Science and knowledge needs to support Canada's implementation of the Kunming-Montreal Global Biodiversity Framework

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Disclaimer

The recommendations and views expressed in this report reflect the opinions of the authors and contributors including experts from academia, Indigenous scholars, and specialists from Non-governmental Organizations and from federal, provincial and territorial governments. Authors were invited to contribute to the report on the basis of their subject matter expertise rather than representing the positions of their institutional affiliations.

The authors and contributors participated in workshops to exchange knowledge, and assisted with writing and editing the report. This resulting report represents a diverse range of scholarly opinions, and provides independent scholarly advice. Environment and Climate Change Canada (ECCC) acknowledges and values the commitment of the authors to ensuring the Department and Canadians receive the highest quality of scholarly advice.

The authors and contributors recognize that this scholarly advice will be provided for consideration alongside other information and advice received to inform the drafting of Canada’s 2030 National Biodiversity Strategy.

Executive Summary

Global biodiversity has declined rapidly in recent decades due to direct and indirect drivers of change that include changes in land, freshwater, and sea use, overexploitation of flora and fauna, climate change, pollution, disease, and invasive species (Lips et al. 2006, Mace et al. 2018, IPBES 2019). Recognizing this decline, the Convention on Biological Diversity (CBD) was established in 1992. Canada was the first industrialized country to sign the convention and has served as the home of the CBD secretariat since 1996. Despite significant efforts to halt and reverse biodiversity loss, the declines in biodiversity have continued and, in many cases, accelerated. There is increasing recognition that the drivers of biodiversity loss are perpetuated in part by conflicting goals and values across economic, social, political, and technological sectors, and inequity on many scales. Addressing these issues, along with other underlying socioeconomic and political drivers that influence direct risks, will be necessary in order to create the significant and lasting transformative change that is required.

The 2022 Kunming-Montreal Global Biodiversity Framework (KMGBF) aims to build on the achievements, failures and lessons learned from previous multilateral attempts to halt biodiversity loss. It sets more ambitious and better-defined goals and targets than the Aichi targets, seeks to improve the mobilization of resources to achieve these targets, and encourages greater collaboration among governments, Indigenous Peoples and civil society. The framework contains four long-term goals that are to be reached by 2050. These long-term goals are supported by 23 targets, to be achieved by 2030, that fall under three themes: 1) reducing threats to biodiversity, 2) meeting people's needs through sustainable use and benefit sharing, and 3) implementing and mainstreaming tools and solutions.

In Canada, a large community of scholars and experts are actively engaged in the production, mobilization and integration of biodiversity information. Through online surveys and workshop formats, we consulted with a large sample of these experts from diverse fields and sectors, including natural-, social- and Indigenous scientists from academia, environmental non-governmental organizations, and government departments, agencies and crown corporations. The goal of this report is to present this expert community's perspectives on key concepts, information needs, and research opportunities that will help strengthen Canada's ability to achieve the targets of the KMGBF. We first summarized the findings of previous workshops that identified high-priority information needs for achieving Canada's biodiversity goals and placed them in the context of the KMGBF. This preexisting information was integrated with the results of an expert elicitation exercise carried out in June 2023 that focused specifically on the KMGBF and asked experts to identify gaps in knowledge and information that will be

needed to monitor and report on Canada's progress towards the 23 KMGBF targets, as well as key gaps in understanding that would allow us to move from knowledge to action on these targets.

The KMGBF is broad in scope, and solutions to the challenges it identified will necessarily draw from a diversity of perspectives. The priorities related to knowledge and science needs referenced in this report could play an important role in achieving the goals and targets of the KMGBF but should be considered alongside perspectives and priorities identified through other lenses.

The expert community identified several key concepts that are central to supporting transformative change to address biodiversity loss. Although many important gaps in our knowledge remain, these key concepts reflect changes in how we should generate and apply biodiversity information to aid conservation under the KMGBF:

- Much of the knowledge needed for biodiversity conservation already exists but we need to be more effective at transforming this knowledge into action;
- Indigenous science, knowledge and perspectives must play a central role in efforts to conserve Canadian biodiversity, with appropriate mechanisms for ensuring data sovereignty;
- There is a need for holistic and integrated approaches to sharing and applying information in support of KMGBF implementation;
- Improved collaboration across and within sectors will benefit biodiversity conservation;
- Developing knowledge gathering or research initiatives with on-the-ground resource users and managers can increase the usefulness of the resulting evidence, and this co-development can lead to better conservation outcomes;
- Broaden the lens through which we understand and approach challenges to conservation through social science and humanities research that focuses on the societal and ethical dimensions of conservation;
- Data need to be well-managed and accessible while respecting Indigenous data sovereignty and protecting sensitive data;
- A better understanding of how to scale biodiversity information across local- to large-scales increases the applicability of existing knowledge and information.

These concepts are woven throughout the target themes and specific science needs identified by the research community. These information needs are summarised by the three themes and 23 targets of the KMGBF, and range from specific gaps in monitoring

for biodiversity of relevance to KMGBF targets, to suggested research priorities for the evaluation of the effectiveness of existing approaches to conservation. Experts noted that addressing information needs may also address long-standing challenges in conservation, such as a better understanding of cumulative effects, as well as better position Canada to address emerging issues such as equitable sharing of genetic resources. Success in conservation means a shift in our collective behaviour towards greater biodiversity protection. For example, there are many conservation-oriented behaviours and practices already employed by traditional and present-day land stewards that can aid these transitions. New methods and approaches to make information about biodiversity and conservation more available, accessible, engaging and meaningful to all users also figured prominently in expert input.

Availability of information also has important implications here; participants in this effort are experts in their respective fields with broad knowledge of published and unpublished information sources. However, in some cases, the priority information needs identified in this report may exist already but be unknown or unavailable to decision makers. Refining the list of information needs presented here, through prioritization and gap analyses, are important next steps to be completed as Canada's plans for implementation of the KMGBF take shape.

Along with a structured prioritization exercise, we suggest several cross-cutting areas of research that could generate new and important information. These recommendations reflect the priorities of the authors, who collectively represent a cross-section of academia, Indigenous scholars, experts housed in non-profit and private for-profit organizations, government agencies and the Office of the Chief Science Advisor of Canada. These preliminary suggestions for areas of research focus include:

- Studies that directly evaluate the effectiveness of current biodiversity management actions, scenario modeling to evaluate proposed alternatives, and other targeted efforts to support science- and evidence-based decision-making;
- Indigenous biodiversity research initiatives that document biodiversity values and develop tools for knowledge communication to better enable the full participation of Indigenous peoples in biodiversity management;
- Enhanced efforts to integrate social science research into conservation by improving our understanding of people's attitudes and behaviours towards biodiversity conservation, and the role of biodiversity in fostering human well-being;
- Increased focus on the many ways that societies and cultures value natural capital and ecosystem services, and how these are represented and reflected in economic structures.

These proposed areas of research could support progress towards the broad goals of the KMGBF. However, as the national plan for KMGBF implementation takes shape, these suggestions and the specific information needs identified in this report should be reviewed collaboratively with implementation plan leaders to refine and prioritize the most pressing needs.

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Introduction

The current loss of biodiversity and the ecosystem services that biodiversity provides is unprecedented in human history (Purvis et al. 2019) and threatens human economies and societies (Dasgupta 2021). More than 30 years have passed since the Rio Earth Summit in 1992, where the first global commitments to reversing biodiversity loss were made, and the Convention on Biological Diversity (CBD) was negotiated. Canada has shown international leadership in its commitment to the CBD, as the first industrialized country to ratify the convention in 1992, and by providing the home to the CBD secretariat since 1996. However, despite ongoing commitment from Canada and countries around the world, halting and reversing the loss of biodiversity and achieving the goals of the CBD has remained elusive.

The five most significant drivers of global biodiversity loss are habitat loss and degradation, direct overexploitation of organisms, climate change, pollution, and invasion of alien species (IPBES 2019). These issues are complex and multi-faceted, underpinned by a wide array of indirect socioeconomic drivers of change. In their landmark 2019 Global Assessment Report of Biodiversity and Ecosystem Services, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) reported that the human-induced loss of global biodiversity is already having severe consequences for human well-being, including increased vulnerability to climate change and decreased food security. However, despite biodiversity's importance, addressing the issues underlying its loss will remain difficult unless there is a significant and lasting change in society's relationship with nature. To halt and eventually reverse biodiversity loss, there needs to be a fundamental shift towards more sustainable practices, a greater recognition of the values of nature in decision-making processes, and an emphasis on living in harmony with nature. In Canada and around the world, the drivers of biodiversity loss are perpetuated in part by exploitative practices associated with colonial paradigms and the resulting inequities caused by these practices. Addressing these issues is also instrumental to this goal of living in harmony with nature.

The Global Biodiversity Framework and its Goals

Canada and the 195 other parties to the CBD have made coordinated efforts for the conservation of global biodiversity since 1992. Most recently, these efforts were guided by the Strategic Plan for Biodiversity 2011-2020, commonly referred to as the "Aichi Targets". In an effort to demonstrate global commitment to the achievement of the targets, the United Nations declared 2011-2020 the "United Nations Decade on Biodiversity" (United Nations 2011). For its part, Canada developed a national

framework to support domestic achievement of these global goals – the 2020 Biodiversity Goals and Targets for Canada (Environment and Climate Change Canada 2016). Canada made some notable achievements during the Decade on Biodiversity, for example by increasing the size of its network of terrestrial and marine protected areas (Environment and Climate Change Canada 2019). However, despite some positive examples of policy change, the global success at achieving the Aichi Targets, and more generally at halting and reversing biodiversity loss, has been disappointing (Xu et al. 2021). The CBD concluded that not a single Aichi Target was fully met at the global scale, although noteworthy progress was made towards achievement of six of the 20 Targets (Convention on Biological Diversity 2020).

The low success in achieving the Aichi Targets has been ascribed to a combination of factors including limited financial resources, weak policy frameworks, and a lack of well-defined goals and indicators (Mace et al. 2018, IPBES 2019, Lin et al. 2021). The KMGBF aims to build on the achievements and learn from the shortcomings of the Aichi Targets, and aligns with the United Nations 2030 Agenda for Sustainable Development (United Nations 2015), in order to achieve its vision of "Humans living in Harmony with Nature by 2050" (Convention on Biological Diversity 2022). By setting more ambitious and well-defined goals, improving the mobilization of resources to achieve the goals, and encouraging greater collaboration among governments, communities and all of civil society, the KMGBF hopes to foster a significant and lasting "transformative change in society's relationship with nature" (IPBES 2019, Convention on Biological Diversity 2022).

The KMGBF is composed of two main parts (Figure 1). First, the framework contains four long-term goals that are to be reached by 2050; these goals encompass the protection and restoration of ecosystems and threatened species, including genetic diversity (Goal A), the sustainable use of biodiversity to restore ecosystem function and benefit current and future generations (Goal B), the sustainable use and equitable sharing of genetic resources (Goal C), and adequate implementation of the GBF through technological and scientific knowledge transfer, financial resources and capacity-building (Goal D). These long-term goals are supported by 23 targets that are to be reached by 2030, organized under three themes: 1) Reducing threats to biodiversity (Targets 1-8), 2) Meeting people's needs through sustainable use and benefit sharing (Targets 9-13), and 3) Tools and solutions for implementation and mainstreaming (Targets 14-23). The goals and targets are interconnected, should be viewed holistically, and each is crucial for success (CBD 2022).

The KMGBF also contains 18 important considerations that are to be understood, acted upon, implemented, reported and evaluated in the progress towards achieving the KMGBF targets and goals. These considerations include recognition of the rights and contributions of Indigenous Peoples, the national circumstances in how each country contributes to the goals and targets of the KMGBF, the importance of gender equality, and equity in the access to and distribution of benefits from biodiversity and its uses. The considerations advocate whole-of-government, whole-of-society, ecosystem and One Health approaches for achieving the targets, and underscore the need for the full implementation of the objectives of the CBD in a balanced manner. Importantly, “the implementation of the Framework should be based on scientific evidence and traditional knowledge and practices” (see Section C of the GBF for the complete list).

Transformative Change through a Reimagined Approach to Conservation

It is widely recognized that to achieve conservation goals nationally and internationally, we need to focus on the "how" rather than the "what" (Cooke et al. 2022). There is broad acknowledgement that biodiversity loss is difficult to solve with established methods (e.g., Sharman and Mlambo 2012). Novel, interdisciplinary and cross-cultural approaches are required, and in particular, approaches that address the socio-political and socio-economic influences that are the "indirect drivers" of biodiversity loss (Chan 2019, 2020). The KMGBF is an attempt to reimagine our approach to conservation (Figure 1) through a transformative change in society's relationship with nature by ensuring a diverse and equitable inclusion of persons and perspectives. Targets 14-23 in particular are focused on the foundations and tools that enable outcomes which implement the necessary societal changes for halting and reversing biodiversity loss; these tools and solutions were a more minor component of the previous Aichi targets.

This emphasis on society's relationship with nature is evident throughout the framework. Three of the four long-term goals of the KMGBF focus on human interactions with biodiversity: 1) goals for sustainable development, 2) equitable sharing of the benefits arising from ecosystem services, and 3) adequate financial resources, equitably shared, for

What is meant by "information and science"?

The term "information and science" is intended to include all forms of knowledge, data, and research. Through consultation with diverse experts, we attempt to present a diversity of perspectives, from various disciplines of western science, to Indigenous knowledges and Indigenous Science. We also recognize that appropriate use of information can vary, from Open Data to Ownership, Control, Access, and Possession (OCAP®) principles to ensuring data sovereignty for Indigenous Peoples (The First Nations Information Governance Centre 2020).

The KMGBF explicitly recognizes that diverse perspectives are necessary for success in biodiversity conservation, and that Indigenous Peoples in particular have an important role to play. Many of the information needs identified here are based on the ideas, beliefs, concepts, and perceptions of Indigenous Peoples; ideas shaped by cultural heritage, traditions, values, and history, and influencing a community's relationship with the surrounding environment (McGregor 2004, Buxton et al. 2021).

These relationships between humans and nature are central to the vision of conservation articulated in the KMGBF. And for Indigenous Peoples in Canada, a key priority is to maintain or re-establish the relationships and uses that have conserved the lands and waters for thousands of years (Indigenous Circle of Experts 2018). The historical and recent conservation successes observed on Indigenous lands are a great testament to the value of Indigenous ways of knowing, and the contributions that Indigenous knowledge systems can make to the implementation of the KMGBF.

global implementation of the framework.

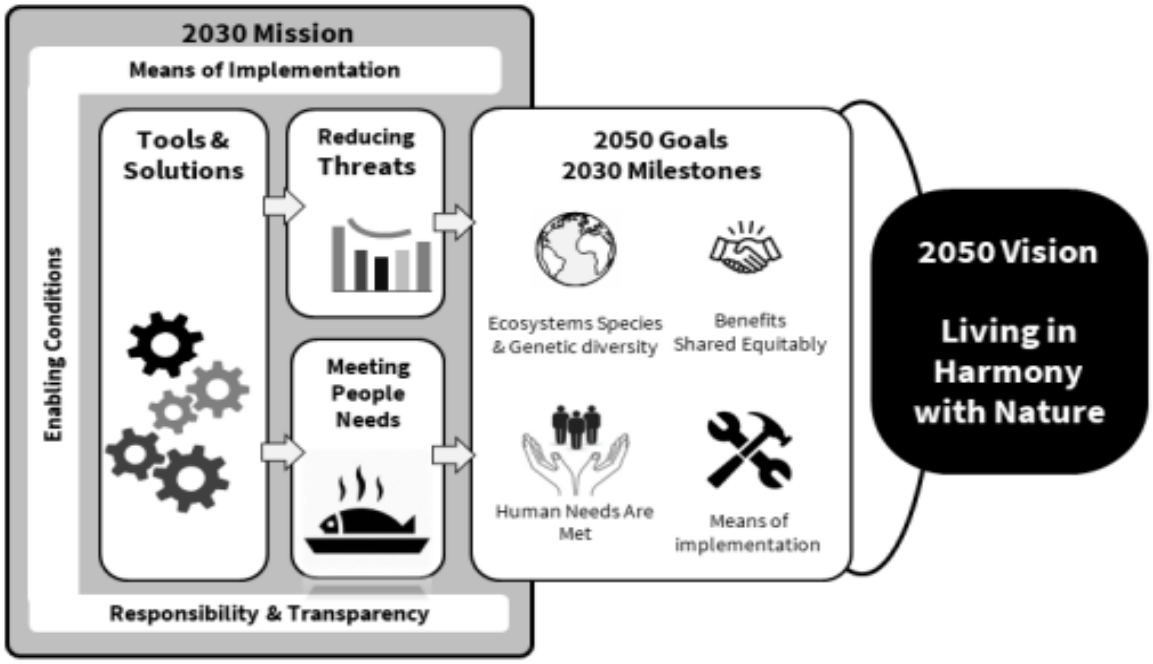

Figure 1. *Theory of change diagram for the "Post-2020 Global Biodiversity Framework", which later became the KMGBF (Convention on Biological Diversity 2020).*

Similarly, the KMGBF places a high emphasis on the involvement of a wide range of rights holders and stakeholders in the decision-making process, particularly Indigenous groups and local communities. This emphasis is featured throughout the targets with some targets focused specifically on ensuring full representation of these groups in the implementation of the framework (e.g. Targets 22 and 23). In Canada, Indigenous Peoples, in particular, have key roles to play in biodiversity actions. Studies clearly show that Indigenous-managed lands and waters contribute in under-appreciated ways to the conservation of biodiversity (Schuster et al. 2019, Frid et al. 2016) and have the potential for substantial additional contributions (Turner & Bitonti 2011, Wulder et al. 2018, Zurba et al. 2019). In Canada, Indigenous-managed lands protect as many or more vertebrate species, and threatened vertebrate species, than conventional protected areas and unprotected areas (Schuster et al. 2019). There are also important lessons to be learned about the biodiversity management approaches used on Indigenous-managed lands and waters, and how these could be applied elsewhere. Among these lessons is the value of Indigenous knowledge systems, which can bring together experiential and experimental lines of thought on topics such as the abundance

of, and threats to, species in decline.

To achieve its broad and ambitious scope, the KMGBF is presented as a vision of “living in harmony with nature” by 2050, with targets for 2030 viewed as milestones on that path (Figure 1). Still, achieving these milestones by 2030 will require urgent action.

Goals of this Report

Our goal for this report is to identify the key concepts, information and science needs, and research opportunities that would strengthen Canada’s ability to achieve the targets of the KMGBF. We built on previous exercises that identified high-priority information needs for achieving Canada’s biodiversity goals by summarizing those needs and placing them in the context of the new framework. We then engaged experts in a series of virtual discussions in late June 2023, designed to elicit information needs relevant to the 23 KMGBF targets, with a focus on information needs that support implementation. Below, we present the results of those summaries and consultations, highlight the overarching concepts that experts consider important to advance knowledge for the successful implementation of the KMGBF, and offer recommendations on specific high-priority science and information-related opportunities that could aid in the implementation of the KMGBF. At the time of writing, some aspects of the KMGBF monitoring framework are still under development. The needs listed here could be further prioritized and refined once the national plan for monitoring progress towards targets is finalized.

Methods

Biodiversity Workshops Drawing on National Experts

A previous effort by ECCC and Carleton University in 2020 engaged experts via a survey and workshop to identify key concepts and science needs that would help move from knowledge to action for biodiversity conservation, and was therefore directly relevant to this current effort (Buxton et al. 2021; hereafter ‘Information Needs Workshop’). This Information Needs Workshop used a three-stage process to identify information needs: an online survey (July-September 2019), an in-person workshop (January 29-30, 2020) and email discussion to refine the outputs of the workshop (February-September 2020) (Figure 2). The online survey was sent to 400 Canadian experts on biodiversity from across a diverse range of fields and organizations. The survey asked experts to identify five information needs that would help overcome obstacles to biodiversity conservation in their area of expertise and to rank these needs based on importance and feasibility. This stage resulted in 276 information needs from

76 survey respondents, with 51% of respondents self-identifying as having predominantly terrestrial expertise and 49% having primarily aquatic (marine and freshwater) expertise.

The survey results and the themes in the 2020 Biodiversity Goals and Targets for Canada (Environment and Climate Change Canada 2016) were used to design the in-person workshop discussion in stage 2. The in-person workshop included 51 expert participants with 38 that conducted research or management in the natural sciences, 7 that focused on social science, and 6 that were policy analysts or managers. Many participants worked across disciplines and at the interface between science, policy and management. Sixteen were affiliated with academic institutions, 22 worked for the federal government, 3 for provincial and territorial governments and 10 for non-governmental organizations. During the in-person workshop, participants were assigned to break-out groups and asked to identify the top 3-5 priority needs, within their respective areas, from the list of information needs identified in the online survey, considering importance and feasibility. A preliminary list of priority needs was then created based on those considered to be most important and feasible. An Indigenous elder led the group in a discussion of ethical space (Ermine 2007), and the group undertook a re-evaluation of priorities. At the workshop, and through subsequent online discussion, this list was then refined to create the final list of the top 50 priority information needs for biodiversity conservation in Canada that was subsequently published in Buxton et al. (2021).

For this new report on the science and knowledge needs for KMGBF implementation, the core authors cross-referenced this list of 50 priority information needs with the four broad goals and 23 specific targets arising from the KMGBF. Some science needs were combined or modified slightly to reflect current priorities. The authors from Buxton et al. (2021) were then invited to review these changes and contributed to the development of this report. The Information Needs Workshop also identified important concepts for how biodiversity information could be generated, communicated and applied more effectively. These key concepts were also reviewed in the context of the KMGBF and included here where relevant.

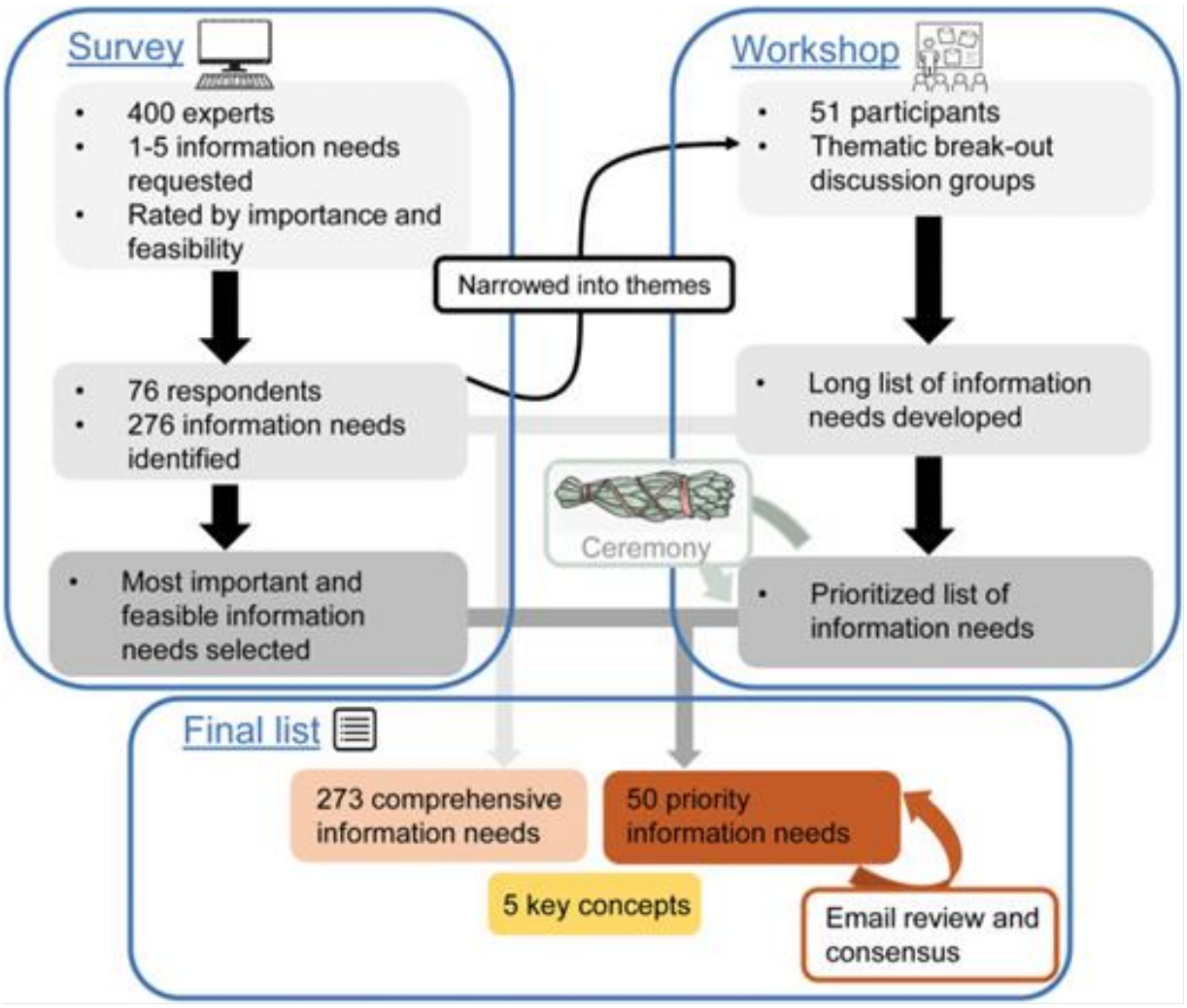

Figure 2. *Overview of the expert elicitation process to identify information needs for biodiversity conservation in Canada (from Buxton et al. 2021).*

Two other biodiversity-related workshops held in 2021 also elicited expert advice on the information needed for successful biodiversity conservation in Canada, and were therefore considered in producing this report. First, Canada's Natural Sciences and Engineering Research Council (NSERC), in collaboration with several federal departments, including ECCC, held a survey and workshop of experts to explore the creation of a Canada Biodiversity Observation Network (CanBON, NSERC 2021). Second, the sustainability non-profit organization Future Earth Canada held a workshop on Biodiversity Pathways for Sustainability in Canada supported by the Social Sciences and Humanities Research Council (SSHRC) (Lin et al. 2021). These two workshops did not specifically identify science and information needs, as in Buxton et al. (2021), and are therefore not explicitly linked to the targets of the KMGBF. However, they did provide useful concepts, suggestions for innovative solutions, and other expert perspectives that supported the development of this report on the science and

knowledge needs for KMGBF implementation.

ECCC Science and Technology Virtual Sessions to Elicit Expert Information (June, 2023)

The focus of the Buxton et al. (2021) Information Needs Workshop was complementary to the objectives of this report. However, because that workshop was carried out in 2020 and because the KMGBF and post-2020 goals have evolved since that time, additional consultation was done to ensure that views specific to the KMGBF were included. Six virtual meetings were held between June 19-29, 2023, to elicit scientific considerations to strengthen the implementation of the KMGBF in Canada. These considerations encompassed western and Indigenous sciences, and natural and social sciences. Participants were identified based on their expertise in each session's theme (Table 1), and were affiliated with federal, provincial and territorial governments (48%), academic institutions (23%), NGOs (13%), Indigenous scholars (11%), international agencies (3%), and industrial (2%) sectors. Sessions were two hours long and limited to approximately 10 expert participants to encourage interactive participation. Several observers were also present in each session to hear participants' ideas directly and follow-up after the meeting for any clarification; these observers were primarily individuals leading the development of the implementation plans for the targets being discussed. At each session, participants discussed 1) scientific information that facilitated design and evaluation of policy options to support progress against the targets, 2) scientific and knowledge considerations that support monitoring and reporting against the targets, and 3) synergies, pitfalls and trade-offs related to actions to meet the targets.

Participants were sent an informed consent form prior to the meeting to explain how information would be used and whether and how their name would be acknowledged. This information was also explained at the start of each session. Due to the need to limit participant numbers in the virtual sessions, a parallel process was held to invite written input on these same topics from subject matter experts unable to participate virtually. Over 70 entries were collected via written input; most were not attributed by name and some experts likely contributed multiple entries.

Table 1. *Themes and associated targets of the six virtual sessions to elicit scientific considerations to strengthen GBF implementation in Canada.*

Theme	**Associated GBF Targets**
Landscape/ Seascape-scale Planning and Conservation	1, 2, 3, 11, 12

Targeted Conservation (Species at Risk, Invasive Species)	4, 6
Biosafety, Digital Sequence Information (DSI)	13, 17
Drivers of Biodiversity Loss: Climate Change, Pollutants	7, 8
Sustainable Use of Nature	5, 9, 10
Mainstreaming, Policy, Tools	14, 15, 16, 18, 21, 22, 23

Assembly of key concepts, science needs and research opportunities to support GBF implementation

Our results focus on three main sections. First, we include a set of key concepts that represent overarching ideas and approaches that experts believe to be important in the acquisition of knowledge and science for the successful implementation of the KMGBF. Second, we present individual science needs grouped by target. Many identified information needs could be associated with more than one KMGBF target and therefore we attempted to identify the most closely associated target, but also note other related targets. Third, we identified a set of opportunities that represent key areas of research which, if enacted, would help address some of the key concepts and collections of related science needs.

We acknowledge that the science needs listed in the tables below may have been addressed to varying extents and that further examination of any need should begin with an assessment of what is already known. We also acknowledge that the indicators for some targets are still under development, so additional science and information might be required to support the assessment of these indicators.

Results

Key Concepts

Several key concepts emerged from the workshops and expert elicitation sessions that are central to support transformative change in our relationship with nature in Canada, and thus the success of the KMGBF. Experts emphasized that substantial information needed for biodiversity conservation in Canada already exists and that much of what

already exists is not being utilized effectively for conservation decisions. These concepts are also evident throughout the needs identified in Tables 2-4. However, because they cut across several targets and themes, they are highlighted below.

We need to transform what we already know into action. Experts emphasized that much of the information needed for biodiversity conservation in Canada already exists but is not being effectively used. Gaps include mobilizing knowledge and tools that allow for the translation of information into action, such as understanding the societal and political barriers that impede biodiversity conservation, the effectiveness of conservation actions in different sectors, and being more judicious about collecting new information when the information in hand already may be sufficient for the need, even if imperfect (Martin et al. 2012, Meek et al. 2015, Buxton et al. 2022).

Indigenous science, knowledge and information must play a central role in efforts to conserve Canadian biodiversity, with appropriate considerations for data sovereignty. We need co-development and co-management with Indigenous Peoples at all stages and improved guidance on methods to allow for multiple ways of knowing to work in parallel to achieve collective biodiversity solutions. Achieving these objectives will require Indigenous leadership to be respected and the co-creation of solutions with Indigenous Peoples to be prioritized (Chapman & Schott 2020). Two key pathways to co-creation were emphasized by workshop participants: 1) ethical space, a partnership model of cooperative spirit between Indigenous Peoples and Western institutions, where space is created for these worldviews to interact (Ermine 2007), and 2) principles such as “Two-Eyed Seeing”, a guiding principle for equitably embracing multiple perspectives, to reconcile the use of Western methodology and theory with Indigenous knowledge systems for the benefit of all (Bartlett et al. 2012). In Canada there has been little progress on operationalizing these different approaches for biodiversity conservation, which makes it more difficult to diverge from the default Western approaches that are typically used. Effective implementation of KMGBF in Canada will require new approaches that allow conservation practitioners and decision-makers to embrace and apply multiple ways of knowing in order to achieve positive conservation outcomes.

The need for holistic and integrated approaches when generating information in support of KMGBF implementation. The KMGBF is structured around a series of 23 targets, but there was considerable agreement among experts that we should move away from an approach to science and knowledge needs identification based on individual targets in favour of an integrated approach that considers those needs for multiple targets simultaneously, as called for in the CBD Decision containing the KMGBF. This focus would further promote knowledge that aids conservation actions

that produce co-benefits for biodiversity and human well-being and is consistent with a broader ecosystem-based approach that considers conservation from the perspective of a functioning ecosystem. For example, Targets 5, 9 and 10 relate to the sustainable use and management of ecological resources for the benefit of biodiversity and people. Although each target has unique aspects, the science and knowledge needs for these targets will frequently be the same and would thus be more effectively considered together. Similarly, Targets 2, 3, 11 and 12 focus on restoration and protection of ecosystems for biodiversity and people; although the target indicators differ, the science needs and conservation actions to achieve these indicators are similar.

Improved collaboration across and within sectors will benefit biodiversity conservation. Many experts noted a need for improved collaboration across sectors (e.g., government, academia, public and private organizations, and civil society), within sectors (e.g., municipal, provincial, and federal governments) and even across departments within the same sector (e.g., Fisheries and Oceans Canada with Environment and Climate Change Canada). An improvement in how we collaborate and communicate information for biodiversity conservation, through formal and informal structures, could aid the implementation of the KMGBF in several ways. First, information held by one group may complement the information held by another, meaning all decision-makers would have broader access to the information needed to make informed decisions (Roux et al. 2008, Young et al. 2014). Second, collaboration can lead to more efficient use of limited resources because different groups share information and will not be 'reinventing the wheel'. Third, and perhaps most importantly, better collaboration can help avoid antagonistic outcomes, such as unanticipated conflicting outcomes from management actions (Wiedemann & Ingold 2022). Examples were raised where interventions to limit invasive species could negatively impact efforts to recover threatened species. Effective collaboration and communication of information may identify options that make progress towards all desired outcomes while avoiding such potential conflicts.

Social science perspectives are necessary to identify ways to address the underlying socioeconomic and political drivers threatening biodiversity. Human relationships with nature are central to the KMGBF, and changing these relationships will be necessary in order to effect positive change for biodiversity (Ives et al. 2018). We therefore need to understand the many indirect drivers of biodiversity loss such as how people connect to nature and how to increase the appreciation of the value of these connections (IPBES 2019). Understanding the political, institutional, societal and economic barriers to more sustainable behaviours and developing improved methods for sharing information on the importance of biodiversity using the full range of knowledge systems are two of many information needs identified in this report that draw

on the social sciences. Addressing human-induced biodiversity loss necessarily means sharing information that helps foster more informed human attitudes and behaviour, leading to broader social and system change (O'Brien 2016, Bennett et al. 2017, Eyster et al. 2022, Naito et al. 2022, Miller et al. 2023).

Data needs to be well-managed and accessible to be actionable. The need for improvements in the availability and accessibility of information, for example through open science practices and FAIR principles (Findability, Accessibility, Interoperability, Repeatability), was repeatedly emphasized in all of the workshops and virtual sessions. Vast quantities of environmental data, relevant for the implementation of the KMGBF in Canada, exist already but are difficult to access (e.g., Jacob et al. 2018, Westwood et al. 2019). Barriers to accessibility (e.g., information existing only in analog format, inability to contact those who collected data, private proprietary interests trumping public interest) make it difficult to determine whether the necessary data exist but are inaccessible, or whether new data must be collected (e.g., Poisot et al. 2019). Eliminating barriers to data accessibility while respecting Indigenous data sovereignty and protecting sensitive data requires better engagement with data holders, open data and open science policies, practices that require data collectors to deposit data in an open access repository (ideally under CC0 creative commons designation), and coordination of information management approaches across institutions, disciplines, and sectors. Better coordination with existing repositories, many located at or affiliated with institutional libraries, would also help bridge the gap between data collection and availability.

Better conservation outcomes result from initiatives and information sharing with on-the-ground resource users, rights holders, stakeholders and other individuals affected by the conservation decisions and outcomes. Conservation decisions can be more effective and accepted when they are made in consultation with local communities, rightsholders, and others affected by conservation decisions, as these are the individuals who are typically most familiar with the state of the ecosystem and most affected by the management actions put in place (Milner-Gulland et al. 2020, Prno et al. 2021). Stronger engagement with local communities in both knowledge co-production and their role in decision-making over resources can help ensure greater support for the conservation actions that are to be implemented (Cooke et al. 2021, Nyboer et al. 2021).

A better understanding of how to scale and transfer information on biodiversity conservation across regions and jurisdictions is needed for more effective coordination. Implementation planning for the KMGBF is being developed at a national scale in Canada; however, most natural resource decisions and conservation work are

carried out at regional or local scales. Different ecoregions in Canada are expected to respond differently to stressors (Rehfeldt et al. 2012), and the stressors, socioeconomic drivers, and legislative frameworks vary across political jurisdictions. Ecosystem services (nature's contributions to people) that are created in one part of Canada (or elsewhere) may be delivered to people in an entirely different jurisdiction (Mitchell et al. 2021). Thus, national-scale conservation strategies may not have equal effects at regional or finer scales, and vice versa (e.g., Ostrom 2009), leading to inconsistencies in top-down versus bottom-up conservation actions. A better understanding of how to scale and transfer information on threats to biodiversity and the effectiveness of conservation actions is therefore needed.

Thematic Information Needs

Reducing Threats to Biodiversity (Targets 1,2,3,4,6,7,8)

KMGBF Targets 1 to 8 focus on actions to reduce threats to biodiversity. These targets address well known threats such as invasive species, climate change and pollutants, and the direct actions needed to protect and restore biodiversity, such as protected area planning and ecosystem restoration. We identified 7 themes and 30 specific information needs that align with these targets (Table 2). Target 5 (sustainable use of wildlife to protect biodiversity) was grouped with Target 9 (sustainable use of wildlife for people), as the information needs for these two targets were closely related (see Table 3).

Experts identified several information needs related to refining the targets or monitoring progress towards them. They noted a need for baseline information on the current distribution of native and invasive species in Canada (per Canadian Endangered Species Conservation Council 2022), the extent of pesticide application, the lethality of pollutants used, and the condition of terrestrial, freshwater and marine ecosystems. Although some new field monitoring and documentation is required to fill these needs, information already exists or could be feasibly collected through the application of new tools, such as advances in remotely sensed technology. Some needs identified will also help to define the target indicators. For example, Target 2 requires that 30% of "degraded" lands are under "effective restoration", and experts noted a need for consistent and repeatable approaches for defining these states. This is a challenging need because of the inherent variability within and across ecosystems (Choi et al. 2008), and because the desired goals of restoration may vary (Jackson & Hobbs 2009).

Making the transition from knowledge to action is a persistent challenge in conservation in Canada and around the world. Experts suggested many information needs to facilitate this transition and set the stage for conservation action. First, there was an

emphasis on evaluating the effectiveness of our conservation actions to identify those that have and have not been successful in halting declines and restoring biodiversity and populations of Species at Risk. In particular we need to identify the factors and circumstances that influence the effectiveness of each action. Experts identified several suites of management actions that should be a priority for evaluation, and in many cases the necessary data to do this exist or can be drawn from examples from outside of Canada. Examples of management actions that could be evaluated using pre-existing information include: 1) the relative success of ecosystem restoration efforts based on direct intervention versus “passive restoration”, where areas are allowed to recover naturally (Target 2, Holl & Aide 2011, Jones et al. 2018), 2) the success of recovery efforts for Species at Risk based on single species, multispecies and integrative ecosystem planning approaches (Target 4, Howell et al. 2021), and 3) how the effects of pollutants on biodiversity can be reduced through nature-based solutions (Target 7, Dudley & Alexander 2017). Whenever possible, meta-analysis of multiple cases where a method has been applied in different circumstances is desirable to guide interpretation and generalize the findings of any single study. Where information does not exist to evaluate actions, approaches such as adaptive management (Walters 1986, Williams & Brown 2014) or experimental studies (e.g. Before-After-Control-Impact studies, Stewart-Oaten & Bence 2001) could be employed to determine the effectiveness of alternative conservation actions. Finally, there is also a need to identify where actions aimed at benefiting one target have the potential to negatively influence progress on another target. For example, experts noted that efforts to reduce the impact of invasive species for Target 6 might negatively impact Species at Risk, compromising progress on Target 4.

For many targets, experts recognized that better inclusion of Indigenous science and practices could lead to more successful implementation of the KMGBF. This need is highly relevant for protected areas planning and Species at Risk recovery. In some countries, Indigenous-managed lands protect as many or more vertebrate species, and threatened vertebrate species, compared to conventional protected areas and unprotected areas (Schuster et al. 2019). There is an opportunity to learn from the stewardship of these lands to improve the management of other Indigenous lands and conventional protected areas. Similarly, there is an opportunity to more effectively braid Indigenous science into the evaluation and recovery processes for Species at Risk (Hill et al. 2019).

Experts noted that decision science has been underused in Canadian biodiversity conservation efforts. Decision science tools and techniques could be extremely useful for evaluating the benefits and costs of alternative management strategies, and to achieve greater transparency in decision processes (Bower et al. 2018, Schwartz et al. 2018). For example, global analyses that include Canada have found that protected

areas planning approaches often fail to prioritize areas of high importance for biodiversity when they overlap with areas of anthropogenic importance (e.g., high agricultural productivity), instead favouring remote areas with a lower risk of conflicting priorities for land use (Watson et al. 2016). Systematic planning tools, in contrast, can incorporate representativeness to ensure that all components of biodiversity are adequately represented and can include other aspects such as beneficial ecosystem services, land cost, connectivity, and risks associated with governance at local, regional and national scales (Target 3, Moilanen et al. 2009, Schuster et al. 2023). The IPBES Values and Valuation Assessment also presents tools which help with the reciprocal task of taking into consideration the values and needs of Indigenous and other minority cultures when designing biodiversity conservation plans (IPBES 2022b). Priority Threat Management is a type of systematic planning tool that can be used to increase the efficiency of Species at Risk recovery, by identifying the cost effectiveness (i.e., benefit per unit cost) of various conservation actions (Target 4, Martin et al. 2018). Another decision support tool, Value of Information analysis, could help managers decide when to proceed with conservation action despite incomplete information versus prioritizing the collection of further research and monitoring data (Bennett et al. 2018). Failure to act in a timely manner to address species declines can have profound consequences, and uncertainty about the best course of action is a common reason for the delays (Martin et al. 2012, Buxton et al. 2022). Decision support tools can help to overcome these uncertainties, clarify the costs and benefits of alternative strategies, and support managers in making effective and efficient decisions.

Modelling alternative scenarios is another means of assessing the possible impacts of different management actions. Experts noted a specific need for modelling of how different policy and management scenarios could influence the spread of invasive species (Target 6), and the need to model various aspects of species' and ecosystems' responses to climate change scenarios (Target 8). Within this theme, information needs related to climate change often pertained to understanding how progress towards KMGBF targets would be impacted under different scenarios for climate change (see also Hellmann et al. 2008, Wilson et al. 2020).The need for a framework to evaluate multiple benefits of conservation action was discussed for several targets, in particular Targets 2-4.

Table 2. Science themes and specific information needs to reduce threats to biodiversity (Targets 1-8), for the implementation of the Kunming-Montreal Global Biodiversity Framework. The science themes relate primarily to a single target, noted with bold font in parentheses. However the set of information needs within each theme will benefit multiple targets and these are noted in regular font within the parentheses. Needs related to sustainable use of wildlife for biodiversity goals (Target 5) were grouped with needs for sustainable use of wildlife for human benefits (Target 9).

Science Theme and Specific Information Need
Ensuring all areas are under integrated biodiversity-inclusive spatial planning (1,14**)**
Research to identify biodiversity hotspots under different criteria (e.g., Species at Risk richness, Indigenous biodiversity values, endemism) in terrestrial, freshwater and marine ecosystems and how these could be incorporated into spatial planning and management in ways that maximize biodiversity representation.
Informing the restoration of degraded lands (2,4,11,12**)**
Examine the necessary and sufficient information to identify a degraded landscape across all biomes (terrestrial, freshwater, marine) and the properties of desired endpoints and biophysical indicators for when a landscape has been restored.
Development of cost-effective, scalable approaches to improve our ability to classify, map and monitor terrestrial ecosystems at multiple scales (local, regional, national), including vegetation, landform, soils, and wildlife habitat components.
Development of cost-effective, scalable approaches to improve our ability to classify, map and monitor freshwater ecosystems at multiple scales, including flows, water quality, species diversity, population trends, substrates, and wildlife habitat components.

Science Theme and Specific Information Need
Development of cost-effective, scalable approaches to improve ability to classify, map and monitor marine ecosystems at multiple scales, including physical and chemical oceanographic features and processes, bathymetry and benthic substrates.
Develop novel science-based procedures and performance measures to assess the outcomes of restoration actions within the context of ecosystem resiliency, land use history and landscape type including comparisons of direct intervention (e.g, tree planting) versus passive restoration. Includes an understanding of how different restoration actions influence particular components of biodiversity (e.g., endemic species, threatened species).
Evaluate the use of language as a tool for monitoring the state of the ecosystem and change over time, as they contain information about ecosystem condition and function.
Spatial planning and effectiveness monitoring for protection of Canadian ecosystems (3,8,12,22**)**
Develop and improve systematic conservation planning approaches to identify and develop protection strategies for key areas on lands and waters (freshwater and marine) that ensure connectivity and the representation of important biodiversity features.
Review the ways in which Indigenous-led land stewardship programs (e.g., Indigenous Guardians Programs, Indigenous Protected and Conserved Areas) have been successful, and identify the unrealized opportunities for land protection and other conservation goals that come through treaties.
Identify how advances in remote sensing technology can be used for improved monitoring of Canada’s species and ecosystems.

Science Theme and Specific Information Need
Examine the magnitudes and distribution of costs across local communities and other affected bodies arising from establishing protected areas to inform the necessary dialogue about their establishment and management.
Examine the status and trends of species across protected areas and in comparison to unprotected areas, to identify their effectiveness in conserving biodiversity depending on factors such as protected area size and location, ecosystem type and land use intensity.
Understand how climate change will influence the effectiveness of current and proposed protected areas and the locations of climate refugia as these will be important sites for protected area planning.
Recovery of declining and threatened species (4,14,20**)**
Review the characteristics of listed species to identify biases in the listing process in relation to factors such as economic importance and data availability.
Assess the intensity of required data collection and feasibility of measurement for target indicators in the assessments of species recovery.
Assess the effectiveness of different conservation actions for Species at Risk in relation to expected benefits, costs and feasibility (e.g. comparison of recovery efforts based on single species, multispecies and integrative ecosystem planning approaches).

Science Theme and Specific Information Need
Review policies, initiatives and management actions among government departments and jurisdictions to identify those that lead to conflicting goals for the conservation of threatened species.
Understand and predict how the impacts of climate change on ecosystems will affect our ability to identify and meet critical habitat designation requirements for Species at Risk.
Identify stressors for Species at Risk, including through cumulative effects, that arise from other conservation strategies (e.g., using pesticides to control invasive species can negatively impact Species at Risk).
Reducing the impacts of invasive species (6,2,3,4,12**)**
Increase our knowledge on the current distribution of invasive species in Canada, the pathways by which they spread, their ability to establish and persist within an ecosystem, and their long-term interactions with other ecosystem components.
Develop scenarios for the spread or reduction of invasive species abundance and distribution under different scenarios for climate change, and examine the performance of alternative policies for each scenario.
Improve understanding of the mechanisms through which invasive species affect native species and ecosystem integrity.
Identify the potential logistical and legislative barriers that might prevent action on the management of invasive species.
Reducing the impacts of pollutants (7,2,3,4**)**

Science Theme and Specific Information Need
Assess how pesticides are being used in different regions and ecosystems.
Examine the lethal and sub-lethal effects of pesticides and pollutants on biodiversity in order to provide information to develop guidelines and management options for pesticide and pollutant application.
Examine how nature-based solutions could alter and reduce the use and impacts of pesticides.
Planning for climate change impacts on biodiversity (8,10**)**
Model projected ecosystem changes as a result of climate change to understand the future status of species and ecosystems.
Project spatially explicit short- and long-term species and ecosystem responses to climate and land-use change under a range of future scenarios to identify potential climate refugia and areas important for climate connectivity.
Identify how to most effectively take advantage of the carbon storage potential of natural ecosystems, and carbon offsets, to benefit biodiversity conservation while mitigating climate change, and assess the implications of prioritizing carbon capture storage in those areas/ecosystems for other uses of the areas.
Understand the different responses of biodiversity to stresses imposed by mean changes in climate (e.g., rising average seasonal temperatures or precipitation) versus extreme events (e.g., heat waves, droughts, category 4 and 5 hurricanes).

Meeting people's needs through sustainable use and benefit sharing (Targets 5, 8, 9, 10, 11, 12, 13, 21)

Sustainable Use of Wildlife (Targets 5,9,10)

The direct exploitation of species by humans is the most important or second most important driver of biodiversity loss across marine, freshwater and terrestrial biomes (IPBES 2019). Human use of wild species therefore figures prominently in the KMGBF. Targets 5, 9 and 10 focus on actions to ensure the sustainable use of wildlife, as a means of both reducing threats to biodiversity and of meeting people's needs through sustainable use and benefit-sharing. Target 5 focuses on the sustainable[1], safe, and legal, use, harvest and trade of wild species[2]. The target highlights a diverse set of goals, including preventing overexploitation, minimizing impacts on non-target species and ecosystems, and reducing the risk of pathogen spillover (e.g., in agricultural practices). It further suggests that this target can be achieved by focusing conservation actions from a whole ecosystem perspective, while respecting and protecting customary sustainable use by Indigenous Peoples and local communities.

Target 9 prioritizes sustainable management of the wild species whose harvest is intimately linked with people in vulnerable situations, and those directly dependent on use or harvest of wild species. Target 10 expands on the actions that may be taken to achieve sustainable management, including a suite of management practices and other innovative approaches for key productive sectors. Expected outcomes are the resilience and long-term efficiency and productivity of these production systems, including their ecosystem functions and services.

These targets have direct links to other targets, including Target 8, which aims to minimize the impact of climate change and ocean acidification on biodiversity through management actions. Ocean warming has already led to reduced fisheries catches in

[1] *Sustainable use* is defined by the Convention on Biological Diversity (United Nations, 1992) as "the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations.". The IPBES Sustainable Use Assessment reviewed current conceptualizations of sustainable use in global and national legislation, scientific literature and cultures, and noted that sustainable use must be evaluated on seven factors – status of the resource being used, impacts of the harvest of that species on other components of the ecosystem, impacts of the methods of use on habitats, revenue generated, employment created, well-being of dependent communities and cultures, and equity. Not all dimensions may be relevant in individual cases, but a use must be sustainable on ALL relevant dimensions. (IPBES 2022a)

[2] *Wild species* refers to populations of any species that have not been domesticated through multigenerational selection for particular traits, and which can survive without human intervention. This does not imply a complete absence of human management and recognizes various intermediate states between wild and domesticated. This assessment excludes feral and introduced populations. (IPBES/9/6)

some areas, with negative consequences for Indigenous Peoples and communities, although in some areas, there has been an expansion of suitable habitat and concomitant increases in the abundance of some species (IPCC 2022). In inland systems, climate change has impacted vegetation and wild species such as reindeer and salmon, compromising food and water security and disrupting access to, and food availability within, herding, hunting, fishing, and gathering areas (IPCC 2022). Such changes are harming the livelihoods and cultural identity of Arctic peoples. There are also links to Target 21, which instills practices of transparent and equitable sharing of data, information and knowledge to all stakeholders, and recognizes the importance of free, prior and informed consent, particularly with respect to Indigenous Peoples and local communities, and to Target 22 which includes inclusive decision-making processes for access and uses of biodiversity and respect for cultures and livelihoods dependent of uses of Nature.

Information needs related to these targets appear in Table 3, and include needs for the development of effective indicators, enhanced monitoring of indicators, and targeted research to facilitate action. Recurring themes include: the importance of Indigenous, local community and social science perspectives, the inadequacy of harvest information for some species, the uncertainties that climate change introduces into harvest management, and our current inability to adequately manage cumulative effects. These key themes are discussed below.

A focus of the considerations for Targets 5, 9 and 10 was the importance of developing new methodologies and pathways for incorporating social science, local, and Indigenous science into decision making (Sellheim & Ojanperä 2022). This focus aligns with the *Key Concept*, described above, that Indigenous knowledge systems must play a central role in Canada's conservation efforts. There is also a need to recognize a diversity of decision-makers (e.g., Indigenous youth; Sellheim & Ojanperà 2022). The wealth of information held by traditional knowledge holders and people living close to the land is invaluable but this information can only be used while respecting all communities and cultures, and especially Indigenous self governance and the needs of Indigenous communities, as the desired outcomes of conservation can have direct relevance to the livelihoods, food security and cultural identity of Indigenous Peoples and local communities. There is a need to consider the different ways in which Indigenous and non-Indigenous cultures view relationships with the natural world and how that influences perspectives on sustainability (Table 3). These perspectives can differ from current paradigms of "biodiversity is good" and lead to complex negotiations in decision making. For example, Indigenous Elders in the Coast Salish nation do not think about the *right* to hunt, but the *responsibility* to maintain a relationship with wildlife and that includes harvesting and consuming (E. Enns, pers. comm.). Currently, knowledge held by people living in the landscape is not well used or communicated

(IPBES/9/14/Add.1). There is a need for more use of methods that capture socio-cultural trends that are ‘recorded’ by observations and expressed in narratives.

A key requirement for determining sustainable harvest levels is to co-develop models for scenario testing of how different policies, actions and economic conditions can influence sustainable management of wild species and ecosystems (Table 3). Consideration of traditional harvest calendars may also provide insight into optimal harvest strategies (IPBES 2022) and how these are shifting with climate change (Charlie et al. 2022). In the context of sustainable harvest regulations, it is essential that decision makers have all of the information on harvest levels, including Indigenous harvest and harvest by local communities. There was a perception that this information is not currently shared consistently, and that special protocols may be needed to allow decision makers and assessment scientists access critical knowledge, including data, needed for sustainable management. To do that we also need to know how to archive and make available information and data on harvest from Indigenous and non-Indigenous users in ways that allow for effective decision making while respecting data sovereignty and ensuring the data are not misused (Table 3). For example, for First Nations communities and organizations, approaches to manage and make decisions regarding who can access their collective information (data sovereignty) are outlined in the OCAP principle (Ownership, Control, Access and Possession; FNIGC 2020). One avenue for requests for information is through the First Nations Information and Governance Centre (https://fnigc.ca). More broadly, data-sharing may be facilitated through the creation of an environment of trust and reciprocity that allows such information and data to be used.

The issue of climate change is pervasive, and as noted by IPBES, “the world is dynamic and to remain sustainable, use of wild species requires constant negotiation and adaptive management. It also requires a common vision of sustainable use and transformative change in the human-nature relationship” (IPBES/9/14/Add.1). Sustainable harvest rules need to be tested against future scenarios; both for situations where the environment may not be able to maintain its current levels of productivity, and ones where productivity may be increased by climate change and harvests are over-stringently constrained by regulations developed for less productive conditions. As a high priority, there is a need to identify where historically effective management of wildlife and ecosystems is no longer sustainable because of the added stress from climate-change related impacts (Table 3). The need to develop models for scenario testing was highlighted and research into how to scale the models is a high priority (e.g., how to connect landscape scales obtained through remote sensing with sampling at small scales in a relevant way). It was recognized that not only will the distributions, migrations and population dynamics of wild species change, but human land- and sea dependencies and uses will also change, creating different pressure points impacting

the species. Virtual models of different management options were seen as a means to communicate the impacts of different scenarios to decision makers and stakeholders using a data-driven approach. Likewise, Indigenous and local cultures may contain knowledge and practices that may be valuable in addressing future challenges from climate change, and Target 8 and 9 together highlight how the protection of cultural diversity in relationships with Nature is also valuable for meeting the challenges of the future. There is also a need to develop innovative and efficient approaches to expand the monitoring of non-commercial aquatic species or commercial species outside of their harvested range in order to predict changes in distribution and ecosystem effects (Table 3). This could involve greater engagement with citizen and community science, which have not yet been widely applied in conservation and management in Canada, but have great potential.

Cumulative effects of human activities on biodiversity are complex and difficult to measure. New scientific knowledge and information and ways to combine this knowledge and information with the knowledge of Indigenous Peoples and local communities, whose narrative knowledge may span far longer time periods than scientific databases, are needed, in order to enable the necessary managerial reforms. Specific knowledge of the impacts of multiple stressors on key wildlife species (identified from Target 9) is urgently needed as the foundation for application of an ecosystem approach. Improved methods are needed for evaluating low impact activities in light of the number of other low impact activities in the affected area, which may collectively have a high impact on the ecosystem. Increased knowledge of stressor-response relationships and how multiple stressors (e.g., industrial development, agricultural expansion) interact with natural processes across space and time is needed to support decisions on managing cumulative environmental effects, and to overcome barriers in applying existing evidence (Table 3).

There is an urgent need to evaluate the effectiveness of beneficial management practices for biodiversity in fisheries, agriculture, forestry, and other sectors through a combination of systematic reviews, experimental studies and adaptive management (Table 3; Buxton et al. 2022), including consideration of social dimensions that can influence compliance and attitudes towards conservation. There is also a need to refine evidence-based guidance for precautionary approaches. For harvest control rules in the fisheries sector, for example, the IPCC Climate Change 2022: Impacts, Adaptation and Vulnerability report (IPCC 2022) recommended “strengthening precautionary approaches, such as rebuilding overexploited or depleted fisheries, and responsiveness of existing fisheries management strategies” to mitigate the negative climate change impacts on fisheries, but recognized there is a limited ability to address ecosystem change.

Although many policies around biodiversity and climate change operate synergistically, tradeoffs appear to arise between biodiversity protection and poverty, food security and community well-being, particularly in a system where access and benefit sharing is inequitable and theer is a lack of commitment to policies that reduce vulnerabilities. Developing practices that build trust with resource users will be essential (Buxton et al. 2022). Research into how to address this issue is urgently needed to fully consider Target 5, pertaining to respecting and "protecting customary sustainable use by Indigenous Peoples and local communities".

Enhancing Nature's Contributions to People, Integrating Biodiversity and Human Health in Urban Environments, and Fair and Equitable Sharing of Genetic Resources (Targets 11, 12, 13)

Targets 11, 12 and 13 focus on enhancing nature's contribution to people by improving the goods and services that nature provides, and by ensuring equitable sharing of benefits that arise from the utilization of genetic resources and from associated digital sequence information (DSI). Target 11 lays out the objectives of restoring, maintaining and enhancing nature's contributions to people, providing examples of some ecosystem services to consider (air quality, soil health, clean water), and suggesting means to achieve the desired outcomes (nature-based solutions and/or ecosystem-based approaches). Target 12 focuses on urban green and blue spaces as promising pathways towards biodiversity conservation in cities, which support the physical and mental health of residents and can heighten biodiversity awareness in densely populated areas (IPBES 2022). Urban gathering of wild species may also increase food security and help to maintain cultural identity (IPBES 2022).

Fulfillment of these targets requires research that explores how actions, such as nature-based solutions, deliver benefits for both ecosystem health and people's quality of life (IPBES 2022). This aligns with the need to identify targets that allow us to jointly monitor biodiversity and human well being from a *One Health*[3] perspective (Zinsstag et al. 2015), rather than considering them as separate classes of indicators (Table 3). The expert consultations also recommended developing engineering standards and urban planning guidelines that promote urban biodiversity and reflect the need for green and blue spaces in urban areas (Table 3). In doing this, there is a need to evaluate potential synergies and/or conflicts between biodiversity conservation and ecosystem services in conservation planning (Table 3; Kremer et al. 2016, Ziter 2016). Given the rich diversity of people in cities, diverse perspectives must be essential elements of biodiversity conservation in urban areas, where lenses like social justice and anti-racism are used

[3] 'One Health' is an integrated, unifying approach to balance and optimize the health of people, animals and the environment. World Health Organization (https://www.who.int/teams/one-health-initiative)

when undertaking urban environmental research (Buxton et al. *in review*).

Target 13 addresses the need for fair and equitable access and sharing of benefits that arise from the utilization of genetic resources and from digital sequence information (DSI) on genetic resources, as well as traditional knowledge associated with genetic resources. This target reflects the third pillar of the CBD Convention itself, augmented by the CBD COP 15. Goal C of the KMGBF called for equitable sharing of the benefits from use of DSI, and envisaged an important role for Indigenous Peoples and communities in using the resources generated by the establishment of a multilateral mechanism, including global funding, to support conservation and sustainable use of biodiversity. DSI decisions are also informed by other international fora, such as the Food and Agriculture Organization of the United Nations (FAO) International Treaty of Plant Genetic Resources for Food and Agriculture. Complicating this issue are unresolved territorial claims, where we need to better understand how to resolve disputes over ownership related to ancestral land.

An important issue in developing a framework for fair and equitable access and benefit-sharing is finding the balance between sharing (open access) and protecting the rights of those involved and those affected, even if they are unaware of the research and benefits. Creation of an asset map to inventory and assess genetic resources for Canada could facilitate decision making for benefit sharing (Table 3). This has been done in other countries, such as in the European Union where an asset map for genetic resources of plants and animals used in agriculture has been created, https://www.geneticresources.eu/map/), and those case studies can be used to guide efforts in Canada. Commercial enterprises may have an important role to play in developing mechanisms for benefit sharing and capacity building, to allow full and equitable participation in accessing genetic resources and developing commercial products. In some cases, data rescue efforts may be required if companies have gone out of business (Table 3). Reporting on sources of DSI by Canadian science publications and funding agencies could provide data for monitoring progress. The experts endorsed the use of Local Contexts Traditional Knowledge (TK) and Biocultural (BC) Labels and Notices (https://localcontexts.org/). These are a mechanism for establishing equality and equity, by embedding information about Indigenous rights and interests within digital infrastructures, such as metadata.

Table 3. Science themes and specific information needs to meet people's needs through sustainable use and benefit sharing (Targets 5, 9-13) for the implementation of the Kunming-Montreal Global Biodiversity Framework.

Science Theme and Specific Information Need
Sustainable use of wildlife and biodiversity across sectors (5,9,10,8,21**)**
Identify metrics best reflect species composition, ecosystem well being, and Indigenous and other community values across various ecosystem and land and water uses.
Develop and apply new tools, such as eDNA, to monitor difficult to detect species, species in remote regions (especially Species at Risk) and commercial species outside of their harvested range. eDNA could also be integrated with other tools that provide information across broad areas (e.g., community science, museum collections, ad-hoc datasets) to increase knowledge for these species and regions.
Evaluate the effectiveness of beneficial management practices for biodiversity in agriculture, forestry, fisheries, energy and other sectors through a combination of systematic reviews, experimental studies and adaptive management.
Increase knowledge of stressor-response relationships and how multiple stressors (e.g., industrial development, agricultural expansion) interact with natural processes across space and time to support decisions on managing cumulative environmental effects.
Identify how agricultural intensification versus extensification, crop type, agricultural land use, and rotation affect biodiversity.
Explore how the concept of intensification applies to other uses of biodiversity, including forestry and fishing, where plantation forests and aquaculture produce an increasing proportion of forest and fish products in commerce.

Science Theme and Specific Information Need
Develop models for scenario testing of how different policies, actions and economic conditions can influence sustainable management of wildlife, fish populations and ecosystems.
Identify cases where historically effective management of wildlife, fisheries and ecosystems is no longer sustainable because of the added stress from climate change-related impacts.
Increase understanding of the diverse and different ways in which Indigenous and non-Indigenous cultures view relationships with the natural world and how that influences perspectives on sustainability.
Develop approaches for the storage and availability of data on harvest from Indigenous and non-Indigenous users in a way that informs effective decision making while respecting data sovereignty and ensuring the data are not misused.
Enhancing nature's contribution to people (11,12)
Increase understanding of how the diverse values of biodiversity and ecosystem services can be effectively assessed, interrelated and integrated into all aspects of decision making.
Explore and characterize potential synergies and/or conflicting tensions between planning for ecosystem services and biodiversity conservation, including consideration of the cost of inaction.
Identify the knowledge gaps and opportunities for nature-based solutions to aid in mitigation and adaptation to climate change.
Integrating biodiversity and human health in urban environments (11,12,2,3**)**

Science Theme and Specific Information Need
Identify indicators and benchmarks that are effective for the joint monitoring of biodiversity and human well being from a One Health perspective.
Improve understanding of how to integrate ecological needs and biodiversity protection into engineering standards and municipal planning including the allocation of protected areas and other green and blue spaces in urban environments.
Identify new approaches that conserve and restore connected networks of ecosystems for key urban biodiversity, in ways that are compatible with urban planning needs and climate change adaptation.
Fair and equitable sharing of benefits from genetic resources (13,21)
Develop an asset map that inventories and assesses genetic resources for Canada, guided by similar efforts completed for other countries.
Identify how improvements in open science across all sectors (e.g., government, academia, private) can help foster the sharing of knowledge regarding genetic resources and the benefits derived from that knowledge. Includes an exploration of where data rescue can be used to restore lost genetic resources (e.g., private companies that are no longer operational) and include those in standardized open source data banks.

Tools and solutions for implementation and mainstreaming (Targets 14,15,16,17,18,19,20,21,22,23)

KMGBF Targets 14 to 23 focus on tools and solutions to implement and mainstream the framework and are integral to the objective of a transformational change in society's relationship with nature. These tools and solutions include broader integration of biodiversity considerations into regulations and planning, changing perceptions of the value of biodiversity, phasing out harmful subsidies, improving education, data access and knowledge transfer, ensuring representation and full participation in decision making by Indigenous Peoples and local communities, and ensuring a diverse and equitable inclusion of persons and perspectives. We identified 7 themes and 30 specific information needs to inform the targets, or aid in their implementation (Table 4). These information needs relate directly to Targets 14 to 21. The concepts related to equality, equity, diversity and inclusion that are the focus of Targets 22 and 23 are captured in the key concepts and information needs presented throughout this report.

Greater use of social science for biodiversity conservation was emphasized as a high priority by the experts and has been noted elsewhere (Bennett et al. 2017, Miller et al. 2023). Multiple specific information needs focused on what changes to individual perspectives could aid more positive attitudes towards biodiversity. It was recommended that more effective approaches to share information will help inform people of the impacts of their actions, incentives/disincentives that guide the adoption of conservation-oriented behaviours, and improve perceptions of biodiversity's value. It is important to recognize that education should flow in both directions; for example, we need to better understand people's perceptions and valuations of biodiversity, especially non-monetary cultural, recreational and aesthetic values. These education and communication approaches should draw from all knowledge sources: Western science, Indigenous science and knowledge from local communities. Using all sources will be important in achieving transformative societal change. Finally, there is an important need to identify the major types of malinformation, disinformation and misinformation pertaining to critical elements of biodiversity conservation and how to overcome problems of malinformation, disinformation and misinformation, to ensure that people receive accurate information.

The KMGBF targets recognize the importance of engagement with the business community and place a much stronger emphasis on the role of business compared to the previous Aichi targets, particularly within Targets 14 and 15. Several science needs were identified in order to achieve this multi-sectoral collaboration, including reviewing

the positive and negative, direct and indirect, ways in which businesses influence conservation, increased sharing of information about business activities to more easily identify their net outcomes on biodiversity after considering positive and negative impacts, and identifying the effectiveness of different laws and regulations in promoting compliance on activities that can impact biodiversity. The experts highlighted the need to establish a system to clarify definitions, concepts and methods for biodiversity monitoring and reporting in these contexts, and for measuring impacts on society. Two examples highlighted included the UN's System of Environmental Economic Accounting (SEEA) (Ecosystem Accounting | System of Environmental Economic Accounting) and the Ontario Biodiversity Council's reporting portal on the State of Ontario's Biodiversity (https://sobr.ca/). Recognizing the importance of biodiversity for balance sheets, financial institutions, international governments and other stakeholders have organized the Taskforce on Nature-related Financial Disclosures (TNFD), an effort to mainstream the assessment and reporting of nature-related risks and shift global financial flows away from nature-negative outcomes and toward nature-positive outcomes (Taskforce on Nature-related Financial Disclosures 2023). Given its global scale and strong engagement from the private sector, the TNFD merits additional research attention as a potential source of relevant new biodiversity information.

Whether from the private-sector or other sources, the need for enhanced and sustained financing for conservation is more strongly emphasized in the new KMGBF targets compared to the previous Aichi Targets, and is the central focus of Target 19. Experts noted that we could look to other sectors and jurisdictions to identify alternative mechanisms that could be employed to finance the conservation of biodiversity in Canada. For example, research could explore the possibility of user fees for nature-related recreational activities (as used in hunting and fishing), or voluntary private-land stewardship initiatives through reverse auctions (e.g., Golet et al. 2018). Target 19 is broad and also includes consideration of other non-market based approaches that would achieve similar outcomes to protect land. For example, experts noted a need to improve our understanding of how people and businesses value ecosystem goods and services from multiple perspectives (e.g. economic, ecological, social, cultural, ethical), as this could facilitate actions to protect natural areas and the goods and services that they provide.

Many of the high priority species in decline in Canada are migratory, and species' use of different areas throughout the year can greatly increase the diversity of threats that they face (Wilcove & Wikelski 2008). This includes iconic species like caribou and migratory birds, and in some cases, economically important species such as Pacific salmon, whose conservation is complex because of the need to share information and coordinate management actions across domestic and international borders (Festa-Bianchet et al 2011, Cowan Jr. et al. 2012, Hobson & Wilson 2020). Target 20

emphasizes the need for increased capacity building, technology transfer and scientific cooperation among South-North, North-South and triangular collaborations for biodiversity conservation. Information needs related to these collaborations included the identification of threats to species across jurisdictions, understanding where there is policy conflict among jurisdictions that can hamper conservation action and how to better share information and coordinate conservation actions internationally, while recognizing the distinct limitations within jurisdictions.

The need for improvements in open science and data sharing is the foundation of Target 21. However, the importance of openly sharing data and information was emphasized by experts in all sessions and is well recognized as a priority by the conservation community (e.g., Sunderland et al. 2009, Fuller et al. 2014, Turner et al. 2015). It was noted that in many cases, the data that we need for implementing many of the KMGBF targets already exists but is unavailable to the relevant users. Two specific needs were highlighted: 1) the development of standards to increase the sharing of environmental data among jurisdictions and ensure that decision makers are able to access information, 2) policy improvements in all sectors to increase open sharing of data and information, while recognizing the importance of data sovereignty.

Table 4. Science themes and specific information needs for tools and solutions for implementation and mainstreaming of the Kunming-Montreal Global Biodiversity Framework (Targets 14-23).

Science Theme and Specific Information Need
Measures to encourage businesses to engage in sustainability and biodiversity conservation (14,15,16**)**
Identify standardized indicators and benchmarks of sustainability, against which to evaluate actions like management practices and land/sea conservation.
Identify information on business activities needed to develop relevant metrics of the net outcome of businesses on biodiversity, after taking into account the magnitude and distribution of impacts and gains, and the costs of mitigation.
Review and provide information on the ways in which businesses, ranging from small enterprises to corporations, affect biodiversity in positive and negative ways and knowledge-based scenarios where biodiversity losses can be halted and reversed.
Gather and analyse information indicative of different motivations through which businesses engage in biodiversity conservation (regulations, operational incentives, financial incentives, reputation) to identify new pathways to engage businesses in conservation.
Improve our understanding of how conservation-related laws, bylaws and other regulations are implemented and enforced to identify those that are most effective for biodiversity protection and sustainability.
Improving perceptions of the diverse values of biodiversity (16,19,22,23**)**

Science Theme and Specific Information Need
Improve our understanding of how people value biodiversity, especially the non-monetary cultural, recreational and aesthetic values they place on biodiversity building on the IPBES Values and Valuation Assessment (IPBES 2022).
Synthesize information on beneficial practices of non-governmental actors who want to support biodiversity conservation, and the extent to which these are enabled or impeded by societal structures.
Evaluate how languages and approaches vary in their effectiveness in communicating the importance of biodiversity, to enhance the success of biodiversity policies and stewardship activities.
Identify educational opportunities and other strategies to inform people of the impacts of their behaviours, as many may be willing to adjust behaviour but are not aware of their impacts to biodiversity or the human community (e.g. greenhouse gas emissions, use of pollutants, free roaming domestic cats, overconsumption).
Identify approaches to communicate ecosystem services that may enhance uptake of co-beneficial management practices and actions that promote biodiversity, particularly in an agricultural context.
Identify major types of mal/dis/misinformation (MDM) pertaining to critical elements of biodiversity conservation, including threat mitigation, habitat protection and conservation, ecosystem restoration and species recovery.
Identify the sources of mal/dis/misinformation (MDM) and review techniques that are effective in reducing them.
Implementing and strengthening biosafety measures (17, 21**)**
Identify the benefits and costs of all Canadian biotechnology products within environmental, social and moral realms.

Science Theme and Specific Information Need
Identify where improvements in open science can help with the rapid transmission of knowledge on the benefits and risks of biotechnology.
Review international agreements for biotechnology regulation, and cross-reference these with Canada's approach to identify areas of divergence.
Identifying and reforming incentives and subsidies harmful for biodiversity (18,2,4,10,14**)**
Comprehensive review of subsidies in all sectors (Agriculture, Forestry, Fisheries, Energy, Mining) to identify their respective impact on biodiversity in Canada.
Review subsidy reform efforts in other countries, as these may provide important lessons on successes and failures elsewhere that can be applied to subsidy reform in Canada.
Ensuring financial support for biodiversity conservation (19)
Develop the knowledge needed to inform biodiversity or biocultural-related certifications, or certified frameworks for payments for ecosystem services, by evaluating potential indicators and data needs.
Evaluate the outcomes of offset policies to identify the ecological and socio-economic factors that affect their success, and research to identify new biodiversity offsetting approaches that are efficient and credible.
Evaluate the potential for alternative "user pay" systems in recreational sectors, similar to those associated with hunting and fishing licensing, as these may provide support for habitat management and other conservation programs.

Science Theme and Specific Information Need
Better understand the importance of species and ecosystem services to people and different stakeholders and rightsholders, relative to other goods and interests, and what influences their importance.
Evaluate programs in other countries that provide financial support to remove environmentally sensitive lands from production, and determine whether similar programs might succeed in Canada.
Improved conservation planning across national and international jurisdictions (20,4,21**)**
Determine potential for better synergies among jurisdictions within Canada and internationally for the protection of Canadian wildlife, especially migratory species.
Develop mechanisms to better synthesize and share information across jurisdictions.
Identify how to best coordinate management efforts for species whose ranges cross borders while recognizing distinct needs and constraints operating within jurisdictions.
Identify conflicting policies across jurisdictions that may be simultaneously aiding and hindering the recovery of Species at Risk.
Improved information sharing for decision making (21)
Identify approaches that will increase the sharing of environmental data among jurisdictions and actors to ensure that key information needed for biodiversity conservation is available to decision makers.

Science Theme and Specific Information Need
Improve understanding of how to balance the need for additional research and monitoring with the need to act, including an assessment of the risks of inaction in comparison to the risks of acting given uncertainty.
Identify open access policies that increase the sharing of information but respect the need for data sovereignty and access and benefit sharing.
Review approaches on how science informs decision making both within and outside Canada to identify how we can more effectively transfer information on biodiversity conservation to upper levels of decision making (e.g., ministerial) in a more efficient and timely manner.

Areas of Research to Enable Transformative Action

Biodiversity conservation is complex and multifaceted, as demonstrated by the diversity of information needs listed above. This complexity presents both challenges and opportunities. Each of the information needs listed above could individually contribute to success under various targets, but exploring each need individually would require substantial time and resources. Some of the needs identified above are more cross-cutting than others, and collaborative, interdisciplinary approaches to explore these cross-cutting information needs could allow us to make more rapid progress on multiple targets. Below, we highlight areas of research focus that would address several of the key concepts and science needs in this report, and potentially aid in achieving the transformative change advocated by the KMGBF.

These proposed areas of focus reflect the priorities of the authors, who collectively represent academia, government science, Indigenous scholars, researchers with non-profit organizations, and Canada's Office of the Chief Science Advisor. As the national implementation plan takes shape, these areas of focus, along with the specific information needs, should be reviewed, refined and prioritized in collaboration with policy-makers and KMGBF implementation partners.

Targeted research to evaluate the effectiveness of current management actions and policies in supporting the conservation of biodiversity. Historically, nature assessments have focused on biodiversity status and trends. However, if we are to make new progress at halting and reversing the declines in biodiversity, we need to carefully evaluate our current approaches. A large number of the information needs above relate to this theme. Predicting the future response of biodiversity to real or proposed changes in policy or management actions is even more difficult, requires interdisciplinary study, and remains a challenging frontier in conservation biology. Targeted research to address these knowledge gaps, through syntheses of existing information and the use of adaptive management or natural experiments, could help us to provide the information needed for evidence-based approaches to decision making and policy development. Research themes for consideration include 1) evaluating the success of different approaches (e.g., single vs. multi-species) for the recovery of Species at Risk and identifying socioeconomic barriers to recovery, 2) scenario modeling to evaluate how alternative management actions and policies are expected to influence biodiversity loss, including under different scenarios for climate change, 3) evaluating the benefits and costs of alternative beneficial management practices and how these outcomes differ among sectors and ecosystem types, 4) testing the feasibility and success of alternative methods for restoration of degraded landscapes.

Using Social Science to mobilize a change in people's understanding of, attitudes

and behaviours towards biodiversity and conservation. Humans' relationship with nature and their view of their place in the environment are central to the goals of KMGBF, and understanding the human dimensions of conservation issues is necessary to address the underlying causes of biodiversity loss. The importance of incorporating social sciences into biodiversity conservation is widely recognized by both natural and social scientists (e.g. Bennett et al. 2017); however, achieving this integration across disciplines remains a challenge. Nevertheless, there are important research opportunities where the two disciplines could work together to enable change in society's relationship with nature. For example, key topics include 1) research with community engagement specialists to understand barriers to action on conservation in local communities; 2) working with marketers to understand how to craft messaging to mainstream biodiversity conservation in different types of media; 3) working with educators to identify different approaches for informing people of how their actions impact biodiversity and identify what messaging best promotes a change in behaviour; 4) research to examine how conservation actions for biodiversity interact with and influence people's perceptions and values of nature/biodiversity with a goal of identifying positive feedback loops where conservation actions lead to values changes that reinforce each other; 5) how to better reflect equity and promote participatory processes, and address biases that can hamper progress; 6) how to use knowledge co-production and arts-based approaches to better understand issues of biodiversity loss and conservation.

Advance Indigenous Science through Indigenous Biodiversity Research Initiatives*.* The full participation of Indigenous Peoples in conservation is a national priority and required for the success of the KMGBF. Several information needs would aid this initiative and could be a focus of new research collaborations including: 1) a comprehensive review of the values of biodiversity (utilitarian, monetizable, or otherwise, including especially intrinsic, cultural, and spiritual values) based on the perspectives of a broad diversity of Indigenous institutions, governments and communities; and 2) an associated set of indicators that, in the view of Indigenous Peoples, provide for an evaluation of whether such values are appreciating, depreciating, or stable over time (see Parlee *et al.* 2022 for review and potential approaches). Additional areas of focus could include 3) Indigenous-led mapping of the landscape of biodiversity initiatives, 4) identifying complementarities and differences in western and Indigenous biodiversity values as well as perspectives on biodiversity conservation.

Increasing the Scope of Natural Capital Accounting and Ecosystem Services Assessment. There are multiple KMGBF targets for which tracking progress requires integrating natural capital accounting (NCA) into Canada's system of national accounts. Particularly lacking are accounts focusing on the non-monetizable values of nature to

Canadians, a matter of particular importance for iconic species and ecosystems, and those of historical and cultural values. While work is ongoing to address some aspects of NCA, additional research is required to ensure that it: 1) captures the full set of important Canadian ecosystems; 2) enables monitoring of Canada's progress towards KMGBF targets; 3) allows for thorough assessment of nature-based solutions to climate change; 4) allows for accounting at a subnational (e.g., provincial, regional and local) level; and 5) ensures that the full costs and benefits of regulatory decisions are accurately captured in Regulatory Impact Assessment Statements. To support this work, the development and use of next-generation process-based analytics to predict either directly, or indirectly, both the supply and actual provision (see Mitchell et al. 2021) of ecosystem services, under a suite of climate and use scenarios is a potential approach. Via these tools, a set of virtual land- and sea-scapes by which to generate and test hypotheses; and importantly, readily gauge management practice impacts on ecosystem services, can be provided. This will create a means to efficiently value natural capital for the services they provide to help incentivize conservation across protected and non-protected landscapes.

Conclusion

This report presents 8 key concepts, 78 specific information needs and 4 areas of research opportunity to aid in the implementation of the KMGBF. Some of the information needs listed above relate to well acknowledged and long-standing challenges that will be difficult to solve, while others reflect emerging issues that have yet to be studied in depth. However, a central message is the need to act quickly on the basis of what we already know. Ongoing, or in many cases accelerating (e.g., Smith et al. 2023) declines of wildlife mean that the number of listed species will continue to grow. Early conservation action to reverse declines, before species become rare, is widely understood to be both more efficient and more effective (e.g., Walls 2018). Resources for conservation are limited, and funds spent to improve monitoring information are unavailable for conservation action (Buxton et al. 2022). In the interest of efficiency, we need to avoid collecting new information when the information in hand already may be sufficient for the need, even if imperfect (Martin et al. 2012, Meek et al. 2015, Buxton et al. 2022). However, this focus on action must be balanced with the need for adequate information; decisions made in the absence of sufficient information can be inefficient, or even counterproductive (Cook et al. 2010).

The information needs listed in this report serve two main functions: 1) to directly aid in reporting under the GBF by informing progress towards the targets and 2) to help us overcome barriers to effective action. International agreements such as the KMGBF play a fundamental role in mobilizing human and financial resources for conservation.

Generating new information to meet the reporting obligations under this agreement will not contribute directly to halting the loss of biodiversity, but can support the achievement of the targets, which does. Similarly, identifying barriers to action does not equate directly to species' recovery. However, in many cases, the necessary actions for recovery are known but cannot be implemented because of these barriers. The needs listed here are presented with these linkages to conservation action in mind.

Despite all needs identified in this report being designed with conservation action in mind, they vary in the immediacy or scale of their impact, as well as their cost and feasibility. A prioritization of the lists presented in this report, on the basis of these parameters, would aid in implementation. As has been suggested in the needs above, co-development of solutions with decision makers and a holistic approach to implementation are key to the success of the KMGBF. This means that the recommendations contained herein should be considered in collaboration with policy-makers and implementation partners, alongside other perspectives as a National Biodiversity Strategy takes shape.

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