Report

# ABMI Ten-Year Review

## Summary of the Input Provided by the Science Expert Committee

Submitted to:

Alberta BioDiversity Monitoring Institute (ABMI)

Submitted by:

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MANAGEMENT & ECONOMIC CONSULTANTS

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### *APPENDICES*

# 1. Summary

This report provides a summary of the input provided by the Science Review Committee (SEC) established by the ABMI as part of its Ten-Year Review process. The information provided below was prepared by an independent facilitator engaged to work with the SEC and has been reviewed and revised by the individual members of the SEC.

# 2. Background

The ABMI's Ten-Year Science Review was initiated in 2017. The Review was overseen by a Steering Committee and involved two distinct streams of evaluative work. A Stakeholder Advisory Group evaluated the extent to which the ABMI is meeting its stakeholder engagement goals and objectives. The Science Review Committee evaluated the extent to which the ABMI is meeting its scientific goals and objectives.

The results of both streams of work will be forwarded to the Steering Committee and the ABMI Board of Directors. The Board of Directors will determine how the results of the Review will impact ABMI operations in the future.

# 3. Science Expert Committee

The SEC was comprised of five subject matter experts recruited by the ABMI for their ecological expertise, strong analytical skills and extensive experience with environmental monitoring. None of these scientists have worked directly with the ABMI in the past.

Overviews of the Science Committee members backgrounds and expertise in biodiversity monitoring are provided in Appendix A.

## 3.1 Science Expert Committee Meetings

The SEC met via teleconference on October 23, 2017 to review its Terms of Reference. It determined at that time that its in-person deliberations would benefit from having an independent facilitator chair at their in-person meetings and work with them to prepare a report on their discussions. The SEC also requested that ABMI staff be present during its in-person meetings to present background information and answer questions.

The five science experts were given access to a draft synthesis report, detailed background reports prepared by ABMI staff and contractors, and a meeting agenda in advance of their two-day, in-person review meeting in Edmonton on November 5-6, 2017.

## 3.2 Science Expert Committee Input

### 3.2.1 ABMI Goals and Objectives

After reviewing the information that was provided to them and listening to the answers ABMI staff provided in response to a wide range of questions (many of which were actually addressed in technical reports), the Committee concluded that the ABMI:

- is doing a "very good to excellent job" fulfilling its goals and objectives;
- has "exceeded the expectations it set out for itself ten years ago" and
- is a "great example" of a long-term biodiversity monitoring program.

The Committee described ABMI's progress to date as a "monumental achievement" and emphasized that its comprehensive approach (taxonomic breadth, spatial scale of monitoring and temporal scale of monitoring) to environmental monitoring is unique in the world. They emphasized that they believe the ABMI's work is "extremely beneficial to stakeholders and the public and well worth the dollar investment".

Finally, while the SEC noted that there are a number of areas where the ABMI may want to consider modifying its approach to biodiversity monitoring as it moves forward, its overall approach to monitoring over its first ten years has been a "major success".

The SEC encouraged the ABMI to be more direct in defining the value proposition of its programs and services. The Committee emphasized that the ABMI is doing and can do far more than "stamp collecting". Its programs and services provide the evidence required to inform a wide range of fundamentally important policy and management decisions.

### 3.2.2 ABMI 10-Year Science Review Document

The Committee indicated that while they thought the document was well done, it actually:

- understates important areas of research undertaken by the ABMI over the past decade, including:
  - climate change monitoring and analyses;
  - rare species and habitat monitoring;
  - partnerships to improve landscape and human footprint mapping, and
  - citizen engagement in data collection.
- does not adequately describe the "herculean effort" required to collect and manage the data, conduct rigorous analyses, and share the results broadly with managers.

The Committee recommended that the draft report be amended to highlight these successes.

Finally, the Committee also concluded that the ABMI has developed very rich databases and needs to be more aggressive in sharing and marketing this information. They encouraged the ABMI to work on increasing its profile and emphasized that increased stakeholder engagement will:

- make more people aware of ABMI's diverse products;
- illustrate to stakeholders the value of sampling sites outside their management areas;
- help stakeholders better understand what is needed to address their questions in a scientifically credible manner, and
- help establish new collaborations that use ABMI's high-quality data.

## 3.3 Program Design

The Committee expressed a high level of confidence in the ABMI's program design and concluded that there are no fatal flaws in its approach to biodiversity monitoring. The Committee observed that ten years is a relatively short time period in the context of monitoring biodiversity and encouraged the ABMI to continue its efforts.

The Committee discussed the sustainability of the current design of ABMI's monitoring programs and advised, if challenged to find savings, ABMI should consider a Value of Information (VOI) approach to rationalize, for example, the list of monitored species. VOI will force ABMI, and others, to come to grips with how much

information is enough to make policy decisions. Specifically, it may be possible to reduce the geographic extent of plot sampling in remote, homogeneous areas, in exchange for targeted sampling in areas of concern due to chronic stressors.

The Committee discussed the lack of sampling in parts of Alberta (mountains and northwest) related to the fact that funders demand sampling in their specific areas. The Committee felt that this was a significant issue because skewing sampling creates a risk to integrity of information, and is short sighted. They thought this could be addressed by taking a bigger skim off the top to allow the appropriate monitoring design to be implemented throughout Alberta.

### 3.3.1 Species

The Committee emphasized that monitoring of more than a few species is very important to achieving ABMI's goals and objectives and argued that removing a taxonomic group would not result in significant cost savings while decreasing the quality of its data. It provided the following input regarding species monitoring:

- trying to monitor rare species would clutter up the ABMI approach and result in a reduction in the quality of data collected;
- there is a difference between rare and patchy species (patchy species not well sampled using a random design, but rare broadly distributed species are detected);
- there may be value in sampling some species groups at a higher frequency (i.e. songbirds more frequently than mites);
- there may be value in informing a rationalization of the list of monitored species from a functional foodweb perspective, in order to capture something of (implied) ecosystem processes as well as elements, i.e., those species in food chains through which major amounts of biomass and energy (or ecosystem services) can be imagined to flow; and
- recommend ABMI investigate technological advances as they appear (e.g. DNA barcoding for taxonomic resolution; isotopes for functional resolution).

### 3.3.2 Land Cover

With respect to land cover, the Committee concluded that human footprint monitoring is very good. They considered both wall-to-wall and 3x7s and suggested that both be maintained, in part, due to the increasing value of temporal datasets.

### 3.3.3 Vegetation

With respect to vegetation, the Committee:

- noted that 3x7s are good for validation, but expressed some doubt regarding the use of human digitizing for second round 3x7s;
- emphasized that remote sensing is changing so fast that ABMI should be strategic in defining alternative methods moving forward;
- recommended targeting areas where big changes in footprint are occurring so that ABMI will have continuous data sets where vegetation is changing rapidly;
- suggested that ABMI investigate using citizen scientists to validate 3x7s digitization.

The Committee noted quality concerns with the existing wall-to-wall (backfilled) vegetation product (the amalgamation of existing products [e.g. AVI, GVI, etc.] is not high quality for all vegetation types). Very important to look at quality of original data, but also how it will be improved into the future.

### 3.3.4 Frequency of Visits and Number of Sites

The Committee concluded that the ABMI should be "proud of its achievements to date" and emphasized that they believe that there is "no conceivable way to do 5-year revisits to all sites unless budgets are doubled". The Committee accepts that ABMI monitoring programs need to be designed within current funding parameters.

The Committee suggested:

- redirecting sampling from planned revisit surveys to sites that have yet to be surveyed, emphasizing that it is very important to get baseline data for all sites;
- maintaining the original ABMI grid, noting that in the future there will be significant value in having gone back to all sites;
- not resampling every 5 years, suggesting that a 10- or 15-year rotation would be sufficient;
- adhering to on-site current sampling design to avoid shifting baselines;
- consideration of stratification if it does not jeopardize the integrity of inferences derived from analyses, noting that:
    - stratification decisions should focus on improving precision in results;
    - an increase in the effort at sites with higher heterogeneity or higher human footprint would enable ABMI to make better inferences;
    - ABMI could stratify with respect to habitat types so all are well sampled;
    - stratification could also result in less intensity in some areas/site types; and
    - if stratification is considered, ABMI needs to do so very cautiously because the random grid is very flexible.
- that it would be "bad science" for funders to specify where monitoring is done, emphasizing that this would "distort the whole project" (one science expert emphasized that funded monitoring is "pragmatic" and that it is "better to have some monitoring than none at all");
- monitoring needs to occur across the **whole** province;
- ABMI should consider rapid assessment sampling (e.g., a combination of remote sensing and measurement of habitat structure and condition at the site);
- giving a lot of information cheaply at many sites so that potential stressors and impacts can be hypothesized, and
- by applying ABMI species models to the rapid assessment sites, ABMI may be able to infer what species would be present.

## 3.4 Other Issues

### 3.4.1 Helicopter Sites

The Committee argued that the issue with helicopters is not financial, accepting that helicopter sites are only 1.3 times more expensive than ground access sites to survey. They emphasized that from a study design perspective, it is critical to survey sites that are hard to access. Again the Committee stressed the importance of sampling the complete ABMI grid for representation of biodiversity.

### 3.4.2 Climate Change

The Committee urged the ABMI to think carefully about how climate change is being incorporated into its mandate and emphasized their recommendation that climate change be part of the ABMI mission. It argued that the ABMI needs to upgrade its base vegetation layer more rapidly to monitor climate change.

### 3.4.3 Non-Native Species

The Committee felt that the ABMI needs to be more granular when analyzing and reporting on non-native species – some of these species have negative ecological effect, others are benign, and others are crops. It noted that the mere presence of non-native species is often enough for people to assume they are guilty of causing negative impacts and that there is value in avoiding the term invasive as it carries a lot of "baggage".

### 3.4.4 Intactness

The Committee heard that ABMI's intactness calculation uses a backfilled method that does not take into account natural variability – temporal variability can change reference dramatically. It suggested that this limitation be noted up front, and that there will be different results under different conditions. This may influence what can be generalized from intactness outcomes. However, since ABMI is focused on evaluating the effect of the human footprint on biodiversity, the Committee concluded that backfilling is a reasonable way to assess these effects.

The Committee concluded that even with the limitations noted above, intactness is a very powerful tool.

### 3.4.5 Site Privacy and Data Access

The Committee was adamant that ABMI sites remain confidential and emphasized that site confidentiality is the only solution that makes sense for the ABMI as it:

- protects the integrity of sites from meddling;
- enlarges the pool of sampling sites by enabling agreements with landowners; and
- protects legal agreements that have already been made.

The Committee emphasized the importance of developing hierarchies/methods/agreements for people to access site locations when they absolutely must have that information and are willing to not compromise the data in any way. It felt that the present ABMI mechanism for this is reasonable.

### 3.4.6 Stakeholder Engagement

The SEC was very supportive of ABMI's decision to include an evaluation of its success in working with a diverse set of stakeholders. Each of the Committee members spoke to the interdependencies between the Review's evaluation of science and stakeholder engagement.

## 3.5 Recommended Updates to the 10-Year Science Review Document

The Committee recommended the following edits be made to the draft 10-Year Science Review document.

- In the Executive Summary and chapter summaries highlight results that show how ABMI has achieved its original goals/objectives. By monitoring status and trend for over 3,000 species, it can be reasonably assumed that this information is very useful to stakeholders in their efforts to assess development effects and cumulative effects.
- In the Introduction, describe that the science of monitoring is not just about producing data, analyses and reports. Emphasize that this process also requires implementation of a feedback mechanism for policy development, management and monitoring to evolve as new information is learned.
- In the Introduction, emphasize that the availability of ABMI data enhances public and stakeholder education.
- In the Introduction, explain that although the present review focused on the original ABMI goals/objectives, additional research and analyses were tackled by ABMI during the past decade as new management questions were raised. These collaborations have leveraged the ABMI data to evaluate:
    - Climate change
    - Rare species and habitats
    - New landscape and human footprint mapping methods
    - Ecosystem services
    - New methods for engaging citizens
    - Grazing management

    The Committee is mindful that this work can provide huge benefits to managers and recommends that ABMI test this notion during its stakeholder evaluation process. If proven to be the case, this should be highlighted in the Introduction, and consideration should be given to expanding this type of applied research for multiple collaborators.
- Where appropriate, change the tone in the text of the report to emphasize what ABMI has completed and accomplished. After doing so, highlight things the ABMI is still working on. This change of tone is needed to highlight the many accomplishments.
- In the Introduction, preface the vegetation map to indicate that it may change over time due to climate change.
- In the Introduction and Data Collection chapters, better describe the reasons for selecting targeted sites and the types of targeted sites that were surveyed.
- On the website, revise the species occurrence maps to emphasize sites that were surveyed and de-emphasize sites that have yet to be surveyed. This will help communicate to users that the species data may or may not represent true abundance or full distribution.
- In the Trend Chapter, add error bars to the estimates of landscape change over time.
- In the Analyses Chapter, add an NDMS ordination that includes:
    - all common species from all taxa;

- habitats/climate/etc. so the reader may see how the species patterns are related to these; and
- rare species so that the reader may better understand where these fall in the ordination and with respect to the habitat variables.

## 3.6 Advice from the Science Experts

The SEC members were asked to provide their thoughts on the future of the ABMI. Four of the science experts provided the following advice.

### 3.6.1 **Dr. Robert Brooks,** Professor of Geography and Ecology, Department of Geography, Pennsylvania State University and Director and Founder of Riparia

Be more explicit about what goes into estimates for each taxon. Do so simply and in a visible web location for stakeholders to see and comprehend.

Increase investment of resources in communicating with various stakeholders (e.g., data users, potential paying clients, etc.), including:

- investing more in user-friendly graphics that would help explain complex findings;
- addressing issues between access, data collection, and benefits between public and private lands (e.g., how does differential access affect sampling results?; what can private landowners gain by allowing access and more explicit publication of data from their lands?);
- given primary funding from tar sands, focusing sampling specifically on highly stressed areas, or those soon to be stressed, and on stressor identification and potential remediation strategies could provide the expected focus the industry wants without impacting ABMI's overall budget;
- more strategic use of ABMI's human footprint data and analyses should be helpful for communicating how biodiversity findings vary to all types of stakeholders;
- using multi-species indicators (and their associated data), whether developed for similar taxonomic species or guilds, or perhaps "response" guilds of multiple taxa that respond to stressors in similar ways, can help transmit concepts and results to stakeholders (indicators also can link back to ABMI's habitat associations and human footprint analyses.

Scales, both spatial and temporal, are addressed throughout ABMI's work, but I think there is even more here to consider. Obviously, the sampling designs address spatial scales, and will need to address temporal changes as data accumulates after repeated samplings. Again, actual and potential stakeholders can benefit by understanding the impact of scale on the results. For example, the range of spatial movements and home ranges/territories among the many species sampled varies by several orders of magnitude, which can complicate how to interpret occurrence and abundance estimates. Similarly, stressors operate at varying spatial and temporal scales, and thus can affect species in many different ways. Communicating such ecological complexities can be challenging.

The ABMI program's sampling intensity exceeds the six ecological monitoring programs I am most familiar with (see Appendix) and comes close to the geographic extent for several of the examples. Simply stated, I am impressed with ABMI's world-class biodiversity monitoring program, it is highly defensible, and I have high hopes for future findings!

### 3.6.2 **Dr. Kirsten de Beurs,** Professor, Department of Geography and Environmental Sustainability, University of Oklahoma

Generally, the ABMI is doing an admirable job collecting information and monitoring change in Alberta. I believe that the bigger scientific community could greatly benefit if ABMI would develop a series of papers discussing what they have learned with respect to setting up a large biodiversity monitoring framework. What are the lessons learned, e.g. the do's and don'ts?

ABMI requested feedback on their very high resolution, fine-scale vegetation maps from satellite data and/or aerial photographs. I suggest ABMI to be very cautious going this route, because it is very hard to distinguish the many different types of vegetation from remotely sensed datasets. In my humble opinion it is better to have fewer vegetation classes, with very high accuracy, than lots of vegetation classes with low accuracy. It will be unavoidable to have significant confusion between some of the classes.

That said, I note that ABMI does not use LiDAR and/or Radar data very much in any of their classification efforts. I suggest that considerable accuracy can be achieved if such datasets would be used more regularly. For example, LiDAR data can be used to distinguish vegetation height, or landscape roughness, e.g. how varied is the vegetation in space. This might help in distinguishing more vegetation types. Recent high-resolution RADAR data (e.g. Sentinel 1) might also be very helpful in this endeavor.

Lastly, I found the land use analysis over time very interesting and elegant. It is simple, but effective and I believe it could result in some very interesting observations and papers.

### 3.6.3 **Dr. Thomas Nudds,** Professor Emeritis, Department of Integrative Biology, University of Guelph

The ABMI needs to carefully examine its approach to hypothesis/question-free data acquisition. It needs to use the data it collects to inform participatory decision-analyses to resolve critical uncertainties in the management of complex, socio-ecological systems. It needs to question the misguided notion that scientific integrity is somehow compromised if non-scientists are involved with scientists. I recommend reviewing the governance of the ABMI with a view to better involving the "great unwashed" in co-creation of the research questions to which the monitoring data will be put.

The ABMI is at a critical juncture wherein budget constraints mean it will be increasingly difficult to mount an "all things to all potential future end-users of data"-style monitoring program. Decisions about governance will likely have to be made with regard to involving stakeholders in the co-generation of the key questions around which the next-generation ABMI can be strategically developed.

### 3.6.4 **Dr. Rob Rempel,** Research Scientist, Centre for Northern Forest Ecosystem Research, Ontario Ministry of Natural Resources and Forestry

In general, I felt the program has done a very effective job for its principal mandate of tracking change over time, irrespective of specific causes related to specific changes in human footprint. I agree with most of what is written in this assessment report. I do worry, however, that the systematic design and lack of stratification may impede the program's ability to separate general human footprint and management effects from climate change effects as the principal cause of change. For example, if surveys were stratified by protected/non-protected area status, and if a species abundance was stabled in protected areas, but was declining outside the protected area, then a reasonable conclusion is that development footprint effects outside the protected area might have caused the decline (and climate change is effectively excluded as a likely cause of decline). Without such stratification, then

perhaps a general, albeit lower level decline, would be attributed to climate change and/or footprint effects. As a result, there would be less weight of evidence to suggest footprint thresholds have been exceeded.

In general, I still find it difficult to understand how climate change effects will be partitioned from Alberta-specific footprint effects without some form of stratification and balanced sample design. I don't believe that adding sample sites targeted specifically to carefully selected strata (e.g., protected/non-protected areas) will harm the integrity of the ABMI program, even if the additional samples don't follow the systematic design and would perhaps require some over-represented sites to be sampled less frequently. My suggestion for moving forward is to consider incorporating some very general level of stratification related directly to footprint and the mandate of the ABMI program.

## 3.7 Facilitator Observations

It was very evident that each of the members of the SEC had carefully reviewed the draft ABMI 10-Year Science Review Document. The five scientists asked a significant number of questions regarding the report and were provided with detailed responses by ABMI staff. Many of the SEC's questions sought to understand whether the ABMI "had tried to do this" or "considered that" over the past ten years. Affirmative responses were provided to a strong majority of these types of questions.

The facilitator was tasked with ensuring that SEC deliberations were informed, but not inappropriately influenced by ABMI staff, and confirms with confidence that this was indeed the case.

# Appendix A Science Committee Member – Overview of Background and Expertise

### *Dr. Robert Brooks, Professor of Geography and Ecology, Department of Geography, Pennsylvania State University and Director and Founder of Riparia*

Dr. Robert P. Brooks is Professor of Geography and Ecology, and Founder and Director of Riparia at the Pennsylvania State University. Riparia is celebrating 25 years of success during 2018. He is a practicing wetland scientist, and wildlife biologist certified by the Society of Wetland Scientists and The Wildlife Society, respectively. He received a B.S. in Biology from Muhlenberg College, and masters and doctoral degrees from the University of Massachusetts in Wildlife and Fisheries Science. For over 35 years, Dr. Brooks has built a research program in wetlands science and wildlife ecology that spans the full realm of topics relating to the ecology, management, policy, and conservation of wetlands, streams, and riparian areas, and their associated biota. He has published over 100 scientific articles and secured over $30 million to fund his students, staff, and projects. He has mentored 46 graduate students (33 masters, 13 doctoral) to completion of their degrees. He is the 2013 recipient of the National Wetlands Award for Science Research from the Environmental Law Institute, was elected as a Fellow to the Society of Wetland Scientists in 2017.

Through his leadership, Riparia has established numerous environmental indicators across multiple biological taxa (i.e., mammals, birds, amphibians, plants, and macroinvertebrates) and landscapes scales (i.e., wetland, stream reach, watershed, and landscape). He led the establishment of Penn State's Riparia Reference Wetlands Collection, comprising 222 natural wetlands distributed across Pennsylvania, which is becoming an essential resource for Pennsylvania and Mid-Atlantic regulatory and resource agency personnel. Dr. Brooks continues to work with an array of institutions, agencies, corporations, utilities, citizen groups, and individuals concerning natural resources issues and management, with an emphasis on assessments of wetlands and streams, habitat modeling for wetland-dependent wildlife, and restoration of aquatic ecosystems.

Dr. Brooks is familiar with a variety of ecological monitoring programs, such as:

- **U.S. Environmental Protection Agency – Environmental Monitoring and Assessment Program;** established a tessellated, hexagonal grid across the U.S., and sampled multiple habitats and taxa. Offshoots continue to sample about 1,000 aquatic sites per year per type on a 5-year rotating basis for streams, rivers, estuaries, lakes, and wetlands – National Aquatic Resource Surveys (NARS; see - https://www.epa.gov/national-aquatic-resource-surveys - for extensive protocols, Quality Assurance/Quality Compliance, and publications). Brooks' team has participated in 2011 and 2016 in the National Wetlands Condition Assessment portion).
- **U.S. Fish & Wildlife Service's Gap Analysis (late 1990s, early 2000s) –** State-based habitat modeling for vertebrate species, constrained by a national grid and landscape-level protocol. Identifies "gaps" in the conservation network, usually based on existing data. Suggested options to add to ABMI's Program.
- **U.S. National Park Service – Inventory and Monitoring Program;** identifies "vital signs", primarily biological and ecological resources that are chosen for each park unit to establish baseline condition; usually based on existing data, but can involve new data collection. https://science.nature.nps.gov/im/about.cfm

- **Breeding Bird Survey –** U.S.-based bird sampling program conducted by volunteers on road-based routes nationwide since 1967 (https://www.pwrc.usgs.gov/bbs/ ); has provided long-term trends for 100s of bird species; we have compared these trends to intensive bird sampling plots in the Mid-Atlantic Region.
- **Breeding Bird Atlas (BBA) Projects –** usually state-based projects in U.S. to document abundance and geographic distribution of breeding bird species on a fairly fine grid; Brooks' team participated in the first PA BBA, and helped design the 2nd BBA, 20 years later.
- **Riparia Reference Wetlands Database –** Brooks established and manages intensive sampling of 222 natural reference wetlands randomly selected in Pennsylvania, which are re-sampled at 10-year intervals (in third cycle now).

### *Dr. Kirsten de Beurs, Professor, Department of Geography and Environmental Sustainability, University of Oklahoma*

Kirsten de Beurs is an associate professor in the Department of Geography and Environmental Sustainability at the University of Oklahoma. Since 2015, she also serves as the Chair of the Department, leading a dynamic and growing department that offers a wide array of paradigmatic approaches and topical specialties within the fields of geography, sustainability, and Geographic Information Science (GIS). Her research focuses on the analysis of satellite data to detect, assess and attribute ongoing changes on the terrestrial land surface. Specifically, she is interested in land surface phenology, the statistical analysis of long image time series for trend detection, and the application of these methods for the observation and monitoring of land cover and land use change.

She has also expanded her research interests to the analysis of time series of satellite data with higher spatial resolution (30m) and analysis of LiDAR data. She is an author on more than sixty research papers and peer-reviewed book chapters, her Google Scholar h-index is currently 28, and her research has been cited well over 3000 times. She has been the PI or Co-PI on several successful nationally competitive proposals, mainly funded by NASA and NSF.

### *Dr. Thomas J. Givnish, Professor of Botany and Environmental Studies, University of Wisconsin-Madison*

*[Forthcoming]*

### *Dr. Thomas Nudds, Professor Emeritis, Department of Integrative Biology, University of Guelph*

Tom completed BSc and MSc (1974, 1976) degrees at the University of Windsor, a PhD at the University of Western Ontario (1980), and a postdoctoral fellowship with Migratory Birds Branch of the Canadian Wildlife Service. He taught and researched wildlife ecology and management at Guelph between 1981 and 2012, during which he (co)authored over 175 papers, book chapters and technical reports, and advised over 50 graduate students and postdoctoral fellows. He was Associate Editor at the Journal of Wildlife Management and the Canadian Journal of Forest Research, and Co-Editor-in-Chief of Avian Conservation and Ecology, and held Visiting/Associate Professorships at the Universities of California, Montana State, Saskatchewan and Agricultural Sciences, Sweden. He advised a number of agencies and organizations, such as Parks Canada, Environment Canada, Auditor General of Canada, National Round Table on Economy and Environment, Federal-Provincial Parks Council, Bird Studies Canada, the Nature Conservancy of Canada and Ontario's Endangered Species Legislative Review Panel. He continues to serve on Ontario's Provincial Forest Technical, and Wolverine

Recovery Team Advisory, Committees. He was Principal Investigator for the Decision Analysis and Adaptive Management (DAAM) Project for Great Lakes Fisheries and facilitated DAAM workshops for the Missouri Department of Conservation, Ducks Unlimited Canada, OMNR Forest Policy Section, and Ontario Parks.

A principal theme running through his research program was the use of long-term, large-scale data collected through monitoring programs (e.g., Breeding Bird Survey, Ontario Breeding Bird Atlas, Waterfowl Breeding Population and Habitat Survey), often to detect environmental effects of human activities on biodiversity amongst variation in biodiversity caused by other factors. The challenges in bringing both the process and the results of science to bear on policy and management decisions cemented his resolve to encourage better engagement by stakeholders, managers and policy makers in the co-creation and execution of research, including monitoring, designed to address critical uncertainties in complex socio-ecological systems.

### *Dr. Rob Rempel, Research Scientist, Centre for Northern Forest Ecosystem Research, Ontario Ministry of Natural Resources and Forestry*

Rob Rempel is the Program Lead for the Forest Guideline Effectiveness Monitoring (GEM) program at the Ontario Ministry of Natural Resources, where he has gained years of experience in developing broad-scale research and monitoring programs. This GEM program treats “policy as hypothesis”, where the objective is to evaluate the effectiveness of forest management policy and guidelines in terms of conserving biodiversity (wildlife populations and communities), quality habitat, and ecological processes. Rob works principally with forest migratory birds, moose and caribou, and has led or been involved with development of a number of monitoring approaches and technologies to better assess ecological integrity, including GPS collars and autonomous audio recording units. Currently, Rob is working on developing a long-term ecological monitoring plan for Ontario’s far north and associated regional-scale cumulative effects assessment program.

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