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Essay, part of a Special Feature on Conservation of Boreal Birds

Toward actionable, coproduced research on boreal birds focused on building respectful partnerships

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ABSTRACT. Recent research on boreal birds has focused on understanding effects of human activity on populations and their habitats. As bird populations continue to decline, research is often intended to inform conservation and management policies and practices. Research produced under the typical “loading dock” model by Western-trained researchers often fails to achieve desired conservation outcomes. There is growing global consensus that science is most actionable when produced in collaboration between scientists, potential end-users of the science, and communities implicated in or affected by the research and its outcomes. A fully collaborative research process, which we call “coproduced research,” involves partners in the design, execution, and communication of research. To coproduce research, it is first important to understand the sociocultural context of a research project. For boreal bird conservation in Canada, this context includes complex linkages between Indigenous communities, governments, and rights-holders, multiple levels of government, nonprofit organizations, companies, and industry consortiums, civic communities, and others. We explain this context, and give particular attention to best practices for coproduction of research between non-Indigenous researchers and Indigenous partners. We also introduce a self-assessment tool for researchers to gauge the strength of their relationships with potential partners.

We highlight the challenges of doing coproduced research, including cross-cultural communication and lengthy timelines to build relationships. We propose a guide for coproduced research in four stages: (1) identify potential partners; (2) build relationships; (3) identify mechanisms to inform policy and management; and (4) execute research and communications plans. We illustrate the stages with examples of “bright spots” to demonstrate successful coproduction partnerships. Although we focus on research to improve knowledge for boreal bird conservation and management, many of the lessons we share for adopting a coproduced research model would apply to terrestrial or marine wildlife, or any natural resource.

Vers une recherche en coproduction exploitable sur les oiseaux des régions boréales, axée sur l'élaboration de partenariats respectueux

RÉSUMÉ. Les recherches récentes au sujet des oiseaux des régions boréales portaient principalement sur la compréhension des effets de l'activité humaine sur les populations et leurs habitats. Alors que le déclin des populations aviaires se poursuit, les recherches ont souvent pour objectif d'informer les politiques et les pratiques en matière de conservation et de gestion. Toutefois, les recherches réalisées selon le modèle typique de la science « brute » par les chercheurs de formation occidentale ne produisent généralement pas les résultats souhaités en termes de conservation. Il semble de plus en plus communément admis que la science est plus exploitable lorsqu'elle est le fruit d'une collaboration entre scientifiques, utilisateurs finaux potentiels et communautés impliquées ou concernées par la recherche et ses résultats. Un processus de recherche entièrement collaboratif, que nous appelons « recherche en coproduction », fait intervenir des partenaires dans la conception, l'exécution et la communication des résultats. Pour coproduire la recherche, il faut avant tout comprendre le contexte socioculturel d'un projet. En ce qui concerne la conservation des oiseaux des régions boréales du Canada, ce contexte fait appel à des liens complexes entre les populations indigènes, les gouvernements, les ayants-droits, de multiples niveaux de l'administration, des organisations à but non lucratif, des entreprises et des consortiums industriels, des associations civiques et autres. Nous expliquerons ce contexte et accorderons une attention toute particulière aux bonnes pratiques en matière de coproduction de la recherche entre chercheurs non-indigènes et partenaires indigènes. Nous présenterons également un outil d'auto-évaluation qui permet aux chercheurs d'estimer la solidité de leurs relations avec des partenaires potentiels.

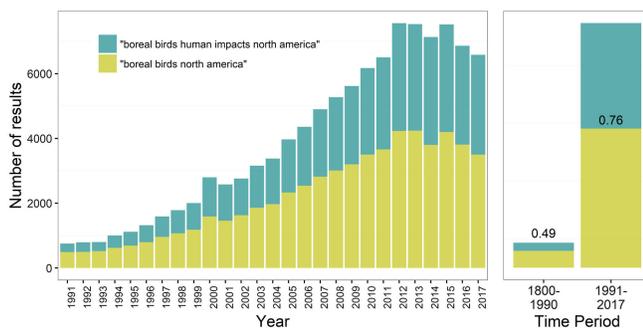
Nous mettrons en évidence les défis inhérents à la recherche en coproduction, y compris la communication interculturelle et les longs délais nécessaires à l'élaboration des relations. Nous proposons un guide de la recherche en coproduction en quatre étapes : (1) identification des partenaires potentiels ; (2) création des relations ; (3) identification des mécanismes permettant d'informer la politique et la gestion ; et (4) exécution des plans de recherche et de communications. Nous illustrons ces différentes étapes à l'aide d'exemples de « points positifs » qui présentent des partenariats de coproduction efficaces. Même si nous nous concentrons sur des recherches visant à améliorer nos connaissances en matière de conservation et de gestion des populations d'oiseaux des régions boréales, bon nombre des enseignements que nous partageons pour adopter un modèle de recherche en coproduction pourraient également s'appliquer à la faune terrestre ou marine ou à toute ressource naturelle.

Key Words: *boreal forest; conservation; comanagement; Indigenous engagement; actionable science; boreal birds*

INTRODUCTION

Although Canada's vast boreal forest (5.5 million km²; Brandt 2009) supports billions of birds from over 300 species (Wells and Blancher 2011, Wells et al. 2014), many bird populations are declining (North American Bird Conservation Initiative Canada 2016). In recent decades, research on boreal birds has increasingly investigated human impacts on bird habitats and populations (Fig. 1; for overviews, see Wells 2008, Wells and Blancher 2011). Canada's boreal forest is undergoing rapid changes because of increasing resource development (Carlson et al. 2015), climate change (Park et al. 2014), and altered forest fire and insect disturbance regimes (Boulanger et al. 2014, De Grandpré et al. 2018), all of which are expected to impact bird populations (Mahon et al. 2014, Stralberg et al. 2015). Presumably, much of the research on human impacts related to boreal birds is intended to inform their conservation and management (e.g., Morissette et al. 2019, Stralberg et al. 2019, Westwood et al. 2019a; other papers in this feature issue).

Fig. 1. Comparison of the number of results in Google Scholar (<https://scholar.google.ca/>) for two different search terms: “boreal birds North America” and “boreal birds human impacts North America” from 1991 to 2017 (left panel) and percentage of results for the search string “boreal birds North America” also including the words “human impact” before and after 1991 (right panel).



Research that leads to data, analysis, or tools that directly inform decision and policies can be termed “actionable” (definition adapted from Palmer 2012, Beever et al. 2014, Walsh et al. 2015, Beier et al. 2017). There is growing global consensus that science is most actionable when produced in collaboration between scientists, potential end-users of the science, and communities implicated in or affected by the research process and outcomes (Houde 2007, Thompson et al. 2011, Armitage et al. 2012, Kothari

et al. 2013, U.S. Fish and Wildlife Service 2016, Beier et al. 2017, Evans and Cvitanovic 2018). A fully collaborative research process, which we refer to as “coproduced research,” involves partners in the design, execution, and communication of research results and outcomes (Enquist et al. 2017).

There are substantial gaps between conventional conservation science approaches and ensuring that research informs policy and practice (Cash et al. 2006, McNie 2007, Young et al. 2014, Bertuol-Garcia et al. 2018, Coristine et al. 2018, Moore et al. 2018, Salomon et al. 2018). Research is often conducted under the “loading dock” model: a linear transaction whereby researchers conduct studies, and the results are placed in a written report or peer-reviewed literature under the assumption that it will be found by prospective users (Cash et al. 2006, Young et al. 2014, Beier et al. 2017). The loading dock model limits actionability: research designed without input from potential end-users is less easily applied to decisions or translated into policy (Rogers 1997, Fernández 2016, Beier et al. 2017). End-users may also be unlikely to encounter relevant research in the course of their normal work (Walsh et al. 2015), lack access to academic journal articles (Born et al. 2009), or when they do have access, may not have the time to translate journal articles into policy recommendations (Dasgupta 2017). Given that English is the *lingua franca* of scientific publication, language may also be a significant barrier to participation and access for nonanglophone end users (Ramírez-Castañeda 2020).

Researchers who want their work to be actionable for addressing conservation challenges can adopt a coproduced research model (Lemos and Morehouse 2005, Dilling and Lemos 2011, Moser 2016, Wall et al. 2017). Coproduced research also improves credibility and saliency over the loading dock model (Moser 2016, Page et al. 2016), and importantly, has the potential to result in more inclusive, just, and socially relevant research (Parsons et al. 2016, Temper and Del Bene 2016, Salomon et al. 2018). This is particularly important in the boreal forest context where scientific research has in many cases ignored or discounted the knowledge systems of Indigenous peoples^[1], disregarded their rights, resulted in inequitable sharing of resources, and negatively impacted their lives, livelihoods, cultures, and connections to the land (Wyatt 2008, Brunet et al. 2016, Indigenous Circle of Experts 2018). There is growing recognition that best efforts in conservation and management include Indigenous peoples as full partners (Nuna 2002, Cantin et al. 2004, Wyatt 2008, Castleden et al. 2012, Kothari et al. 2013, Adams et al. 2014, Papillon and Rodon 2017, Indigenous Circle of Experts 2018), and that Indigenous knowledge and science can improve the quality and actionability of research (Gadgil et al. 1993, Adams et al. 2014, Parsons et al. 2016, Ban et al. 2018, Kutz and Tomaselli 2019).

Coproduced research can present challenges. It is generally much more time consuming and complex than traditional disciplinary sciences (Castleden et al. 2012, Moser 2016). It can be difficult to obtain funding for coproduced research, and funding cycles are often shorter than the timelines needed to build and maintain productive relationships (Théberge et al. 2019). Members of Indigenous communities can also be mistrustful of Western-trained researchers and reluctant to collaborate, particularly if they view the aim of the researchers being to extract Indigenous knowledge, which can be seen as exploitation (Nadasdy 1999, Paci et al. 2002, Baker and Westman 2018). Members of Indigenous and rural communities who do participate in coproduction can also experience significant personal stress (Young et al. 2020). These challenges are particularly salient in the boreal forest of Canada, where the socioeconomic and cultural context is incredibly complex: spanning dozens of jurisdictions when considering Indigenous peoples, provinces, territories, municipalities, and other actors involved in boreal forest conservation and management (Wells 2011).

In this paper, we aim to help Western-trained academic researchers, particularly those in the natural sciences and early career stages, navigate this complex context. How does one identify potential research partners, initiate a partnership, and work respectfully with these partners in a transdisciplinary way? The skills required to initiate and execute coproduced research are rarely taught as part of Western science pedagogy. We contextualize coproduced research on boreal birds by introducing potential partners for boreal bird research, and in particular we emphasize best practices for coproduction of research between non-Indigenous researchers and Indigenous partners. We introduce a four stage model for coproducing research: (1) identify potential partners, (2) build relationships, (3) identify mechanisms to inform policy and management, and (4) plan and execute research. We provide accompanying tools to identify potential partners and evaluate partnership strength, as well as “bright spots” (Cvitanovic and Hobday 2018): examples of coproduced research on boreal birds influencing policy and practice. Throughout, we invite researchers to consider the diverse perspectives of many knowledge-holders through development of intercultural relationships in support of better conservation of boreal birds.

CONTEXT FOR COPRODUCED RESEARCH ON BOREAL BIRDS

Coproduction of ecological research is sometimes termed translational ecology or transdisciplinary science (Lang et al. 2012, Moser 2016, Enquist et al. 2017). We define coproduction of research according to Enquist et al. (2017:542)^[2]: “an approach that embodies intentional processes by which ecologists, stakeholders, and decision makers work collaboratively to develop and deliver ecological research that, ideally, results in improved environment-related decision making.” Various authors have defined coproduction and its stages differently (e.g., a three-stage model enumerated by Page et al. 2016), but generally, most definitions of coproduced research include elements of research design, conduct, and dissemination that are completed in relationship with partners. We define a partner as an individual, organization, or community who participates in all phases of a research project to a degree that they have autonomously determined.

In Canada’s boreal forest, researchers should expect to consider different sectors of society as potential partners. We simplify these sectors to six: Indigenous peoples, Canadian government agencies and programs, private industry, nongovernment organizations (NGOs), citizens groups, and academia. Before initiating a partnership, it is important that researchers understand these sectors of society, their governance, and their potential interest in actionable research on boreal birds. We give a brief review for context.

Indigenous peoples

Boreal birds have been stewarded by Indigenous peoples for millennia, and many bird species continue to have great importance in Indigenous cultures (Kuhnlein and Humphries 2017). There are approximately 600 Indigenous communities in the Canadian boreal forest (including First Nations, Métis, and Inuit; Wells et al. 2013, Reid 2014), and communities and their members generally hold Aboriginal and Treaty Rights or Land Claim Agreements on their traditional territories. Indigenous nations, rights-holders, and communities have jurisdiction over boreal lands and therefore researchers must follow their laws, protocols, procedures, and guidelines to receive approval to conduct research. Indigenous governments, comanagement boards, communities, and individuals often lead their own research (Cram and Phillips 2012). Such groups may seek out academically trained scientists from outside the community to assist with this research, such as recruitment of scientists to provide training on bird species at risk by Moose Cree First Nation (MCFN 2018). There is a mandated requirement for Indigenous knowledge to be included in some environmental decision-making processes, such as impact assessment (*Impact Assessment Act*, S.C. 2019, c. 28, s. 1).

Though we include comanagement boards in this section, they represent institutes of public governments that are created by land claim agreements. Comanagement boards include representatives appointed by Indigenous and non-Indigenous governments, and often lead or conduct research (Box 1).

Box 1: Bright spot: Indigenous communities leading research priorities for the Gwich'in Renewable Resources Board

The Gwich'in Renewable Resource Board (GRRB) is a public comanagement body established under the Gwich'in Comprehensive Land Claim Agreement (GCLCA; 1992) as the main instrument of wildlife, fish, and forest management in the Gwich'in Settlement Area (GSA), Northwest Territories. The Board acts in the public interest, representing all the parties to the GCLCA: the Gwich'in, the people of the Northwest Territories, and all Canadians. Many Gwich'in families still maintain summer and winter camps and lead traditional lifestyles, hunting, trapping, and fishing. The GRRB relies on Renewable Resources Councils in the regional communities to be the eyes and ears on the land, identifying research interests at the community level, as well as providing advice on the GRRB’s work.

GRRB staff are active in collecting information on community research interests even if it is not directly related to the Board’s mandate. Every five years, the GRRB holds a workshop in collaboration with their partners to establish research priorities.

This assists the Board in allocating support to individual research projects. The GRRB encourages research that is meaningful to the communities. Through its Wildlife Studies Fund and Youth Work Experience Program, the GRRB provides funding to various organizations to implement projects that will assist with renewable resource management in the GSA. In addition to funding, the GRRB may also provide in-kind support to researchers and communities, such as staff involvement, office space, admin support, equipment, transportation, letters of support, and advice. Overall, the GRRB helps inform researchers of existing processes and context in the GSA, bridge gaps between researchers and communities, and ensure community interests are considered.

density models for the three species (Haché et al. 2014). However, ECCC scientists found that these models were not accurate enough for identification of critical habitat, leading to tighter collaboration between partners, and an iterative process for refining and improving the models. This included adapting previously used approaches for boreal-breeding birds and other wide-ranging species (e.g., caribou) in an effort to develop a standardized approach to the identification of critical habitat that could be used for other species in the future. This collaborative process will help ensure that the resulting research products meet the recovery planning needs of ECCC, fulfilling legal requirements under SARA.

Canadian government agencies and programs

Canadian government agencies^[3] at federal, provincial, and territorial levels run programs intended to fulfill their legislated obligations, including delivering on responsibilities toward the protection of boreal birds and their habitat. These programs conduct or fund research, participate in comanagement boards and regulatory processes, and plan, establish, or implement protected areas. Agencies commonly fund other partners, including conservation or education actions by NGOs or other groups (e.g., projects funded by Ontario's Species at Risk Stewardship Fund, the Northwest Territories Species Conservation and Recovery Fund, and others) or academic research, such as through Canada's National Research Council. Agencies regularly partner with researchers, Indigenous governments, Indigenous communities and organizations, comanagement boards, NGOs, local people, and citizen scientists to accomplish shared objectives of research and conservation implementation (Box 2).

Box 2: Bright spot: A research partnership to support critical habitat identification under the Species at Risk Act

Once a species is listed as threatened or endangered under Canada's federal Species at Risk Act (SARA; S.C. 2002, c.29), it is legally required that their critical habitat be identified and protected on federal lands. Typically, scientists at the relevant agency—Environment and Climate Change Canada (ECCC), Department of Fisheries and Oceans, or Parks Canada, depending on the species—are tasked with conducting the research and consultations required to identify critical habitat. In some cases, agencies coproduce research with partners to support critical habitat identification. For example, in 2013, ECCC requested the help of the Boreal Avian Modelling Project (BAM; Cumming et al. 2010), a consortium of academic and government scientists. This collaboration was designed to support identification of critical habitat for three species listed as threatened at the time (Common Nighthawk, *Chordeiles minor*; Olive-sided Flycatcher, *Contopus cooperi*; Canada Warbler, *Cardellina canadensis*) and to ensure policy decisions for these species were made based on best-available information.

ECCC and BAM worked together to design, execute, and refine the research. BAM initially produced national-scale population

Industry

The boreal forest is rich in many natural resources, including fresh water, wood fiber, peat, oil and gas, minerals, and hydroelectric potential, among others. Half of Canada's annual timber harvest occurs in this region, with nearly 200 communities (both Indigenous and non-Indigenous) dependent on forestry (Reid 2014). Mineral and oil and gas deposits, most yet untouched, are projected to be worth billions of dollars (Marshall 2016, CAPP 2017). On the other hand, the ecosystem services of the boreal forest are estimated to be worth over Can\$700 billion annually (Anielski and Wilson 2009). Most of the boreal forest region comprises publicly owned lands, and companies lease geographically defined tenures on a long-term basis from governments (Reid 2014). Forestry, mineral, oil and gas, and hydroelectric rights are leased separately to companies in those sectors, often on spatially overlapping tenures (Cumming and Armstrong 2001). Private companies, or umbrella organizations representing an industry, frequently partner with researchers to gain insight into the impacts of resource development on wildlife. Some organizations broker partnerships between academic researchers and industry (e.g., Mitacs Inc., <https://www.mitacs.ca/en/about>). Some companies or organizations also provide funding opportunities for research.

Nongovernment organizations

NGOs are usually nonprofit organizations acting to effect changes at international, national, or subnational levels. Here, we specifically refer to NGOs interested in environmental conservation as related to boreal birds. NGOs vary greatly in size, capacity, and approaches to achieve conservation outcomes (Redford et al. 2003). They may be focused on a particular geographic area, species, habitat type, or threat. Some NGOs have staff scientists and/or coordinate with volunteers to conduct research or monitoring activities to support their objectives (e.g., Kareiva et al. 2014). Some fund academic research on birds, for example, the Peregrine Fund or the Institute for Wetland and Waterfowl Research, providing direct opportunities for coproduction between NGOs and researchers. Some NGOs engage in advocacy and lobbying of government and industry to change legislation, policy, and practices to better support conservation objectives.

Citizens' groups

Citizen scientists, naturalists, and community knowledge holders are often-underutilized partners in boreal bird research (Bonney

et al. 2014, 2016). Although reports and data collected by citizen scientists are often used in research products (FitzGerald et al. 2017, La Sorte et al. 2017), citizen scientists themselves are rarely involved as full partners in coproduced research (Bonney et al. 2016). Yet, citizen scientists are a resource of enormous potential and skill: the most popular global platform for citizen ornithology, eBird, has almost 400,000 members who have contributed over 27 million checklists since 2002 (<http://www.ebird.org>). Although citizen scientist platforms are easily accessible by academic researchers, e.g., eBird, iNaturalist, or Facebook groups for local birding associations, formal partnership with citizens' groups generally needs to be initiated by researchers.

Academia

Academically trained scientists are usually skilled at locating and initiating partnerships with colleagues in their field of study. Potential academic partners involved in boreal bird research can generally be located by searching the literature, participating in conferences or symposia, or joining relevant academic societies (e.g., Society of Canadian Ornithologists, <https://www.sco-soc.ca/>). It can be more difficult to locate colleagues in other disciplines who may research similar subjects with a different lens. Transdisciplinary academic partnerships may be particularly useful for producing actionable research by combining the expertise of biologists and ecologists with that of legal scholars, sociologists, anthropologists, and political scientists (e.g., Moore et al. 2018, Westwood et al. 2019b, c).

INITIATING A COPRODUCED RESEARCH PROJECT

For researchers new to coproducing research with partners, we offer two observations. To be done well, coproduced research takes time, particularly in the phase of establishing active, respectful relationships (Castleden et al. 2012, Parsons et al. 2016). Second, building these relationships is of limited value as an isolated affair or when too narrowly focused. A coproduction model is much more effective when sustained for mutual benefit over the long term (Armitage et al. 2009, Kothari et al. 2013, Balvanera et al. 2017).

We provide guidance for and examples of coproduced research on boreal birds in the following four stages (Fig. 2): (1) identify potential partners; (2) build relationships; (3) identify mechanisms to inform policy and management; (4) execute research and communications plans. Researchers should also consult the accompanying worksheets (Appendix 1), which include exercises to guide a project through consideration of each of the stages of coproduced research.

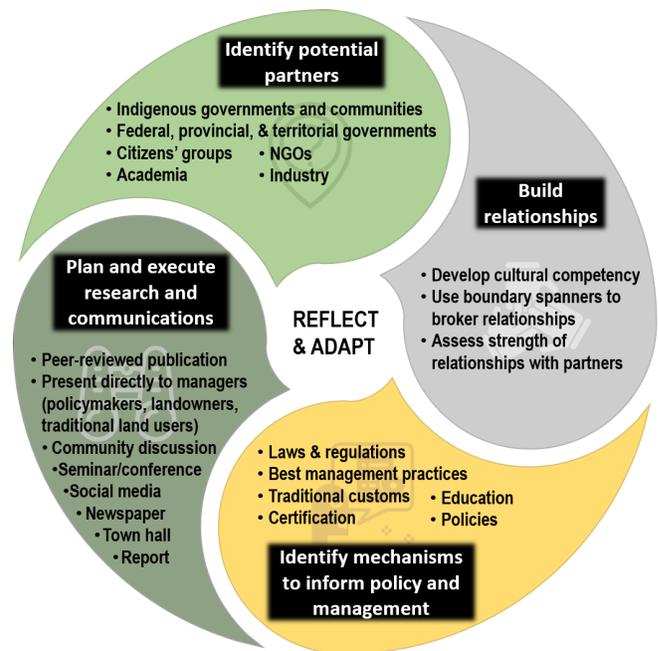
Identify potential partners

A coproduced research project can be initiated in many ways. For example, researchers can begin with a research interest in a particular species or region and then approach potential partners. In other instances, entities that have their own defined research interests may approach researchers. In the context of existing partnerships, researchers and their partners may jointly identify research interests.

Potential partners will include those who have a vested interest in, or may be affected by, the research questions, process, or

outcome.^[4] For example, potential partners may be interested in the bird species the researcher wishes to study. They may live on, have rights to, or use resources on the land under consideration for the study. The results of the research may have legal implications for a potential partner, e.g., locating a species at risk on privately owned land.

Fig. 2. Stages for researchers to undertake when coproducing research (dark green blocks) including best practices (light green blocks) and examples of potential partners, conservation mechanisms to target, and communication tools to use (text in circles).



If relationships are not already established, researchers can begin their search for partners based on the species or geographical area on which they are interested in conducting research. However, researchers with existing partnerships should also consider the evolving context for their work and whether they should reach out to additional partners. Boundary spanners are the individuals or organizations who cultivate and maintain relationships between sectors (Safford et al. 2017, Council of Canadian Academies 2019) and offer a good starting point for establishing new partnerships. Boundary spanners^[5] may assist in convening partners or coordinate coproduced research (Cash et al. 2006). Boundary spanners are particularly important because evidence demonstrates that communities often experience “consultation fatigue” (Expert Panel for the Review of Environmental Assessment Processes 2018, Young et al. 2020), with individual community members experiencing significant personal stress and exhaustion from ongoing consultation, coproduction, and/or cogovernance relationships. For this reason, we recommend that researchers first contact Indigenous organizations and governments, comanagement boards, Canadian government agencies, industry, NGOs, groups of citizen scientists, and consortiums comprising representatives from multiple sectors to

serve as boundary spanners, rather than approaching communities directly.

We discuss here some boundary spanning consortiums specifically related to conservation of boreal birds. Some focus on recovery and conservation of a single species at risk, like the Canada Warbler International Conservation Initiative (Box 3) or the International Rusty Blackbird Working Group (<http://rustyblackbird.org/>). Large multisector boundary spanners include the North American Bird Conservation Initiative (<http://nabci.net/>), BirdLife International (Devenish et al. 2009), and Partners in Flight (<https://partnersinflight.org/>), the North American Waterfowl Management Plan (<http://nawmp.wetlandnetwork.ca>), and the Canadian Migration Monitoring Network (McCracken et al. 2012). Many boundary spanning consortiums may focus on particular geographic regions and include taxa other than birds, such as the Northwest Boreal Landscape Conservation Cooperative (NWB LCC 2015). Others focus on a particular industry (e.g., Canadian Boreal Forest Agreement, <http://cbfa-efbc.ca/>), or a combination of geographic area and industry (e.g., Joint Oil Sands Implementation Plan, <https://www.canada.ca/en/environment-climate-change/services/oil-sands-monitoring.html>). The Conservation for Reconciliation Partnership (<https://conservation-reconciliation.ca/>) aims to bring together Indigenous leaders and communities with conservation researchers and organizations to promote Indigenous-led conservation. Consortiums like those listed above generally require research support to achieve their goals, and their activities foster advancement in policy and practice toward conservation of boreal birds. They also provide a forum for engaging experts who are well-acquainted with the research and management landscapes and priorities, through regular meetings and other communications. They can be valuable advisors for planning coproduced research, as well as for providing the architecture and enthusiasm to sustain research partnerships over time. By contacting boundary-spanning consortiums, researchers may obtain introductions to potential partners. However, researchers should also do their own outreach and ask known contacts about potential partners related to a region or species of interest.

Box 3: Bright Spot: The Canada Warbler International Conservation Initiative

The Canada Warbler International Conservation Initiative (CWICI; <http://naturecanada.ca/what-we-do/bird-conservation/canada-warbler/>) is a multinational collaboration to support and coordinate recovery efforts for the Canada Warbler across its full annual migratory cycle. Launched in 2013, the focus of CWICI is to support research and conservation actions for this rapidly declining species at risk (Environment Canada 2014). CWICI members work for Indigenous communities and organizations, Canada's federal government, NGOs, industry, and academia across seven countries. CWICI recognizes the need for collaborative participation if recovery is to be successful, and understands that management solutions must be respectful of local community values (Kennedy and Cheskey 2016).

The CWICI network has supported coproduced research initiatives, including studies of migratory connectivity and demography (Wilson et al. 2018, Céspedes and Bayly 2019), habitat management (Harding et al. 2017, Westwood et al. 2017a),

and spatial prioritization of areas for management (Westwood et al. 2017b, 2020). These initiatives were communicated in a variety of ways to partners, including on-the-land demonstrations of habitat, individual presentations, reports, and data products with instructions for use.

It is critical that before beginning any field-based study, researchers identify the holders of rights to lands and resources within their proposed study area. Just as one would obtain permission from a private landholder, researchers should ask permission of Indigenous rights-holders (and acknowledge them in publications and communications products). Researchers should be aware of the traditional territories and treaties relevant to the geographic area they wish to study (for maps of Indigenous lands: <https://native-land.ca/> or <https://geo.aadnc-aandc.gc.ca/cippn-fnpim/index-eng.html>). Though this is particularly salient for field studies for which land use permissions or permits may be required, Indigenous government approvals should be sought, and community involvement considered, when conducting reviews and meta-analyses.

Boundary spanners, particularly government agencies, can help locate private landowners and other rights-holders. National NGOs that work on bird conservation, such as Ducks Unlimited Canada, Bird Studies Canada, or the Nature Conservancy of Canada, are also likely to have staff who are aware of other NGOs operating in the region of interest, as well as other contacts. In addition, many naturalist groups hold regular meetings, presentations, nature walks, and information sessions, and are often very active on social media. These groups may yield vital information for researchers, such as occurrences of hard to find species, and local knowledge about habitats and land use change.

Build relationships

Building positive relationships early in the research planning and design process will foster collaboration and may lead to greater awareness, acceptance, and willingness from partners to use research results in their policies and management activities (Beier et al. 2017). Building such relationships takes time (Castleden et al. 2012). There are many Indigenous and resource-dependent communities dispersed throughout Canada's boreal forest, and conserving birds and habitat for the present and the future will require building respectful, long-term relationships with communities as partners.

After assessing potential partners as well as identifying boundary spanners who can facilitate partnerships, researchers should ensure they are sufficiently aware of and competent in the culture of their potential partners. They should self-assess their own ethical responsibilities toward both new potential partnerships, and existing partnerships (Box 4; Appendix 1), and consult Cram and Phillips's (2012) readiness scale for transdisciplinary research. By doing both of these exercises, researchers can identify areas of weakness, and work with partners to strengthen relationships. Being unable to answer self-assessment questions does not necessarily preclude establishing a partnership, but elucidates gaps that require learning and deeper engagement (although see Aveling 2013, where a non-Indigenous researcher concluded that they should not conduct research within Indigenous contexts).

Box 4: Self-assessment of research partnerships: questions to ask before engaging in research

Before beginning a research project, or initiating relationships to coproduce research, researchers should ask themselves the following questions related to consent from potential or current partners (adapted from Grant 2015). When considering potential partners, researchers should contemplate not only the individuals, organizations, and communities with which they wish to engage to conduct the research, but also, those who may be affected by the research outcomes. Potential partners may include formal entities like non-Indigenous or Indigenous governments, Indigenous groups or communities, comanagement boards, local communities, NGOs, and companies, and/or informal entities like citizen's groups, student groups, or existing research partnerships.

1. What is my research intent, e.g., serving my own interest, serving mutual interest, addressing partner-defined research questions, etc.?
2. Would I consider myself a member of this partner's community?
3. How am I entering into this relationship? Who invited me? Am I inviting myself?
4. What impacts have past research or researchers had on this partner?
5. Are there sensitive areas or topics I should avoid or be aware of?
6. What relationship do the funders of the research have with this partner?
7. What relationship do my other research partners have with this partner?
8. What has this partner told me about how to collaborate with them? Have they developed guidance documents or protocols?
9. Will this partner's knowledge be used to design the research?
10. Will my work contribute toward self-determination of this partner? For example, can I hire or train people from the local community?
11. Am I prepared to value the relationships with this partner above my research interests?
12. If tensions arise, have we or how will we establish interculturally appropriate protocols to resolve conflict?
13. Who will own or have intellectual property rights over the research results? Who will be credited, and how?

When non-Indigenous researchers wish to work with Indigenous partners, it is important to consider the historical context of Indigenous peoples and researchers or institutions involved in

research. In the boreal region, it has been reported that Indigenous perspectives and priorities for environmental resource management have been consistently ignored and/or marginalized (Stevenson 2004, Morse et al. 2005). There is increasing awareness of the need to move away from "researcher-driven" protocols and shift to partnerships with full and meaningful participation of Indigenous communities that respect their Aboriginal and treaty rights (Karst 2010, Stiegman and Castleden 2015).

Any socially just approach to bird research on Indigenous lands or traditional territories must include Indigenous partners as they wish to be included (Forsyth 2008, Papillon and Rodon 2017). Canada has recently signed the United National Declaration on the Rights of Indigenous Peoples (UNDRIP; United Nations 2008), and prior to pursuing research partnerships with Indigenous governments and communities, researchers should familiarize themselves with how UNDRIP may apply to their organization's work or that of other partners (see A-In-Chut Atleo 2012). Researchers should ensure to meet, if not exceed, norms of free, prior, and informed consent (see Papillon and Rodon 2017 for a discussion) by actively pursuing Indigenous government approvals and engaging Indigenous and other local communities at all steps as partners, whenever possible.

Western-trained researchers should make themselves aware of and open to different knowledge systems that may be involved in cross-cultural collaborations (Wyatt 2008, Cram and Phillips 2012), before seeking to work with Indigenous scientists and knowledge-holders. They should also follow respectful practices when engaging Indigenous governments and communities in coproduction of research (Box 5). Many Indigenous communities self-define their knowledge systems (ITK 2018). Although there are many Western-led discussions of bridging knowledge systems or coproducing research between Indigenous and Western researchers (Gadgil et al. 1993, Tengö et al. 2014, Alexander et al. 2019, Institute on Governance 2019, Thériberge et al. 2019), many Western conceptions of Indigenous knowledge have not been defined by Indigenous peoples themselves (Nelson 2005). By better understanding these knowledge systems, researchers can more meaningfully include Indigenous knowledge in their work, often adding value to the ecological nature of the study (Gadgil et al. 1993).

Box 5: Suggested practices for respectfully engaging Indigenous communities in research

This nonexhaustive list of respectful practices for engaging Indigenous governments and communities in coproduction of research is based on author experience and existing best practices in the literature.

- Follow the "Four R's" of respect, relevance, reciprocity, responsibility (Kirkness and Barnhardt 2001) and build relationships first (Castleden et al. 2012);
- Familiarize yourself with research guides prepared by Indigenous governments and groups (e.g., Gwich'in Social & Cultural Institute 2005, ITK 2018);
- Work with Indigenous partners to understand their research interests and priorities (Adams et al. 2014), and identify their

concerns and questions. Look for opportunities to help them advance their own initiatives before asking if they would like to partner on your research;

- Codesign research goals, objectives, and methods. Preparation and clarity are important, but plans need to be flexible;
- Do not be afraid to politely ask for help or guidance. Community members understand the landscape and can recommend where to go, or areas to avoid based on cultural significance;
- Respect the place-based setting and the authority of the government or community (Adams et al. 2014, Théberge et al. 2019). Use Indigenous language where appropriate, e.g., greetings, place names, wildlife, and plants, but be sensitive to concerns about cultural appropriation. When in doubt, ask;
- Hire and train local people using job descriptions that recognize and accommodate their skillsets;
- Analysis usually occurs away from the community, creating a disconnect. Keep the conversation going: build in iterative opportunities for feedback and verification;
- Ask partners how they wish to receive results (Salomon et al. 2018), which will often be in person. Follow principles of good public communication: avoid jargon and present results in accessible formats such as plain language summaries, but be prepared to answer complex questions. Be conscious of sensitive or confidential material (Adams et al. 2014);
- Present results at local or regional meetings to reach a wider audience, e.g., during the annual general meeting of a hunting, fishing, and trapping association. If you cannot present in person, send a plain language report, share on social media, and/or contribute to a local news show;
- Know that translation may be needed, including live translation during presentations. Your partner may be able to help organize translation services;
- Ensure that Indigenous knowledge holders are credited for the information they provide, and follow ethical and permitting guidelines (e.g., Gwich'in Social & Cultural Institute 2005). Be prepared to pay knowledge holders for their time and/or to sign data-sharing or intellectual property agreements;
- Respect established protocols for storage, sharing, and dissemination of data (First Nations Information Governance Centre 2014), or codevelop new ones;
- Create opportunities for shared learning by going into schools, giving workshops, providing and participating in on-the-land activities, and others (Adams et al. 2014). Attend community events when possible; and
- Thank your partners appropriately for allowing you to conduct work on their land and in partnership with them.

Identify mechanisms to inform policy and management

To improve conservation outcomes for boreal birds, research can target specific mechanisms for policy or action, most of which involve preventing or remediating human impacts on habitat. We group mechanisms that can inform conservation policy and initiatives into four types: (1) legal mechanisms, (2) land conservation, (3) industrial management, and (4) education and training. We briefly discuss the types of boreal bird research that can inform each type. Identifying relevant mechanisms can also help identify potential partners who have the leverage to use or change those mechanism (Evans and Cvitanovic 2018).

Legal mechanisms

In Canada, legal mechanisms for achieving conservation goals typically include laws, set as Acts of Parliament or Legislature, and the regulations that specify how an act will be implemented. Responsibility for protection and management of birds is divided between the federal government and provincial/territorial governments as a result of the Canadian Constitution. The federal government also has the power to ratify international agreements, which may then be enacted nationally through an act. Provinces and in some cases, territories, can also enact legislation and associated regulations. These jurisdictions may further delegate to municipalities the right to enact certain bylaws pertaining to wildlife.

The management of most migratory bird species on any lands is a federal responsibility because of the 1916 Migratory Bird Convention between the United Kingdom, representing Canada, and the United States. Protections were then enshrined under the Migratory Birds Convention Act (S.C. 1994, c.22) in 1917, and later amended in 1994. For example, under this Act, the hunting of migratory game birds, e.g., ducks and geese, is regulated primarily by the federal government whereas provinces and territories have jurisdiction over the hunting of nonmigratory game birds such as grouse, ptarmigan, and turkeys. Management of most boreal forest lands is the jurisdiction of the provinces or territories. However, the federal government can implement habitat protection orders on provincial Crown lands under the SARA (S.C. 2002, c.29), though this power is rarely exercised.

Although some summaries of government laws and regulations related to boreal birds exist, many are outdated or only relevant to a specific topic (wildlife conservation in Canada, Lynch-Stewart et al. 1999; species at risk in North America, Temby and Stoett 2017; forest management practices in Canada, NCASI 2014). We summarize key Canadian laws and agreements related to conservation of boreal birds (Table 1) and encourage others to compile and share regional, provincial, or territorial summaries (for Newfoundland and Labrador, see Appendix 2). Laws and regulations related to agreements with Indigenous peoples can change depending on specific land claim agreements or treaties, such as the ability to take wildlife under harvesting rights, e.g., the Nunavik Inuit Land Claims Agreement and others (see also Istvanffy 2011). As unsettled land claims evolve in the courts (Government of Canada 2018), the future may bring greater Indigenous governance over boreal lands and resources, which could have profound implications for conservation for boreal birds.

Table 1. List of major Canadian statutes and international agreements impacting bird conservation in Canada. Legislation can be direct (purposed with protecting wildlife, including birds), or indirect (not purposed with protecting wildlife, but potentially beneficial through protection of habitat, prevention of harm, or other mechanisms). Years in brackets are the years of first introduction, and if repealed and replaced, the year of most recent replacement given following the title. Legislation that was repealed without replacement is not included.

Act/Agreement	Type	Other Signatories	Impact on boreal birds
[1916] Migratory Bird Convention (Bilateral)	Direct	U.S.	Protects most migratory birds from unregulated kill or capture from physical disturbances or hunting.
[1917] Migratory Birds Convention Act 1994	Direct		Includes measures for protecting migratory birds and their nests, regulations for migratory bird hunting, and enables creation of federal migratory bird sanctuaries, among other items.
[1930] Canada National Parks Act 2000	Indirect		Has the goal of establishing national parks and grants government authority to control activities conducted therein. Parks may serve as long-term protected areas that can be used to maintain populations.
[1973] Convention on the International Trade in Endangered Species	Direct	183 parties	Ensures that international trade in birds or their materials does not threaten the survival of species.
[1985] Canada Wildlife Act	Direct		Allows for creation, management, and protection of wildlife areas for research activities, conservation, and/or interpretation with emphasis on migratory birds and species at risk.
[1985] Canadian Energy Regulator Act 2019	Indirect		Regulates approvals for large-scale transboundary energy projects such as pipelines that may impact bird habitat, survivability, or increase or mitigate climate change.
[1985] Forestry Act	Indirect		Governs forest research, protection, and utilization of forest lands under jurisdiction of the federal government. May impact habitat of forest-dwelling birds.
[1986] North American Waterfowl Management Plan	Direct	U.S. and Mexico	Partnership to conserve waterfowl populations through management decisions based on science.
[1992] UN Convention on Biological Diversity	Direct	196 parties	Agreement to protect biodiversity, use biodiversity without destroying it, and share benefits from genetic diversity equally. This has led to important conservation outcomes in such as development of the Species at Risk Act and complimentary provincial acts, and a federal/provincial commitment to protect 17% of Canada's lands and inland waters by 2020.
[1994] Commission for Environmental Cooperation	Direct	U.S. and Mexico	Facilitate environmental cooperation and enforcement as related to trade issues.
[1995] Impact Assessment Act 2019	Indirect		Regulates approval process for some resource extraction and development projects outside of the Northwest Territories, the Yukon, and Nunavut that may impact bird habitat, survivability, or increase or mitigate climate change.
[1996] Trilateral Committee for Wildlife and Ecosystem Conservation and Management	Direct	U.S. and Mexico	Fosters cooperation and development of partnerships among wildlife agencies and other interested parties of the three countries.
[1998] Parks Canada Agency Act	Indirect		Outlines obligations and authorities of the Parks Canada Agency for protecting nationally significant natural and cultural heritage, including stewardship of species at risk.
[1998] Mackenzie Valley Resource Management Act	Indirect		Regulates approval process for some resource extraction and development projects in the Mackenzie Valley region (Northwest Territories) that may impact bird habitat, survivability, or increase or mitigate climate change.
[1999] Canadian Environmental Protection Act	Indirect		May control toxic exposure of harmful chemicals for birds.
[2002] Species At Risk Act	Direct		Prevent wildlife species from being extirpated or becoming extinct, provide for recovery of species that are extirpated, endangered, or threatened as a result of human activity, and manage species of special concern.
[2003] Yukon Environmental and Socio-economic Assessment Act	Indirect		Regulates approval process for some resource extraction and development projects in the Yukon that may impact bird habitat, survivability, or increase or mitigate climate change.
[2008] Federal Sustainable Development Act	Indirect		Governs development and implementation of a federal sustainable development strategy that may impact birds and their habitat through location and intensity of development activities.
[2010] Environmental Enforcement Act	Indirect		Amends other acts to harmonize tools for prosecuting offenders for breaking environmental law, including harm of birds and bird habitat.
[2013] Nunavut Planning and Project Assessment Act	Indirect		Regulates approval process for some resource extraction and development projects in Nunavut that may impact bird habitat, survivability, or increase or mitigate climate change.
[2016] U.N. Declaration on the Rights of Indigenous Peoples	Indirect	148 parties	Recognizes the right of Indigenous Peoples to their traditional territories, as well as to the conservation of medicinal plants and animals, and other rights to development and decision making on traditional territories.

Research is needed to support the implementation of, or adherence to, laws. Reducing harm to species and habitats is an ongoing challenge for industry and government, and scientists are often asked to support the development of policies or practices to address these issues (e.g., NCASI and FPAC 2016, CEA 2018). In addition, scientists (usually consultants) may be hired by a company to conduct surveys or develop species-habitat models to determine the presence, and in some cases trends of, migratory bird populations in their operating areas, with a focus on species at risk. Research is also conducted to identify possible impacts of new industrial development on species. Federal, provincial, and territorial government staff can be useful boundary spanners for understanding the interface between research and law.

Land conservation

Boreal birds can be protected from human impacts by conserving land. Methods for land conservation range from government-led creation of new parks and wilderness areas, to private preservation and stewardship of land by NGOs, to areas managed for resource use by Indigenous communities, and many others (MacKinnon et al. 2015). Research is needed to identify new areas to protect or manage for boreal bird species (Westwood et al. 2017b, Stralberg et al. 2018, Bale et al. 2020). Research is also needed to support ongoing management, monitoring, and evaluation of the effectiveness of protected areas for conserving boreal birds (Westwood et al. 2019a). Future expansion of protected areas within the boreal forest will necessarily involve Indigenous governments as well as comanagement boards. Indigenous peoples are currently leaders in some of the most progressive, cutting-edge land and wildlife comanagement plans and models in the world (Badiou et al. 2013, Carlson et al. 2015; Box 6).

Box 6: Bright spot: Indigenous protected and conserved areas in Canada

Historically, Indigenous peoples have been forcibly relocated or excluded from Canada's national parks (Langdon et al. 2010, McNamee 2010). Parks Canada's policies were updated in the 1990s (Parks Canada 1994) to specify that when land claims exist or are under negotiation in an area, in order to establish a new park, agreements must be developed with Indigenous governments and communities to ensure the protection of their rights to carry out traditional and customary activities within the park (Langdon et al. 2010). This has led to the creation of various forms of cooperative management for new national parks, and virtually all of the > 150,000 km² expansion of Canada's national park system from 1992 to 2017 involved such agreements. Comanagement boards and committees have a strong role in advising Parks Canada and the responsible Minister on management of the parks; among other things, this typically includes providing advice on research priorities and research permit requests and ensuring the inclusion and consideration of Indigenous knowledge in park research programs.

The presence of Indigenous Protected and Conserved Areas (IPCAs) in Canada is likely to expand in the immediate future (ECCC 2018a, Indigenous Circle of Experts 2018, Lavoie 2018). This change is partly driven by a federal government-led desire for reconciliation between Indigenous and non-Indigenous societies, and Canada's goal of protecting at least 17% of its

terrestrial habitats by 2020 (Convention on Biological Diversity 2010). IPCA creation has been substantial: with the partnership of the Decho First Nations, there has been a ~25,000 km² expansion of Nahanni National Park Reserve (Badiou et al. 2013) and the creation of the 14,000 km² Edézhzhie Protected Area (ECCC 2018a). Several First Nations communities joined to protect 28,000 km² of bird-rich habitat along the Manitoba-Ontario border under the name of Pimachiowin Aki, the Land that Gives Life (Davidson-Hunt et al. 2012, Wells et al. 2013). In 2019, Łutsël K'é Dene First Nation signed an agreement with the governments of Canada and the Northwest Territories to protect a 26,000 km² area of boreal forest called Thaidene Nënë, or Land of the Ancestors (Hoag 2019). These areas protect millions of breeding birds, and the rise of IPCAs in Canada may also represent a rich opportunity for coproduction of conservation-oriented knowledge that benefits both Indigenous and non-Indigenous societies.

Industrial management

Market pressures have incentivized industries to offer products considered to be more environmentally and socially acceptable than those produced by competitors (Rametsteiner and Simula 2003, Cashore et al. 2005, Luckert et al. 2011). In the boreal forest, forest certification is an important mechanism to ensure forest management is done to a standard that reduces harm to wildlife (Kneeshaw et al. 2000, Rametsteiner and Simula 2003). All three certification standards used in the boreal forest (Canadian Standards Association Group 2016, Forest Stewardship Council Canada Working Group 2004, SFI 2015) include requirements pertaining to conservation of biodiversity, migratory birds, and species at risk. All major forest management companies in Canada are now certified under one or more of these systems (Certification Canada 2018). Some of these certifications require companies to directly fund or provide in-kind support to research on migratory birds (e.g., Loehle et al. 2006, ABMI 2009) while others provide grants to NGOs or academic institutions for conservation-related research (e.g., SFI 2018) and updating standards of practice (Finney 2013).

Although other resource sectors in Canada have not implemented certification programs, the mining industry has developed an independently verified management program called, "Toward Sustainable Mining" (TSM; Mining Association of Canada 2017), which incorporates biodiversity commitments, planning, and reporting, among other measures.

Research about human impacts on birds is directly relevant to companies' best management practices (BMPs). BMPs detail practices that may be applied during planning, execution, or monitoring phases of a project, and are intended to have a neutral or net positive effect on migratory birds or their habitat (ECCC 2018b). Research can be used to identify ways of reducing harm to nests and eggs (e.g., Ontario Stone, Sand & Gravel Association 2017), or educate personnel to identify or manage nests or nesting areas (Westwood et al. 2017a). Some industrial sectors have developed BMPs related to migratory birds in Canada on their own, e.g., pipelines (CEPA 2013) or in conjunction with government, e.g., gravel quarrying (Ontario Ministry of Natural

Resources and Forestry 2017). Coproduction between industry and external researchers can allow for better integration of existing scientific knowledge into BMPs, as well as new projects specifically designed to test and improve BMPs (Box 7; Fig. 3).

Fig. 3. Construction of a wetland crossing as part of a coproduced research project for developing best management practices to minimize effects on wetland habitats for birds and other wildlife. Photo provided by Ducks Unlimited Canada with permission from those pictured therein.



Box 7: Bright spot: Collaboration between industry and an NGO to develop best management practices

Coproducing research to develop BMPs has the potential to fulfill mutually compatible goals between industry and other sectors. For example, BMPs for constructing wetland crossings can maintain migratory bird habitat while helping industry reduce road maintenance costs and meet regulatory requirements. To understand the current state of knowledge on wetland crossing techniques as well as conduct field trials to test new techniques, Weyerhaeuser Canada, Louisiana-Pacific Canada Ltd., and Spruce Products Ltd. collaborated with Ducks Unlimited Canada (DUC) and FPInnovations as part of an SFI Conservation and Community Partnerships Grant. Over the three-year project, the partners developed crossing designs to accommodate different types of wetlands in several regions along the Manitoba-Saskatchewan border (Fig. 3). Partners tested these designs using field trials and evaluated their ability to minimize the hydrologic effects of roads, which is important for maintaining habitat for wetland birds (DUC 2014a). The results were used to develop an “Operational Guide: Forest road wetland crossings” for the region (DUC 2014b).

Education and training

Education and training about boreal birds and their habitats are offered in many forms by many partners, ranging from workshops

on bird identification to funding graduate students studying boreal birds, and beyond. Funders support education opportunities that researchers can support and participate in, e.g., the Northwest Territories Species Conservation and Recovery Fund supports several Rusty Blackbird awareness campaigns (NWT Species at Risk 2018). There are many opportunities for researchers to volunteer their time and knowledge with universities, citizen’s groups, NGOs, and more. Indigenous communities across the boreal region are also training on-the-ground guardians, whose duties typically span land and resource management, research and monitoring (including bird-specific monitoring), safety and enforcement, and education in protected areas within their traditional territories (e.g., Łutsël K’è Dene First Nation 2016, Coastal First Nations Great Bear Initiative 2018). Indigenous customs can also inform management, and through coproduction, Indigenous partners may have suggestions for how to apply these to achieve management objectives for boreal birds.

Plan and execute research and communications

After relationships with partners are established around research questions of mutual interest, and partners have collaboratively identified mechanisms by which research can be used to advance conservation of boreal birds, partners can develop formal plans for conducting and communicating research. There exists a great body of work about research planning and execution, but we recommend the following guides in particular that are focused on coproducing actionable research: Wolfe et al. 2011, Lang et al. 2012, Adams et al. 2014, Tondou et al. 2014, ACCCNRS 2015, Chigbu et al. 2016, Moser 2016, Parsons et al. 2016, Beier et al. 2017, Wall et al. 2017.

Beyond those offered in the literature, we make several additional suggestions for areas researchers should consider when planning and executing coproduced research. Each project should be customized to include parameters, timelines, and approaches agreed to by all partners. At all times, researchers should maintain principles of respectful partnership. Involving partners in research planning and implementation is key, and may include guidance and oversight at every step of the research process as well as paid participation of local community members in data collection and analysis. Researchers should also adhere to standards of scientific integrity, including methodological rigor, upholding research ethics, responsible research conduct, reproducibility (where applicable), and openness of information (Innovation Science and Economic Development Canada 2018, Jacob et al. 2018, Westwood et al. 2019c).

Research planning should also be paired with communications planning because communicating research results in a variety of formats is necessary to ensure actionability and maintain relationships (Dasgupta 2017, Kowalczywska and Behagel 2019). Just as a research plan includes when and how partners will participate in research, communications planning should include how and when members of the partnership will communicate with each other and broader audiences. Communications plans should include specific outputs that are desired by partners and that meet their needs (Adams et al. 2014, Moore et al. 2018, Salomon et al. 2018). Many partners do not have access to scientific literature, so upholding standards of open access is important (Government of Canada 2016, Gregr et al. 2017, Westwood et al. 2019c) as well as

making brief plain-language summaries and presentations available. In remote communities, internet access may not be reliable, universally accessible, or culturally appropriate. Researchers should consider broadening their usual areas of communications to include radio ads, community web and social media pages, community groups, publications in trade magazines and newspapers, and media interviews. Briefing notes can be particularly useful in informing government policy.

Despite the advantages of coproduced research toward actionability for conserving boreal birds, as previously discussed, this approach is of less value as a one-time affair. Ideally, research partnerships will be sustained by their host organizations and evolve, allowing partners to accomplish multiple projects together (Box 8) as research priorities change over time. Reflection and adaptation, as well as iterative reevaluation of partnership strength (Box 4) will be key components in maintaining successful partnerships for research coproduction over the long term.

Box 8: Bright spot: Identifying boreal conservation priorities and habitat objectives for waterfowl

In the late 1980s, the Prairie Habitat Joint Venture (PHJV) was formed to consolidate conservation efforts of government and NGO partners in Canada's Prairie Provinces, in order to better achieve long-term waterfowl population goals. The PHJV expanded in 2001 to include the western boreal forest, which provides key habitats to wetland birds (PHJV 2014). Since that time, a total of 61 First Nations, academic, industrial, government, and NGO partners have contributed to PHJV accomplishments in the boreal forest. The PHJV coordinates research among its partners through means such as reviewing population status of boreal waterfowl and wetland-dependent birds, outlining short and long-term habitat objectives, identifying knowledge gaps, and others (PHJV 2014).

PHJV partners coproduced a new spatial planning tool in order to set objectives for conserving boreal waterfowl habitat. This model was supported by a government-funded, academic-NGO partnership (Barker et al. 2014). Ducks Unlimited Canada scientists advised throughout the model-creation process, worked collaboratively with academic and government scientists to develop the model, and have since used the results to identify and prioritize areas for habitat management.

CONCLUSIONS AND LIMITATIONS

Applying research results to policy and decision making is a challenge that goes well beyond the scientific method (ACCCNRS 2015, Beier et al. 2017, Evans and Cvitanovic 2018, Reed et al. 2018). We hope researchers will use the coproduction model in this paper (and the worksheets in Appendix 1) to engage in research that is not only actionable for the conservation of boreal birds, but fully respects the agency of partners (Reo et al. 2017). Nevertheless, we recognize that the review we have provided has several limitations.

First, environmental governance is ever changing. We have described some potential partners related to boreal bird research,

but this is only a snapshot in time. Further, we have only described potential partners and mechanisms for achieving conservation outcomes to make readers aware of their existence, but we have not evaluated their effectiveness. We welcome future work comparing and contrasting programs, within and between sectors, to assess their effectiveness toward conserving habitat and populations of boreal birds.

We also recognize that many birds that breed in the boreal forest reside or migrate through other parts of North America, the Caribbean, and Latin America (Wells and Blancher 2011). Actions taken in Canada may be insufficient to protect species threatened on their migratory or wintering grounds (Marra et al. 2015). Ideally, coproduction of research for migratory species should be international, spanning the full annual cycle of boreal birds. We encourage researchers to communicate and collaborate with partners outside of species' breeding ranges as much as possible, to ensure that their work is positioned to contribute to a full annual cycle research and conservation framework.

Finally, the authors come from a diversity of sectors, institutions, and cultures living and operating in Canada's boreal forest, or are scholars from outside of this region who study related principles and practices of coproduction. We offer recommendations from our experiences but recognize that we cannot capture all perspectives. Still, we hope this guide will catalyze conversations about coproduced research amongst researchers in their own institutions and communities, as well as offering immediately usable design and process principles.

Conserving and sustainably managing Canada's boreal forest, its birds, and our common future, requires substantive coproduction of knowledge, policy, and natural resource management practice. Although we have emphasized boreal birds, the approach recommended herein could apply to other taxa and regions. We encourage researchers to adopt coproduction practices early in their careers and instill values of coproduction in the scientists they mentor (Courter 2011). In this way, researchers can not only maximize their own contributions to the conservation of boreal birds and their habitats, but also support partners, particularly Indigenous rights-holders, governments, and local communities, to do the same.

^[1] In this paper we use the term "Indigenous peoples" to reflect current convention for the Government of Canada (Government of Canada 2017), though other terms may be used to reflect either the names a given people use to refer to themselves, or historical documentation (such as legal cases, or "Aboriginal peoples" in the case of Canada's Constitution).

^[2] Enquist et al. (2017) defined "translational ecology," however, we use "coproduction" interchangeably and thus adopt the same definition.

^[3] Although Canadian governments use both the term "department" and "agency" to refer to their major branches, we use "agency" as a catch-all inclusive of both agencies and departments.

^[4] We have chosen the word "partners" deliberately. Though some authors would use terms such as "stakeholders," "actors," or "interest groups" synonymously, such language can reinforce obstacles to participation by Indigenous peoples (Reo et al. 2017).

^[5]The term “boundary spanner” is sometimes used synonymously with “knowledge broker” (Cooke and Vermaire 2015) and “bridging organization” (Fernández 2016). However, these terms have other meanings specifically related to knowledge exchange (e.g., Chapman et al. 2015, Alexander et al. 2019) and we use boundary spanner to specifically refer to potential brokers for relationships.

Responses to this article can be read online at:
<http://www.ace-eco.org/issues/responses.php/1589>

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From research to action

Facilitating knowledge exchange in ecology by building respectful partnerships

Worksheets

Overview of a coproduction model to make research actionable

Most scientists studying species, ecosystems, and natural resources hope the results of their research will inform policies and management activities. Making research ‘actionable’ in this way requires effective knowledge exchange between the producers of knowledge (in our case, scientists) and the users who can apply the knowledge. There are many knowledge exchange techniques, but in this workshop, we focus coproduction of research: when scientists partner with those implicated in, or affected by, their research. Scientists and their partners design, execute, and communicate research in a way that is informed by all partner needs. To ensure coproduction of research is both effective and respectful, we introduce a four-stage model (Westwood et al. in press; last page). This workshop will guide you through each stage.

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Further guidance on...

Applying this model: Westwood, A., Barker, N.K.S., et al. 2020. Towards a coproduction research model for actionable research on boreal birds with a focus on building respectful partnerships. *Avian Conservation and Ecology*.

Coproduction generally: Beier, P., L. J. Hansen, L. Helbrecht, and Behar, D. 2017. A how-to guide for coproduction of actionable science. *Conservation Letters* 10(3):288–296.

Coproducing research with Indigenous partners: Théberge, D., M.-A. Picard, J. Leguerrier, J.-M. Beaudoin, and F. Grenon. 2019. Initiative for knowledge co-creation in collaboration with Indigenous communities. Basic approach: Ethics of research. Report submitted to Natural Resources Canada. Quebec, Chair of Educational Leadership in Indigenous Forestry Université Laval. Available at: <https://cfs.nrcan.gc.ca/publications?id=40002>

Stage 2: Self-assess relationships

Before beginning project, or initiating relationships to coproduce research, researchers should ask themselves the following questions to assess the strength of their relationship with potential or current partners. First, select the partner from Stage 1 with whom you have the strongest existing relationship. Then, fill out the following questionnaire to self-assess your strength of that relationship. Note that there are no right or wrong answers: this exercise is meant to encourage reflection and identify areas to strengthen your partnership. Fill out a separate version of the questionnaire for each actual or potential partner for your research project.

1. What is my research intent? (e.g. serving my own interest, serving mutual interest, serving partner-defined research questions, etc.)

2. Would I consider myself a member of this partner’s community?

3. How am I entering into this relationship? Who invited me? Am I inviting myself?

4. What impacts have past research or researchers had on this partner?

5. Are there sensitive areas or topics I should avoid or be aware of?

6. What relationship do the funders of the research have with this partner?

7. What relationship do my other research partners have with this partner?

8. What has this partner told me about how to work in collaboration with them? Have they developed guidance documents or protocols?

9. Will this partner's knowledge be used to design the research?

10. Will my work contribute towards self-determination of this partner? For example, can I hire people from the local community?

11. Am I prepared to value the relationships with this partner above my research interests?

12. If tensions arise, have we or how will we establish inter-culturally appropriate protocols to resolve conflict?

13. Who will own or have intellectual property rights over the research results? Who will be credited, and how?

Stage 3: Identify policy mechanisms

With your group, brainstorm laws, policies, and activities applicable to each of your projects. Consult the examples provided by the facilitator. Include in your list the people who might be in charge of, or carry out, these laws, policies, or activities. Consider:

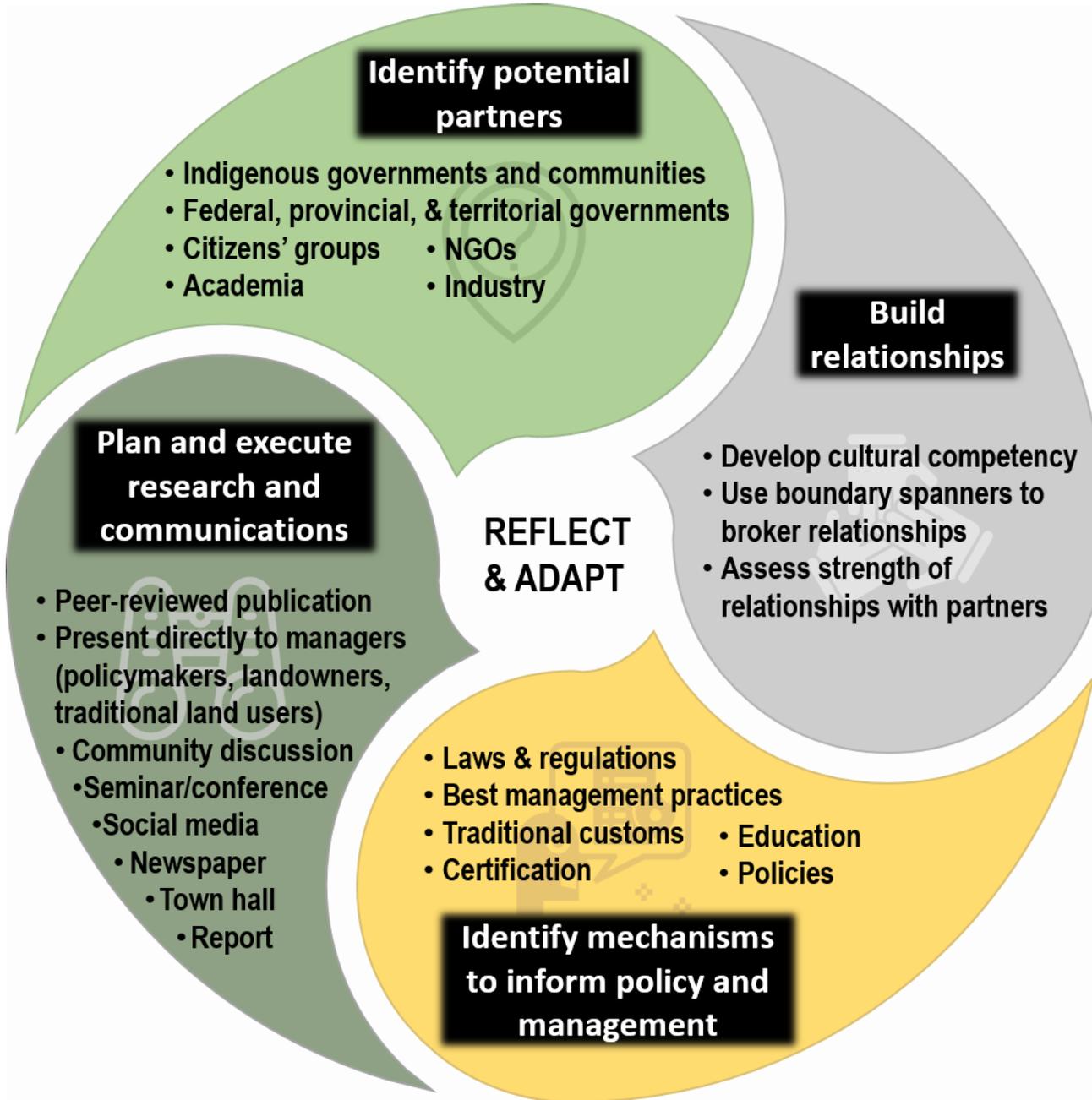
- If you do not know the names of people, how might you find them? (Government directories, introduction from other contacts)
- Is the list of persons reflected on your list of partners from Stage 1? If not, should they be added?

Policy mechanism		How could this mechanism be influenced by evidence from your project?	Knowledge users	
Name	Type (law, activity, etc.)		Responsible for creating or updating the mechanism	Responsible for implementing the mechanism

Stage 4: Plan for knowledge exchange

Note that for a coproduced project, all research and communications planning should be conducted jointly with partners. However, as an exploratory exercise, fill out the following tables to develop communications tools for knowledge exchange with (1) the partner you used for the Stage 2 exercise and (2) a knowledge user identified in Stage 3. Referring to the examples provided by the facilitator, brainstorm a variety of communications tools for all the potential partners and potential knowledge users identified in Stage 1 and Stage 3.

Partner and/or knowledge user	Communications product	Product type (social media, scientific publication, etc.)	Target audience	<i>Coproduced with partner/knowledge user or directed at partner/knowledge user?</i>



Westwood et al. 2020 Avian Conservation and Ecology
Appendix 2

List of major provincial statutes impacting conservation of birds in Newfoundland and Labrador. Legislation type can either be direct (specifically purposed with protecting wildlife, including migratory birds), or indirect (not purposed with protecting wildlife, but having a net benefit to bird conservation through protection of habitat, prevention of environmental harm, or other mechanisms). Years in brackets are the years of first introduction, and if repealed and replaced, the year of most recent replacement given following the title. Legislation which was repealed without replacement is not included.

Legislation/Policy	Type	Impact on boreal birds
1990 Forestry Act	Indirect	Regulation of pesticide application to forests, forest fire response, and general management and licencing of cutting crown land forests.
1990 Mineral Act	Indirect	Regulation of access to mineral rights.
1999 Mining Act	Direct/ indirect	Regulation of mining operations.
1990 Wilderness and Ecological Reserves Act	Indirect	Creation of wilderness areas and ecological reserves.
1990 Wild Life Act	Direct	Regulation of hunting, sale and possession of wild life, wild life parks and reserves, captive breeding of wild life.
1990 Motorized Snow Vehicles and All-Terrain Vehicles	Direct	Prohibition of damaging property and harassing or injuring wildlife.
1990 Provincial Parks Act	Indirect	Acquisition of land to create provincial parks.
1991 Lands Act	Indirect	Regulation of Crown land licencing, granting, and special management areas.
2001 Endangered Species Act	Direct	Provides special protection to species listed as at risk and their habitat.
2001 Farm Practices Protection Act	Indirect	Regulation of pesticide application on farmlands.
2004 Labrador Inuit Land Claims Agreement Act	Indirect	Allows the Inuit of Labrador to control lands as agreed to under the agreement.
2012 Muskrat Falls Project Land Use and Expropriation Act	Indirect	Potential habitat loss to flooding for dam.
2012 Animal Health and Protection Act	Indirect	Governs injured wildlife recovery efforts.
2014 Provincial Sustainable Forest Management Strategy 2014-2024 (policy)	Indirect	Policy direction for commercial forest regarding intact landscapes, habitat connectivity, late-succession forests, rare species and at-risk species, pesticides, forest fires, and special forest management areas.