keys to success. *Journal of Environmental Management, 88*(4), 594-606.

JRP (Joint Review Panel). (2013). *Shell Canada Energy Jackpine Mine Expansion Project*. Calgary (AB): Federal Minister of the Environment and the Energy Resources Conservation Board.

JUS (Department of Justice Canada). (2018). Principles. Respecting the Government of Canada's Relationship with Indigenous Peoples. Retrieved August 2018, from http://www.justice.gc.ca/eng/csj-sjc/principles-principes.html.

Kahn, A. E. (1966). Tyranny of small decisions: Market failures, imperfections, and the limits of economics. *Kyklos, 19*(1), 23-47.

Kates, R. W., Clark, W. C., Corell, R., Hall, J. M., Jaeger, C. C., Lowe, I., . . . Svedin, U. (2001). Sustainability science. *Science, 292*(5517), 641-642.

Kennett, S. A. (2002). *Integrated Resource Management in Alberta: Past, Present and Benchmarks for the Future*. Calgary (AB): Canadian Institute of Resources Law.

Kennett, S. A. (2004). *Integrated Landscape Management in Canada: Initial Overview and Analytical Framework*. Calgary (AB): Canadian Institute of Resources Law.

Keough, H. L. & Blahna, D. J. (2006). Achieving integrative, collaborative ecosystem management. *Conservation Biology, 20*(5), 1373-1382.

Kimmerer, R. W. & Lake, F. K. (2001). The role of Indigenous burning in land management. *Journal of Forestry, 99*(11), 36-41.

Kimmerer, R. W. (2013). *Braiding Sweetgrass. Indigenous Wisdom, Scientific Knowledge and the Teachings of Plants*. Minneapolis (MN): Milkweed Editions.

Klein, J. T. & Falk-Krzesinski, H. J. (2017). Interdisciplinary and collaborative work: Framing promotion and tenure practices and policies. *Research Policy, 46*(6), 1055-1061.

Kling, C. L., Arritt, R. W., Calhoun, G., & Keiser, D. A. (2017). Integrated assessment models of the food, energy, and water nexus: A review and an outline of research needs. *Annual Review of Resource Economics, 9*(1), 143-163.

Laidler, G. J. (2006). Inuit and scientific perspectives on the relationship between sea ice and climate change: The ideal complement? *Climatic Change, 78*(2), 407-444.

Landres, P. B., Morgan, P., & Swanson, F. J. (1999). Overview of the use of natural variability concepts in managing ecological systems. *Ecological Applications, 9*(4), 1179-1188.

Lang, R. (1986). Achieving Integration in Resource Planning. In R. Lang (Ed.), *Integrated Approaches to Resource Planning and Management*. Calgary (AB): The University of Calgary Press.

Langdon, S., Prosper, R., & Gagnon, N. (2010). Two paths one direction: Parks Canada and Aboriginal Peoples working together. *The George Wright Forum, 27*(2), 222-233.

LARPRP (Lower Athabasca Regional Plan Review Panel). (2016). *Review Panel Report 2015: Lower Athabasca Regional Plan*. Edmonton (AB): Alberta Environment and Parks.

Lee, P. & Cheng, R. (2014). *Human Access in Canada's Landscapes*. Ottawa (ON): Global Forest Watch Canada.

Legault, L. H. (2000). Roles of law and diplomacy in dispute resolution: The IJC as a possible model. *Canada - United States Law Journal, 26*, 47-55.

Lertzman, D. A. (2010). Best of two worlds: Traditional ecological knowledge and Western science in ecosystem-based management. *BC Journal of Ecosystems and Management, 10*(3), 104-126.

Leung, W., Noble, B. F., Jaeger, J. A. G., & Gunn, J. A. E. (2016). Disparate perceptions about uncertainty consideration and disclosure practices in environmental assessment and opportunities for improvement. *Environmental Impact Assessment Review, 57*, 89-100.

Levins, R. (1993). A response to Orzack and Sober: Formal analysis and the fluidity of science. *The Quarterly Review of Biology, 68*(4), 547-555.

Lewis, J. L. & Sheppard, S. R. J. (2005). Ancient values, new challanges: Indigenous spiritual perceptions of landscapes and forest management. *Society and Natural Resources, 18*(10), 907-920.

Liu, J. & Taylor, W. W. (2002). Coupling Landscape Ecology with Natural Resource Mangement: Paradigm Shifts and New Approaches. In J. Liu & W. W. Taylor (Eds.), *Integrating Landscape Ecology into Natural Resource Management*. New York (NY): Cambridge University Press.

Lockwood, M., Davidson, J., Curtis, A., Stratford, E., & Griffith, R. (2009). Multi-level environmental governance: Lessons from Australian natural resource management. *Australian Geographer, 40*(2), 169-186.

Lockwood, M., Davidson, J., Curtis, A., Stratford, E., & Griffith, R. (2010). Governance principles for natural resource management. *Society and Natural Resources, 23*(10), 986-1001.

Löfmarck, E. & Lidskog, R. (2017). Bumping against the boundary: IPBES and the knowledge divide. *Environmental Science & Policy, 69*, 22-28.

Lovell, C., Mandondo, A., & Moriarty, P. (2002). The question of scale in integrated natural resource management. *Conservation Ecology, 5*(2), 25.

MAC (The Mining Association of Canada). (2017a). *Facts and Figures 2017: Facts and Figures of the Canadian Mining Industry*. Ottawa (ON): MAC.

MAC (The Mining Association of Canada). (2017b). Towards Sustainable Mining: Progress Report 2017. Ottawa (ON): MAC.

MacDonald, A. (2014). *Cumulative Effects on the Aboriginal Rights and Interests of Carrier Sekani Tribal Council First Nations: A Preliminary Re-Assessment of the Coastal GasLink Project*. Victoria (BC): The Firelight Group.

Macdonald, E. (2016). *Atlas of Cumulative Landscape Disturbance in the Traditional Territory of Blueberry River First Nations, 2016*. Vancouver (BC): Ecotrust Canada.

MacPherson, L., Coombs, M., Reilly, J., Sullivan, M. G., & Park, D. J. (2014). *A Generic Rule Set for Applying the Alberta Fish Sustainability Index*. Edmonton (AB): Environment and Sustainable Resource Development.

Mameamskum, J., Herrmann, T. M., & Füleki, B. (2016). Protecting the 'Caribou Heaven': A Sacred Site of the Naskapi and Protected Area Establishment in Nunavik, Canada. In T. M. Herrmann & T. Martin (Eds.), *Indigenous Peoples' Governance of Land and Protected Territories in the Arctic*. New York (NY): Springer International Publishing.

Manley, J. P. (2017). *Letter to Ministers McKenna, LeBlanc, Carr, and Garneau*. Ottawa (ON): Business Council of Canada.

Manseau, M., Parlee, B., & Ayles, G. B. (2005). A Place for Traditional Ecological Knowledge in Resource Management. In F. Berkes, R. Huebert, H. Fast, M. Manseau & A. Diduck (Eds.), *Breaking Ice: Renewable Resource and Ocean Management in the Canadian North*. Calgary (AB): University of Calgary Press.

Margerum, R. D. (1997). Integrated approaches to environmental planning and management. *Journal of Planning Literature, 11*(4), 459-475.

Margerum, R. D. (1999). Integrated environmental management: The foundations for successful practice. *Environmental Management, 24*(2), 151-166.

Maslin, M., Owen, M., Betts, R., Day, S., Dunkley Jones, T., & Ridgwell, A. (2010). Gas hydrates: Past and future geohazard? *Philosophical Transactions of the Royal Society A, 368*(1919), 2369–2393.

Masuda, Y. J., Liu, Y., Reddy, S. M. W., Frank, K. A., Burford, K., Fisher, J. R. B., & Montambault, J. (2018). Innovation diffusion within large environmental NGOs through informal network agents. *Nature Sustainability, 1*(4), 190-197.

Mattison, J., Nowlan, L., Lebel, M., & Orr, C. (2014). *Water for Power, Water for Nature: The Story of BC Hydro's Water Use Planning Program*. Vancouver (BC): WWF Canada.

McCauley, D. J. (2006). Selling out on nature. *Nature 443*, 27-28.

McDaniels, T., Mills, T., Gregory, R., & Ohlson, D. (2012). Using expert judgments to explore robust alternatives for forest management under climate change. *Risk Analysis, 32*(12), 2098-2112.

McDaniels, T. & Gregory, R. (2004). Learning as an objective within a structured risk management decision process. *Environmental Science & Technology, 38*(7), 1921-1926.

McGregor, D. (2009). Linking traditional knowledge and environmental practice in Ontario. *The Journal of Canadian Studies/Revue d'études canadiennes, 43*(3), 69-100.

McShane, T. O., Hirsch, P. D., Trung, T. C., Songorwa, A. N., Kinzig, A., Monteferri, B., . . . O'Connor, S. (2011). Hard choices: Making trade-offs between biodiversity conservation and human well-being. *Biological Conservation, 144*(3), 966-972.

Menzies, C. R. & Butler, C. (2006). Introduction: Understanding Ecological Knowledge. In C. R. Menzies (Ed.), *Traditional Ecological Knowledge and Natural Resource Management*. Lincoln (NE): University of Nebraska Press.

Meredith, C. (1997). *Best Practices in Performance Reporting in Natural Resource Management*. Melbourne, Australia: Department of Natural Resources and Environment Victoria.

Millennium Ecosystem Assessment. (2005a). *Ecosystems and Human Well-Being: Multiscale Assessments, Volume 4*. Washington (DC): Millennium Ecosystem Assessment.

Millennium Ecosystem Assessment. (2005b). *Ecosystems and Human Well-Being: Synthesis*. Washington (DC): Millennium Ecosystem Assessment.

Miller, C. A. & Wyborn, C. (2018). Co-production in global sustainability: Histories and theories. *Environmental Science & Policy, in press*.

Mitchell, B. (1986). The Evolution of Integrated Resource Management. In R. Lang (Ed.), *Integrated Approaches to Resource Planning and Management*. Calgary (AB): University of Calgary Press.

Mitchell, B., Priddle, C., Shrubsole, D., Veale, B., & Walters, D. (2014). Integrated water resource management: Lessons from conservation authorities in Ontario, Canada. *International Journal of Water Resources Development, 30*(3), 460-474.

Morgan, M. G. & Dowlatabadi, H. (1996). Learning from integrated assessment of climate change. *Climatic Change, 34*(3), 337-368.

Moss, R. H. & Schneider, S. H. (2000). Uncertainties in the IPCC TAR: Recommendations to Lead Authors for more Consistent Assessment and Reporting. In R. Pachauri, T. Taniguchi & K. Tanaka (Eds.), *Guidance Papers on the Cross Cutting Issues of the Third Assessment Report of the IPCC*. Geneva, Switzerland: World Meteorological Organization.

MRBB (Mackenzie River Basin Board). (2015). Who We Are. Retrieved August 2017, from http://www.mrbb.ca/information/15/index.html.

Murray, C. & Marmorek, D. R. (2004). *Adaptive Management: A Spoonful of Rigour Helps the Uncertainty Go Down*. Paper presented at 16th Annual Meeting of the Society for Ecological Restoration, Victoria (BC).

MVEIRB (Mackenzie Valley Environmental Impact Review Board). (2004). *Environmental Impact Assessment Guidelines*. Yellowknife (NT): MVEIRB.

MVEIRB (Mackenzie Valley Environmental Impact Review Board). (2007). *Report of Environmental Assessment and Reasons for Decision On Ur Energy Inc. Screech Lake Uranium Exploration Project (EA 0607-003)*. Yellowknife (NT): MVEIRB.

MVLWB (Mackenzie Valley Land and Water Board). (2018). Co-Management. Retrieved August 2018, from https://mvlwb.com/content/co-management.

Mychajlowycz, M. (2009). *Overview of Logging in Clayoquot Sound: 2000-2009*. Tofino (BC): Friends of Clayoquot Sound.

Nadasdy, P. (1999). The politics of TEK: Power and the "integration" of knowledge. *Arctic Anthropology, 36*(1/2), 1-18.

Nagendra, H. & Ostrom, E. (2012). Polycentric governance of multifunctional forested landscapes. *International Journal of the Commons, 6*(2), 104-133.

Nakashima, D. J., Galloway McLean, K., Thulstrup, H. D., Ramos Castillo, A., & Rubis, J. T. (2012). *Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation*. Paris, France: UNESCO and UNU.

Nanos (Nanos Research). (2018). *Positive Energy Summary*. Ottawa (ON): Positive Energy.

NAS (National Academies of Sciences, Engineering, and Medicine). (2016a). *Integrating Landscape Approaches and Multi-Resource Analysis into Natural Resource Management: Summary of a Workshop*. Washington (DC): The National Academies Press.

NAS (National Academies of Sciences, Engineering, and Medicine). (2016b). *Communicating Science Effectively: A Research Agenda. Report Highlights*. Washington (DC): The National Academies Press.

Natcher, D. C. (2001). Co-management: An Aboriginal response to frontier development. *The Northern Review, 23*, 146-163.

National Forestry Database. (2018). About Us. Retrieved June 2018, from http://nfdp.ccfm.org/en/about.php.

NCC (Nature Conservancy of Canada). (2018a). Applied Conservation Research at NCC. Retrieved March 2018, from http://www.natureconservancy.ca/en/what-we-do/conservation-research/.

NCC (Nature Conservancy of Canada). (2018b). Funding and Other Resources. Retrieved August 2018, from http://www.natureconservancy.ca/en/what-we-do/conservation-research/funding-and-other-resources.html.

NCFNG (National Centre for First Nations Governance). (n.d.). *Governance Toolkit Best Practices: Territorial Integrity - Haida Nation*. Ottawa (ON): NCFNG.

NEB (National Energy Board). (2016). *Canada's Energy Future 2016: Energy Supply and Demand Projections to 2040*. Calgary (AB): NEB.

NEB (National Energy Board). (n.d.). *What is Procedural Fairness?* Calgary (AB): NEB.

Nesbitt, T. H. D. (2016). Increasing Cooperation and Advancing Reconcilliation in the Coooperative Management of Protected Areas in Canada's North. In T. M. Hermann & T. Martin (Eds.), *Indigenous Peoples' Governance of Land and Protected Territories in the Arctic*. New York (NY): Springer International Publishing.

Newbold, T., Hudson, L. N., Phillips, H. R. P., Hill, S. L. L., Contu, S., Lysenko, I., . . . Purvis, A. (2014). A global model of the response of tropical and sub-tropical forest biodiversity to anthropogenic pressures. *Proceedings of the Royal Society B, 281*(1792), 20141371.

Nielsen, J., Noble, B., & Hill, M. (2012). Wetland assessment and impact mitigation decision support framework for linear development projects: The Louis Riel Trail, Highway 11 North project, Saskatchewan, Canada. *The Canadian Geographer / Le Géographe canadien, 56*(1), 117-139.

Noble, B. (2008). Strategic approaches to regional cumulative effects assessment: A case study of the Great Sand Hills, Canada. *Impact Assessment and Project Appraisal, 26*(2), 78-90.

Noble, B. (2010). *Cumulative Environmental Effects and the Tyranny of Small Decisions: Towards Meaningful Cumulative Effects Assessment and Management. Natural Resources and Environmental Studies Institute Occasional Paper No. 8*. Prince George (BC): University of Northern British Columbia.

Noble, B. (2015a). Cumulative effects research: Achievements, status, directions and challenges in the Canadian context. *Journal of Environmental Assessment Policy and Management, 17*(1), 1550001.

Noble, B. (2017). *Getting the Big Picture: How Regional Assessment Can Pave the Way for More Inclusive and Effective Environmental Assessments*. Ottawa (ON): Macdonald-Laurier Institute.

Noble, B. (2015b). *Introduction to Environmental Impact Assessment*. Don Mills (ON): Oxford University Press.

NRC (National Research Council). (2008). *Public Participation in Environmental Assessment and Decision Making*. Washington (DC): National Academies Press.

NRC (National Research Council). (2013). *Sustainability for the Nation: Resource Connection and Governance Linkages*. Washington (DC): National Academies Press.

NRCan (Natural Resources Canada). (2016a). Roles and Responsiblities of Governments in Natural Resources. Retrieved February 2017, from https://www.nrcan.gc.ca/mining-materials/taxation/8882.

NRCan (Natural Resources Canada). (2016b). *The State of Canada's Forests: Annual Report 2016*. Ottawa (ON): NRCan.

NRCan (Natural Resources Canada). (2018). *10 Key Facts on Canada's Natural Resources*. Ottawa (ON): NRCan.

NRT (National Round Table on the Environment and the Economy). (2011). *Paying the Price: The Economic Costs of Climate Change for Canada*. Ottawa (ON): NRT.

Nunatsiavut Government. (2005). *The Labrador Inuit Constitution*. Nain (NL): Nunatsiavut Government.

Nunavut Tunngavik Inc. & GC (Nunavut Tunngavik Inc. and Government of Canada). (2010). *Agreement Between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in Right of Canada as Amended*. Ottawa (ON): Nunavut Tunngavik Inc. and GC.

Odum, W. E. (1982). Environmental degradation and the tyranny of small decisions. *BioScience, 32*(9), 728-729.

Olson, R., Hackett, J., & DeRoy, S. (2016). Mapping the digital terrain: Towards Indigenous geographic information and spatial data quality indicators for Indigenous knowledge and traditional land-use data collection. *The Cartographic Journal, 53*(4), 348-355.

Olsson, P., Folke, C., & Berkes, F. (2004). Adaptive comanagement for building resilience in social-ecological systems. *Environmental Management, 34*(1), 75-90.

Olsson, P., Folke, C., Galaz, V., Hahn, T., & Schultz, L. (2007). Enhancing the fit through adaptive co-management: Creating and maintaining bridging functions for matching scales in the Kristianstads Vattenrike Biosphere Reserve, Sweden. *Ecology and Society, 12*(1), 28.

Olszynski, M. (2016). The Duty to Consult and Accommodate: An Overview and Discussion. In *Seizing Six Opportunities for More Clarity in the Duty to Consult and Accomodate Process*. Ottawa (ON): Canadian Chamber of Commerce.

Olszynski, M. Z. P. (2017). Failed experiments: An empirical assessment of adaptive management in Alberta's energy resources sector. *UBC Law Review, 50*(3), 697-796.

Ostrom, E. (2007). A diagnostic approach for going beyond panaceas. *Proceedings of the National Academy of Sciences, 104*(39), 15181-15187.

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science, 325*(5939), 419-422.

Ostrom, E., Dietz, T., Dolsak, N., Stern, P. C., Stonich, S., & Weber, E. U. (Eds.). (2002). *The Drama of the Commons*. Washington (DC): National Academy Press.

Pannell, D. J. & Roberts, A. M. (2010). Australia's national action plan for salinity and water quality: A retrospective assessment. *Australian Journal of Agricultural and Resource Economics, 54*(4), 437-456.

Parkes, M. W., Johnson, C. J., Halseth, G. R., & Gillingham, M. P. (2016). An Imperative for Change: Towards an Integrative Understanding. In M. P. Gillingham, G. R. Halseth, C. J. Johnson & M. W. Parkes (Eds.), *The Integration Imperative: Cumulative Environmental, Community and Health Effects of Multiple Natural Resource Developments*. New York (NY): Springer International Publishing.

Parkins, J. R. (2011). Deliberative democracy, institution building, and the pragmatics of cumulative effects assessment. *Ecology and Society, 16*(3), 20.

Parkins, J. R., Beckley, T., Comeau, L., Stedman, R. C., Rollins, C. L., & Kessler, A. (2017). Can distrust enhance public engagement? Insights from a national survey on energy issues in Canada. *Society & Natural Resources, 30*(8), 934-948.

Parks Canada. (2010). *Tongait KakKasuangita SilakKijapvinga. Torngat Mountains National Park of Canada Management Plan*. Nain (NL): Parks Canada.

Parrott, L., Chion, C., Gonzalès, R., & Latombe, G. (2012). Agents, individuals, and networks: Modeling methods to inform natural resource management in regional landscapes. *Ecology and Society, 17*(3), 32.

Paton, S., Curtis, A., McDonald, G., & Woods, M. (2004). Regional natural resource management: Is it sustainable. *Australasian Journal of Environmental Management, 11*(4), 259-267.

Pavlikakis, G. E. & Tsihrintzis, V. A. (2000). Ecosystem management: A review of a new concept and methodology. *Water Resources Management, 14*(4), 257-283.

PDAC (Prospectors & Developers Association of Canada). (2016). *2017 Pre-Budget Submission to the House of Commons Standing Committee on Finance*. Ottawa (ON): PDAC.

Pearse, P. H. (1988). Property rights and the development of natural resource policies in Canada. *Canadian Public Policy - Analyse de Politiques, 14*(3), 307-320.

Petersen, A. C., Janssen, P. H. M., van der Sluijs, J. P., Risbey, J. S., Ravetz, J. R., Wardekker, J. A., & Martinson Hughes, H. (2013). *Guidance for Uncertainty Assessment and Communication. Second Edition*. The Hague, Netherlands: PBL Netherlands Environmental Assessment Agency.

Peterson, G. D., Cumming, G. S., & Carpenter, S. R. (2003). Scenario planning: A tool for conservation in an uncertain world. *Conservation Biology, 17*(2), 358-366.

Phare, M.-A., Simms, R., Brandes, O. M., & Miltenberger, M. (2017). *Collaborative Consent and British Columbia's Water: Towards Watershed Co-Governance*. Winnipeg (MB): POLIS Project on Ecological Governance and Centre for Indigenous Environmental Resources.

Pierce, T. W. & Ward, E. N. (2013). Canada Land Inventory. Retrieved June 2018, from https://www.thecanadianencyclopedia.ca/en/article/canada-land-inventory/.

Pierotti, R. (2011). *Indigenous Knowledge, Ecology, and Evolutionary Biology*. New York (NY): Routledge.

Plummer, R., Crona, B., Armitage, D. R., Olsson, P., Tengö, M., & Yudina, O. (2012). Adaptive comanagement: A systematic review and analysis. *Ecology and Society, 17*(3), 11.

Plummer, R., Armitage, D. R., & de Loë, R. C. (2013). Adaptive comanagement and its relationship to environmental governance. *Ecology and Society, 18*(1), 21.

Pottette, A. R., Janssen, M. A., & Ostrom, E. (2010). *Working Together: Collective Action, the Commons, and Multiple Methods in Practice*. Princeton (NJ): Princeton University Press.

Prabhu, R., Ruitenbeek, H. J., Boyle, T. J. B., & Pierce Colfer, C. J. (2001). Between Voodoo Science and Adaptive Management: The Role and Research Needs for Indicators of Sustainable Forest Management. In R. J. Raison, A. G. Brown & D. W. Flinn (Eds.), *Criteria and Indicators for Sustainable Forest Management*. Wallingford, United Kingdom: CAB International.

PRC (Provincial Review Committee to the Administrator of Chapter 22 of the James Bay and Northern Quebec Agreement). (2006). *Eastmain-1-A and Rupert Diversion Hydropower Project*. Québec (QC): PRC.

Pullin, A. S. & Knight, T. M. (2001). Effectiveness in conservation practice: Pointers from medicine and public health. *Conservation Biology, 15*(1), 50-54.

Quinn, M., Tyler, M.-E., Ajaero, E., Arvai, J., Carlson, M., Dunmade, I., . . . Van der Byl, C. (2015). *Landscape Impacts of Hydraulic Fracturing Development and Operations on Surface Water and Watersheds*. Calgary (AB): Canadian Water Network.

Rathwell, K. J., Armitage, D., & Berkes, F. (2015). Bridging knowledge systems to enhance governance of the environmental commons: A typology of settings. *Journal of the Commons, 9*(2), 851-880.

Ray, J. C. (2014). *Defining Habitat Restoration for Boreal Caribou in the Context of National Recovery*. Toronto (ON): Wildlife Conservation Society Canada.

RCAP (Royal Commission on Aboriginal Peoples). (1996a). *Report of the Royal Commission on Aboriginal Peoples, Volume 3: Gathering Strength*. Ottawa (ON): RCAP.

RCAP (Royal Commission on Aboriginal Peoples). (1996b). *Report of the Royal Commission on Aboriginal Peoples, Volume 1: Looking Forward, Looking Back*. Ottawa (ON): RCAP.

Reid, W. V., Berkes, F., Wilbanks, T., & Capistrano, D. (Eds.). (2006). *Bridging Scales and Knowledge Systems: Concepts and Applications in Ecosystem Assessment*. Washington (DC): Millennium Ecosystem Assessment and Island Press.

Renn, O. (1992). Concepts of Risk: A Classification. In S. Krimsky & D. Golding (Eds.), *Social Theories of Risk*. Westport (CT): Praeger Publishing.

Roach, R. & Worbets, B. (2012). *Keeping Pace: Improving Environmental Decision-Making in Canada*. Calgary (AB): Canada West Foundation.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin III, F. S., Lambin, E., . . . Foley, J. (2009). Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society, 14*(2), 32.

Rodela, R. (2012). Advancing the deliberative turn in natural resource management: An analysis of discourses on the use of local resources. *Journal of Environmental Management, 96*(1), 26-34.

Rosa, E. A., Renn, O., & McCright, A. M. (2014). *The Risk Society Revisited: Social Theory and Governance*. Philidelphia (PA): Temple University Press.

Ruhl, J. B. & Fischman, R. (2010). Adaptive management in the courts. *Minnesota Law Review, 95*(2), 424-484.

Russell, D. E., Svoboda, M. Y., Arokium, J., & Cooley, D. (2011). *Arctic Borderlands Ecological Knowledge Cooperative: Can Local Knowledge Inform Caribou Management*. Paper presented at 13th Arctic Ungulate Conference, Yellowknife (NT).

Sadler, K. L. (2005). *A Comparative Analysis of Co-Management Agreements for National Parks: Gwaii Haanas and Uluṟu-Kata Tjuṯa*. Winnipeg (MB): University of Manitoba.

Sandel, M. J. (2012). *What Money Can't Buy: The Moral Limits of Markets*. New York (NY): Farrar, Straus and Giroux.

Satz, D. (2010). *Why Some Things Should Not Be for Sale: The Moral Limits of Markets*. New York (NY): Oxford University Press.

Savo, V., Lepofsky, D., Benner, J. P., Kohfeld, K. E., Bailey, J., & Lertzman, K. (2016). Observations of climate change among subsistence-oriented communities around the world. *Nature Climate Change, 6*, 462-474.

Sayer, J., Sunderland, T., Ghazoul, J., Pfund, J.-L., Sheil, D., Meijaard, E., . . . Buck, L. E. (2013). Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. *Proceedings of the National Academy of Sciences, 110*(21), 8349-8356.

Scassa, T., Engler, N. J., & Taylor, D. R. F. (2015). Legal issues in mapping traditional knowledge: Digital cartography in the Canadian North. *The Cartographic Journal, 52*(1), 41-50.

SCC (Supreme Court of Canada). (1992). *Friends of the Oldman River Society v. Canada (Minister of Transport). 1992 SCC 21890*. Ottawa (ON): SCC.

SCC (Supreme Court of Canada). (2004). *Haida Nation v. British Columbia (Minister of Forests). 2004 SCC 73*. Ottawa (ON): SCC.

SCC (Supreme Court of Canada). (2005). *Mikisew Cree First Nation v. Canada (Minister of Canadian Heritage). 2005 SCC 69*. Ottawa (ON): SCC.

SCC (Supreme Court of Canada). (2010). *Rio Tinto Alcan Inc. v. Carrier Sekani Tribal Council. 2010 SCC 43*. Ottawa (ON): SCC.

SCC (Supreme Court of Canada). (2014). *Tsilhqot'in Nation v. British Columbia. 2014 SCC 44*. Ottawa (ON): SCC.

Schindler, D. W. (2001). The cumulative effects of climate warming and other human stresses on Canadian freshwaters in the new millennium. *Canadian Journal of Fisheries and Aquatic Sciences, 58*(1), 18-29.

Schmiegelow, F. (2007). Benchmarking healthy ecosystems. *Canadian Silviculture, May*, 6-8.

Schnarch, B. (2004). Ownership, control, access, and possession (OCAP) or self-determination applied to research: A critical analysis of contemporary First Nations research and some options for First Nations communities. *Journal of Aboriginal Health, 1*(1), 80-95.

Schneider, R. R., Stelfox, J. B., Boutin, S., & Wasel, S. (2003). Managing the cumulative impacts of land uses in the Western Canadian sedimentary basin: A modeling approach. *Conservation Ecology, 7*(1), 8.

Seitz, N. E., Westbrook, C. J., & Noble, B. F. (2011). Bringing science into river systems cumulative effects assessment practice. *Environmental Impact Assessment Review, 31*(3), 172-179.

SENES Consultants Limited. (2008). *West Kitikmeot Slave Study State of Knowledge Report - 2007 Update*. Yellowknife (NT): West Kitikmeot Slave Study Society.

Serran, J. N. & Creed, I. F. (2016). New mapping techniques to estimate the preferential loss of small wetlands on prairie landscapes. *Hydrological Processes, 30*(3), 396-409.

Service Alberta. (2016). *Open Government Program Plan*. Edmonton (AB): Service Alberta.

Shaw, K., Hill, S. D., Boyd, A. D., Monk, L., Reid, J., & Einsiedel, E. F. (2015). Conflicted or constructive? Exploring community responses to new energy developments in Canada. *Energy Research & Social Science, 8*, 41-51.

Simpson, K. (2016). *Refining the Threshold Approach to Land Management in the North Yukon Planning Region*. Paper presented at Northern Planning Conference, Whitehorse (YK).

Slattery, B. (2007). A Taxonomy of Aboriginal Rights. In H. Foster, H. Raven & J. Webber (Eds.), *Let Right Be Done: Aboriginal Title, the Calder Case, and the Future of Indigenous Rights*. Vancouver (BC): UBC Press.

Slocombe, D. S. (1993). Implementing ecosystem-based management. *BioScience, 43*(9), 612-622.

Slocombe, D. S. & Hanna, K. S. (2007). Integration in Resource and Environmental Management. In K. S. Hanna & D. S. Slocombe (Eds.), *Integrated Resource and Environmental Management*. Don Mills (ON): Oxford University Press.

Smith, W. & Cheng, R. (2016). *Canada's Intact Forest Landscapes Updated to 2013*. Ottawa (ON): Global Forest Watch Canada.

Soga, M. & Gaston, K. J. (2018). Shifting baseline syndrome: Causes, consequences, and implications. *Frontiers in Ecology and the Environment, 16*(4), 222-230.

Squires, A. J., Westbrook, C. J., & Dubé, M. (2010). An approach for assessing cumulative effects in a model river, the Athabasca River Basin. *Integrated Environmental Assessment and Management, 6*(1), 119-134.

Stankey, G. H., Clark, R. N., & Bormann, B. T. (2005). *Adaptive Management of Natural Resources: Theory, Concepts, and Management Institutions*. Portland (OR): United States Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Staples, L. & Askew, H. (2016). *Regional Strategic Environmental Assessment for Northern British Columbia: The Case and the Opportunity*. Vancouver (BC): West Coast Environmental Law and the Northwest Institute for Bioregional Research.

StatCan (Statistics Canada). (2015). About the Environmental and Resource Accounts. Retrieved December 2018, from https://www.statcan.gc.ca/eng/nea/about/env.

Steering Committee (Steering Committee of the State-of-Knowledge Assessment of Standards and Certification). (2012). *Toward Sustainability: The Roles and Limitations of Certification*. Washington (DC): RESOLVE, Inc.

Stevenson, M. G. (1996). Indigenous knowledge in environmental assessment. *Arctic, 49*(3), 278-291.

Stralberg, D., Wang, X., Parisien, M. A., Robinne, F. N., Sólymos, P., Mahon, C. L., . . . Bayne, E. M. (2018). Wildfire-mediated vegetation change in boreal forests of Alberta, Canada. *Ecosphere, 9*(3), e02156.

Stratos Inc. (2015). *Governance Review: Oil Sands Monitoring, Evaluation and Reporting*. Calgary (AB): Alberta Environmental Monitoring, Evaluation and Reporting Agency.

Stratos Inc. (2017). *Cross-Jurisdictional Review of Energy Regulators*. Ottawa (ON): Natural Resources Canada.

Stucki, V. & Smith, M. (2011). Integrated approaches to natural resource management in practice: The catalyzing role of National Adaption Programs for Action. *Ambio, 40*(4), 351-360.

Svoboda, M., Russell, D., & Gagnon, C. (n.d.). Arctic Borderlands Ecological Knowledge Co-Op. Retrieved May 2017, from http://www.eco.gov.yk.ca/pdf/coopscope.pdf.

Teck. (2014). *Elk Valley Water Quality Plan*. Sparwood (BC): Teck.

Tengö, M., Brondizio, E. S., Elmqvist, T., Malmer, P., & Spierenburg, M. (2014). Connecting diverse knowledge systems for enhanced ecosystem governance: The multiple evidence base approach. *AMBIO, 43*(5), 579-591.

Tengö, M., Hill, R., Malmer, P., Raymond, C. M., Spierenburg, M., Danielsen, F., . . . Folke, C. (2017). Weaving knowledge systems in IPBES, CBD and beyond — lessons learned for sustainability. *Current Opinion in Environmental Sustainability, 26-27*, 17-25.

Tester, F. J. & Irniq, P. (2008). Inuit Qaujimajatuqangit: Social history, politics and the practice of resistance. *Arctic, 61*(Suppl. 1), 48-61.

The Canadian Press. (2018, May 3). Ontario Signs Deals to Share Forestry, Mining Revenues With First Nations, *The Globe and Mail*.

The Inuit of Labrador & GC (The Inuit of Labrador and Government of Canada). (2005). *Labrador Inuit Land Claims Agreement*. Nain (NL): The Inuit of Labrador & GC.

The World Bank. (2017). *The Growing Role of Minerals and Metals for a Low Carbon Future*. Washington (DC): The World Bank.

Thiffault, N., Wyatt, S., Leblanc, M., & Jetté, J.-P. (2007). Adaptive forest management in Quebec: Bits of the big and small pictures. *Canadian Silviculture, May*, 26-29.

Thomlinson, E. & Crouch, G. (2012). Aboriginal peoples, Parks Canada, and protected spaces: A case study in co-management at Gwaii Haanas National Park Reserve. *Annals of Leisure Research, 15*(1), 69-86.

Tindall, D. B. (2015). Networks as Constraints and Opportunities. In D. della Porta & M. Diani (Eds.), *The Oxford Handbook of Social Movement*. New York (NY): Oxford University Press.

Tomlinson, R. F. (1962). *Computer Mapping: An Introduction to the Use of Electronic Computers in the Storage, Compilation and Assessment of Natural and Economic Data for the Evaluation of Marginal Lands*. Paper presented at National Land Capability Inventory Seminar, Ottawa (ON).

Toms, J. D. & Villard, M.-A. (2015). Threshold detection: Matching statistical methodology to ecological questions and conservation planning objectives. *Avian Conservation and Ecology, 10*(1), 2.

TRC (The Truth and Reconciliation Commission of Canada). (2015). *Honouring the Truth, Reconciling for the Future: Summary of the Final Report of the Truth and Reconciliation Commission of Canada*. Winnipeg (MB): TRC.

Trosper, R. L. & Parrotta, J. A. (2012). Introduction: The Growing Importance of Traditional Forest-Related Knowledge. In J. A. Parrotta & R. L. Trosper (Eds.), *Traditional Forest-Related Knowledge: Sustaining Communities, Ecosystems and Biocultural Diversity*. Dordrecht, the Netherlands: Springer Netherlands.

Turnhout, E., Bloomsfield, B., Hulme, M., Vogel, J., & Wynne, B. (2012). Listen to the voices of experience. *Nature, 488*, 454-455.

Tyler, N. J. C., Turi, J. M., Sundset, M. A., Strøm Bull, K., Sara, M. N., Reinert, E., . . . Corell, R. W. (2007). Saami reindeer pastoralism under climate change: Applying a generalized framework for vulnerability studies to a sub-arctic social-ecological system. *Global Environmental Change, 17*(2), 191-206.

UN (United Nations). (2008). *United Nations Declaration on the Rights of Indigenous Peoples*. New York (NY): UN.

Usher, P. J. (2000). Traditional ecological knowledge in environmental assessment and management. *Arctic, 53*(2), 183-193.

Valin, H., Sands, R. D., van der Mensbrugghe, D., Nelson, G. C., Ahammad, H., Blanc, E., . . . Willenbockel, D. (2014). The future of food demand: Understanding differences in global economic models. *Agricultural Economics, 45*(1), 51-67.

VNCST (Value of Nature to Canadians Study Taskforce). (2017). *Completing and Using Ecosystem Service Assessment for Decision-Making: An Interdisciplinary Toolkit for Managers and Analysts*. Ottawa (ON): Federal, Provincial, and Territorial Governments of Canada.

Vanclay, J. K. (2000). *Models for Integrated Natural Resource Management: An illustration with FLORES, the Forest Land Resource Oriented Resource Envisioning System*. Paper presented at Integrated Natural Resource Management in the CGIAR: Approaches and Lessons, Penang, Malaysia.

Vandenbergh, M. P. (2013). Private environmental governance. *Cornell Law Review, 99*(1), 129-199.

Vandenbergh, M. P. (2014). The emergence of private environmental governance. *Environmental Law Reporter, 44*(2), 10125-10135.

Vandenbergh, M. P. & Gilligan, J. M. (2017). *Beyond Politics: The Private Governance Response to Climate Change*. New York (NY): Cambridge University Press.

Vogt, K. A., Grove, M., Asbjornsen, H., Maxwell, K. B., Vogt, D. J., Sigurdardottir, R., . . . Dove, M. (2002). Linking Ecological and Social Scales for Natural Resource Management. In J. Liu & W. W. Taylor (Eds.), *Integrating Landscape Ecology into Natural Resource Management*. New York (NY): Cambridge University Press.

Warren, F. J. & Lemmen, D. S. (Eds.). (2014). *Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation*. Ottawa (ON): Government of Canada.

Web of Science. (2018). Web of Science Core Collection. Retrieved October 2018, from www.webofknowledge.com/.

WEF (World Economic Forum). (2018). *Canada: The Global Competitiveness Index 2017-2018 Edition*. Cologny, Switzerland: WEF.

Wenzel, G. W. (2004). From TEK to IQ: Inuit qaujimajatuqangit and Inuit cultural ecology. *Arctic Anthropology, 41*(2), 238-250.

Weyant, J. (2017). Some contributions of integrated assessment models of global climate change. *Review of Environmental Economics and Policy, 11*(1), 115-137.

Wheatley, W. C. (2006). *Co-Management of Gwaii Haanas National Park Reserve and Haida Heritage Site: Panarchy as a Means of Assessing Linked Cultural and Ecological Landscapes for Sustainability. MA Thesis.* Victoria (BC): University of Victoria.

White, G., Christensen, V., & Ehrlich, A. (2007). *Involving Canada's Indigenous Peoples in Environmental Impact Assessment: Co-Management Through the Mackenzie Valley Environmental Impact Review Board.* Paper presented at 27th Annual Conference of the International Association for Impact Assessment, Seoul, South Korea.

Whitney, C. K., Bennett, N. J., Ban, N. C., Allison, E. H., Armitage, D., Blythe, J. L., . . . Yumagulova, L. (2017). Adaptive capacity: From assessment to action in coastal social-ecological systems. *Ecology and Society, 22*(2), 22.

Whyte, K. P. (2013). On the role of traditional ecological knowledge as a collaborative concept: A philosophical study. *Ecological Processes, 2*, 7.

Whyte, K. P., Brewers II, J. P., & Johnson, J. T. (2016). Weaving Indigenous science, protocols, and sustainability science. *Sustainability Science, 11*(1), 25-32.

Wilderness Tourism Association of BC. (n.d.). Value of Tourism. Retrieved January 2019, from https://wilderness-tourism.bc.ca/get-involved/value-of-tourism/.

Williams, B. K. (2011). Adaptive management of natural resources — framework and issues. *Journal of Environmental Management, 92*(5), 1346-1353.

Williams, T. & Hardison, P. (2013). Culture, law, risk and governance: Contexts of traditional knowledge in climate change adaptation. *Climatic Change, 120*(3), 531-544.

Wondolleck, J. (1985). The importance of process in resolving environmental disputes. *Environmental Impact Assessment Review, 5*(4), 341-356.

Wong, C. & Iverson, K. (2004). Range of natural variability: Applying the concept to forest management in central British Columbia. *BC Journal of Ecosystem and Management, 4*(1), 1-14.

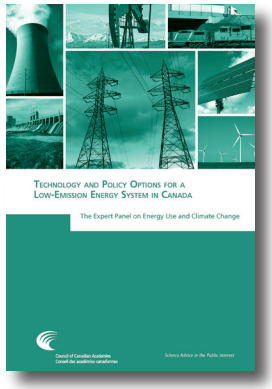
Wong, L. A. (2018). *Water Quality Data to Support Cumulative Effects Decision-Making in the Mackenzie Valley, Northwest Territories. MSc Thesis.* Saskatoon (SK): University of Saskatchewan.

Worte, C. (2017). Integrated watershed management and Ontario's conservation authorities. *International Journal of Water Resources Development, 33*(3), 360-374.

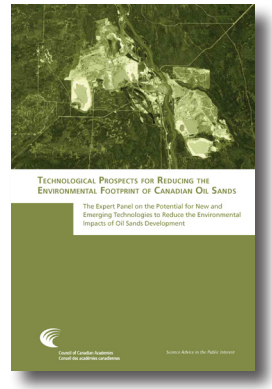
York, R. (2013). Metatheoretical Foundations of Post-Normal Prediction. In T. Dietz & A. K. Jorgenson (Eds.), *Structural Human Ecology: New Essays in Risk, Energy and Sustainability.* Pullman (WA): Washington State University Press.

Council of Canadian Academies' Reports of Interest

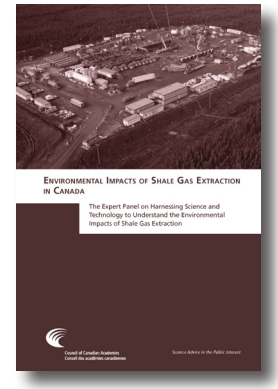
The assessment reports listed below are accessible through the CCA's website (**www.scienceadvice.ca**):



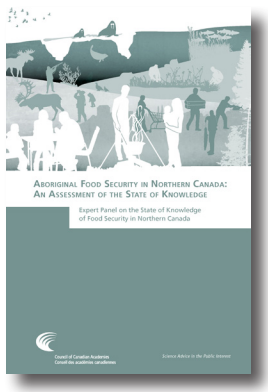
Technology and Policy Options for a Low-Emission Energy System in Canada (2015)



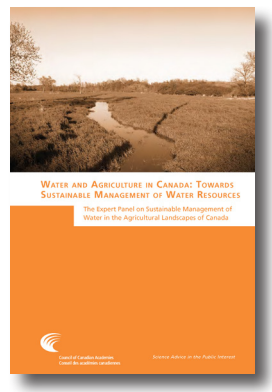
Technological Prospects for Reducing the Environmental Footprint of Canadian Oil Sands (2015)



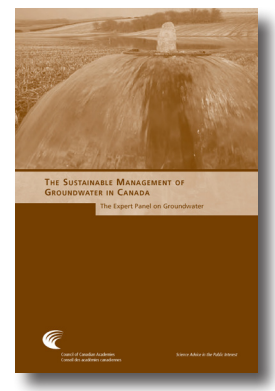
Environmental Impacts of Shale Gas Extraction in Canada (2014)



Aboriginal Food Security in Northern Canada: An Assessment of the State of Knowledge (2014)



Water and Agriculture in Canada: Towards Sustainable Management of Water Resources (2012)



The Sustainable Management of Groundwater in Canada (2008)

Board of Directors of the Council of Canadian Academies*

Scientific Advisory Committee of the Council of Canadian Academies*

Eliot A. Phillipson, O.C., FCAHS, Chair, Sir John and Lady Eaton Professor of Medicine Emeritus, University of Toronto (Toronto, ON); Former President and CEO, Canada Foundation for Innovation (Ottawa, ON)

Karen Bakker, Professor, Canada Research Chair, and Director (Program on Water Governance), University of British Columbia (Vancouver, BC)

David Castle, Vice-President Research and Professor, School of Public Administration; adjunct appointment Gustavson School of Business, University of Victoria (Victoria, BC)

Sophie D'Amours, O.C., FCAE, Rector of the Université Laval (Quebec City, QC)

Jackie Dawson, Canada Research Chair in Environment, Society and Policy, and Associate Professor, Department of Geography, University of Ottawa (Ottawa, ON)

Jeffrey A. Hutchings, FRSC, Killam Memorial Chair and Professor of Biology, Dalhousie University (Halifax, NS)

Malcolm King, FCAHS, Scientific Director Institute of Aboriginal Peoples' Health at Canadian Institutes of Health Research (Saskatoon, SK)

Chris MacDonald, Associate Professor; Director, Ted Rogers Leadership Centre; Chair, Law and Business Department; Ted Rogers School of Management, Ryerson University (Toronto, ON)

Stuart MacLeod, FCAHS, Professor of Pediatrics (Emeritus), University of British Columbia (Vancouver, BC); Adjunct Professor, Community Health and Epidemiology, Dalhousie University (Halifax, NS)

Barbara Neis, C.M., FRSC, John Paton Lewis Distinguished University Professor, Memorial University of Newfoundland (St. John's, NL)

Gilles G. Patry, C.M., O.Ont., FCAE, Executive Director, The U15 – Group of Canadian Research Universities (Ottawa, ON)

Nicole A. Poirier, FCAE, President, KoanTeknico Solutions Inc. (Beaconsfield, QC)

*Affiliations as of April 2019

Council of Canadian Academies | Conseil des académies canadiennes

180 Elgin Street, Suite 1401
Ottawa ON K2P 2K3
Tel: 613 567-5000
www.scienceadvice.ca