


To the reader:

In February 2022, Dr. Brian Starzomski produced this independent report for the Ministry of Forests, Lands, Natural Resources and Rural Development, Together for Wildlife program, titled “Together for Wildlife Goal 2, Action 5: A new vision for wildlife science in British Columbia”.

This report provides recommendations for a preferred wildlife stewardship research delivery structure to address Together for Wildlife Goal 2, Action 5. The report summarizes background information, stakeholder interviews, and examples of wildlife stewardship research in other jurisdictions. The evaluation synthesized reviews of wildlife science structures, and input from interviews with wildlife scientists and stewards.

The Province will carefully consider the recommendations in this report. Implementation of recommendations will depend on government priorities, budgetary constraints and legal, social and economic factors. Successful development of a new wildlife stewardship research delivery structure in BC will require the commitment and co-operation of partners and stakeholders across the province.

The report does not represent an official position or program of government and may support discussions with Indigenous peoples and stakeholders in the development of a research delivery structure.



Together for Wildlife Goal 2, Action 5

A new vision for wildlife science in British Columbia

February 2022
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Executive Summary

British Columbia is at a cross-roads in wildlife stewardship: challenges increase each year in managing the wildlife* values in one of North America's "Last Wildlife Frontiers" (Shackelford et al. 2018). A province dominated by resource extraction, complex land tenures, and a history of wildlife exploitation against a backdrop of increasing management complexity has created many challenges for the province's biodiversity. To address these challenges, the Ministry of Forests, Lands, Natural Resource Operations and Rural Development has developed, in collaboration with First Nations and Stakeholders, the Together for Wildlife Strategy (T4W). This report summarizes background information, stakeholder interviews, and examples of wildlife stewardship research in other jurisdictions to address Goal 2, Action 5 of the T4W.

The evaluation used two major lines of evidence: reviews of wildlife science structures, and interviews with wildlife scientists and stewards. Evaluations asked whether the proposed activities were good for wildlife populations in British Columbia and were likely to increase public trust, create capacity in wildlife stewardship, were efficient and could increase public communication of results, and were likely to solve problems. The evaluation methods were undertaken by Brian Starzomski, PhD, and Sandra Frey, MSc.

Findings and Recommendations: The Preferred Structure

British Columbia has a rich history of excellent wildlife science. British Columbia has many world-class wildlife scientists in academia, industry, governments, and non-governmental organizations (NGOs).

Despite the extensive cross-sector network of research scientists, public wildlife science is underfunded and unable to respond to all challenges. Research funds for wildlife science have decreased significantly since 2000 (BC Public Accounts, N.D.). Wildlife data are not well stored or available for scientists' use. Clear data storage is identified as a significant problem for wildlife science in BC, and there is much concern that government data has been improperly stored, is hard to get access to (especially if multiple datasets need to be gathered together), and that data from industry is not available to wildlife scientists. Further, even basic information on population sizes and trends is lacking: improved wildlife monitoring and tracking data are needed for better population management. All of these things have eroded public trust in government stewardship of wildlife in British Columbia, Canada's most biodiverse province.

Building on research and interviews, and to most efficiently create additional wildlife stewardship knowledge through the combined efforts of new data, information, and knowledge synthesis, as well as supporting priority research for wildlife stewardship through contributions to post-secondary institutions, we recommend the following:

Specific:

- 1. The creation of a BC Wildlife Co-operative Science Unit, supported with long-term funding.** This is a co-operative research arm of government wildlife stewardship based

* Wildlife refers to "A species, subspecies, variety or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years" (<https://cosewic.ca/index.php/en-ca/about-us/definitions-abbreviations.html#W>).

at, and supported by, a university. It is arm's-length from government but working on government wildlife stewardship priorities. **The BC Wildlife Co-operative Science Unit should be outside the Lower Mainland, and staffed by 2-3 research scientists, a public communications specialist, and an administrator.** Overwhelmingly discussants described a landscape of challenges outside the Lower Mainland, but a concentration of money and expertise in the Lower Mainland and Victoria, away from the challenges and difficult to access for people spread around the province. This was described as a barrier to engaging local knowledge holders in wildlife science. **The BC Wildlife Co-operative Science Unit should play a role in improving BC's data collection and management.** Data are hard to get, there are few data standards, and there is a need for standards to be created for all new data to ensure better wildlife monitoring and tracking data are collected for improved population stewardship. **There should be clear, public-facing communications to report out on science and build public trust and support.**

2. **A new MSc and PhD scholarship in wildlife science should be created**, with 7 or more new student scholarships per year. Typical funding levels for these sorts of scholarships are in the range of \$20,000 to \$25,000 per year per student (based on similar Natural Sciences and Engineering Research Council of Canada – NSERC – levels). Further, for rapid response to questions where data exist or are in the process of being collected, post-doctoral fellows could be an excellent solution. Creating 2 annual postdoctoral fellowships of duration of 3 years at \$50,000 per year (similar to current rates across various agencies) would be a step forward. These scholarships should be spread around to all universities in BC: respondents repeatedly stated that more brains and more diverse methods lead to better overall science for wildlife stewardship. Respondents from First Nations were also very keen to increase local capacity through these scholarships.

General:

3. **Create and deepen capacity beyond the co-operative science unit.** Science work should be done on priority questions across the province, involving local community members and stewards wherever possible. A goal should be to leave expertise in communities. **BC Wildlife Co-operative Science Unit** programs to work with Indigenous Knowledge holders and even a program to record this knowledge should be prioritized. Indigenous knowledge must be deeply embedded and respectfully included, recognizing differences in western science and traditional methods of knowledge gathering, sharing, and holding.
4. **Continue, and extend, current science and communication funding initiatives within and outside of government** through increases in funding in places like those from the Habitat Conservation Trust Foundation, the Living Lab program of BC Parks, and to research within ministries like Environment, and Forests, Lands, and Natural Resource Operations and Rural Development.

Introduction

Evidence-based management of wildlife is the core of successful wildlife stewardship (Sinclair et al. 2006, Hessami et al. 2020). A variety of types of independent scientists contribute findings to the evidence needed for strong management, including government scientists, academics, and those spanning the government-academic divide as in co-operative and extension positions. Excellent research, combined with translation to government policy, sets the stage for healthy wildlife populations. Clear public-facing communication of that research builds trust in evidence-based stewardship. Open data deepens this trust by making the data available for review and synthesis. Combining world-class research, translation of that research to policy and management options, and clear public communication of results will translate to more successful wildlife stewardship in British Columbia.

To promote excellent wildlife research, stronger partnerships between government and post-secondary institutions can be facilitated through individual researchers that bridge the gap between policy and academia. Funded researchers established in both government and post-secondary institutions combine the resources, staff, and skills from each organization to pursue research programs that might not otherwise be feasible. Leverage of funding in these partnerships greatly enhances the scope and depth of work. Typically in situations where research is being conducted through an academic group, funds will come from multiple locations: the Principle Investigator may bring operating funds to conduct some of the field research and to cover costs of publishing the work, the university or student may provide scholarship money for graduate student stipends (e.g., a student may be awarded an NSERC scholarship for their research work, and this covers their stipend or salary), and other agencies such as Mitacs may help to enhance the overall support by providing matching funds to support the funds from a cooperating agency like a First Nation or NGO. This can often mean that funds

can be doubled, tripled, or more through bringing all these funding forms together. Government benefits from such partnerships through enhanced funding levels, keeping up-to-date with current knowledge, and also through access to graduate students, while universities benefit from increased research opportunities, supervision of students, teaching, and access to government resources and decision makers. This operates on the important university goal of providing useful information for society. Researchers with affiliations in both government and academia can bring together a team of graduate students and post-doctoral fellows to develop multi-year research programs investigating topics of identified value to inform government policy.

A long-term government-academia collaboration, like that proposed in the Together for Wildlife Goal 2, Action 5, can be developed through processes like the endowment of a research chair, cross-appointment of government staff to post-secondary institutions, or a hybrid of the two where a government researcher is embedded permanently in a co-operative setting at a university. In each case, the link between academia and government is an individual researcher (or researchers) who contributes and participates in both worlds. A key responsibility is bringing world-class evidence to policy development. Post-secondary institutions across Canada have hosted numerous professionals researching questions centred around informing improved wildlife and habitat stewardship. Many of these were established directly through government funding bodies which may influence the direction of the conducted research to align with identified government priorities. Research chairs established through non-governmental organizations (NGOs) and other institutions contribute to the development of a growing body of knowledge on wildlife and habitat management that government may access to help inform policy. Finally, cross-appointed government staff operating research programs in academic

settings can establish programs and may translate the produced knowledge more directly into government processes to help inform policy.

This report summarizes background information, interviews with those engaged in wildlife stewardship in British Columbia and beyond, and examples of wildlife stewardship research bodies in other jurisdictions to address Goal 2, Action 5 of the Together for Wildlife Strategy:

Together for Wildlife Strategy Goal 2.

Data, information, and knowledge drive better decisions. The right data, information, and knowledge are essential for successful wildlife stewardship. Acquiring and sharing the right data, information, and knowledge will require that our data and knowledge systems be modernized in collaboration with Indigenous governments, local governments, resource industries, stakeholders, non-government organizations, and the public. Under the strategy, we will make new investments in biological, social, and economic data collection, cumulative effects assessments, monitoring, innovative population modelling, and information management systems. These tools, processes, and systems will improve the availability, accessibility, and reliability of wildlife stewardship data for all users. This renewed approach will better inform resource stewardship decisions and will support the relationships and structures that enable investments from other organizations and partners.

Action 5

Starting in 2020, we will support priority research for wildlife stewardship through contributions to post-secondary institutions. These contributions will leverage other sources of funding and build stronger partnerships between independent and government researchers, and managers. We will broadly share the results of this research with British Columbians.

Methods

This report summarizes results from two major lines of evidence: reviews of wildlife science structures, and interviews with wildlife scientists and stewards. Evaluations asked whether the proposed activities were good for wildlife populations in British Columbia and were likely to increase public trust, create capacity in wildlife stewardship, were efficient and could increase public communication of results, and were likely to solve problems (Box 1). The evaluation methods were undertaken by Brian Starzomski, PhD, and Sandra Frey, MSc.

We reviewed the literature and examples of wildlife stewardship research from other jurisdictions to identify examples of endowed research chairs and cross-appointed scientists connecting academic research to policy. We review examples of current Canadian research chairs with both government and non-governmental affiliations pursuing research in wildlife and habitat management. We also review and provide case studies of examples of cross-appointed scientists in Canada with established research programs at academic institutions. Throughout, we identify the benefits and challenges of these types of arrangements for bridging the policy-academic gap.

From April to December we conducted interviews with people engaged in wildlife stewardship activities, including people from government, industry, academic researchers, First Nations, and others. Some responded by email, though in most cases one of us (Starzomski) held online (via Zoom, WebEx, MS Teams, etc.) or phone meetings with individuals. These meetings typically lasted from 45 to 150 minutes, and followed a discussion format seeded with the questions below. Here we summarize the discussions, *which point toward the most support for a combination of student funding and a Co-operative/extension-style model* (the BC Wildlife Cooperative Science Unit) for pursuing the goals of Goal 2, Action 5 from the Together for Wildlife Strategy.

Questions asked to seed discussions:

1. What do you hope successful implementation of Action 5 will achieve?
2. What mechanisms to deliver Action 5 should be considered? Examples might include (but are not limited to):
 - establishing one or more new endowed university research chairs or research centres of excellence,
 - establishing United States Geological Survey-style co-op/extension positions,
 - changing the government research funding structure to regularize annual funding allocations to researchers

3. How can we weave Indigenous Knowledge and Western Science together in effective ways?
4. How should different mechanisms to deliver Action 5 be evaluated? What would constitute success for Action 5?
5. What mechanisms would you suggest be avoided and why?

It became clear during initial consultations that 3 major alternatives, not mutually exclusive, were under consideration:

- 1) Establishing one or more new endowed university research chairs or research centres of excellence
- 2) Establishing US Geological Survey-style co-operative/extension positions
- 3) Changing the government research funding structure to regularize annual funding allocations to researchers both within and outside of the provincial government.

These were described as best providing ways to implement many components of wildlife stewardship, including, but not limited to:

- Holding workshops to develop partnerships among researchers, managers and First Nations, and to support co-development of research projects
- Preparing “state of knowledge” reports on high priority issues to support decision-making
- Increasing extension (e.g., solutions, short courses, fieldtrips) to the public and stakeholders on the current state of scientific knowledge and best practices for human activities (e.g., forestry)
- Analyzing existing data collected by government researchers and others (e.g., through post-doctoral fellows and graduate students), and publishing the results
- Creating a communications portal so all researchers (e.g., academics, government, private, etc.) are aware of each other’s work.

Several challenges and limitations were encountered during our work. The first and most difficult was the ongoing pandemic, which made the original plan of getting people together to workshop these questions impossible. Despite the lack of opportunity to get people together, there was an advantage to the current method: we were able to speak with individuals for longer or receive their detailed responses via email, and more people were able to participate from around BC and North America. Second was the lack of information for evaluating certain components of the success of wildlife science in university and co-operative settings. Third was the lack of time to speak with every single person who would like to comment on this issue.

With the convergence on some dominant themes across the large number of people we did speak with, however, we do feel we offer a good cross-section of thought and opinion on the topic, and themes that respondents agreed would be a strong way forward for Goal 2 and Action 5.

We used the following to evaluate the likelihood of success of suggested initiatives, and these can also be used to assess success going forward:

- First and foremost: is it good for wildlife?
- Is it cost effective and efficient?
- Is it good at leveraging further opportunities?
- Does it enhance and deepen current work?
- Can it respond to challenges and provide options?
- Does it effectively address multi-year priorities?
- Can it respond to priorities that arise?
- Can it address and stay abreast of scientific best practices and priorities?
- Is it creating new expertise, new capacity, new opportunities, new partnerships?
- Is it producing open data?
- Is it communicating the results in a way the public can access easily and understand?
- Is it increasing trust in government stewardship of BC's wildlife?

Box 1. Questions for evaluation of proposed initiatives.

Part 1: Supporting priority research for wildlife stewardship: Summary Overview and Analysis of Options

Option 1: Endowed university research chairs: scientists at academic institutions

Science research chairs (functioning as university professors) established through government funding bodies are generally provided with a salary and modest funding to develop a research program. This provides the researcher with the financial stability to develop multi-year research projects and bring together an academic team to conduct research aligned with the priorities of the funding agency. It is expected that these initial funds will be heavily leveraged against other forms of funding, with typical levels of 1:5, 1:10, and higher commonly seen. In some instances, a steering committee may be developed to create guidelines, research priorities, and also to evaluate performance. Chairholders are typically expected to teach (at both undergraduate and graduate levels) and supervise graduate student research projects: up to 40% of a chairholder's time might be allocated to teaching, with up to 20% allocated to university administration.

Typically, however, research chairs have a higher percentage of their time allocated to research than to teaching. Chairholders pursue operating funds such as Natural Science and Engineering Research Council of Canada (NSERC) Discovery Grants (Natural Sciences and Engineering Research Council of Canada, 2021) and scholarships for graduate students. NSERC Discovery Grants are typically modest (less than \$50,000/year), though are reliable for 5 year terms.

NSERC Canada Graduate Scholarships (and other related scholarships) may fund students for from \$17,500/year for one year to \$21,000 (or more) for 3 or more years. An established research chair at a university often provides opportunities for collaborations across multiple government agencies, non-government organizations (NGOs), and First Nations. Across Canada, multiple research chairs have been developed by both government and NGOs to conduct priority

research in wildlife and habitat management and build a stronger network of collaborative programs sharing their knowledge. Similar programs also exist in other countries, including the United States, the United Kingdom, and parts of Africa.

Research Chairs in Canada: Examples

The Canada Research Chair (CRC) program was established in 2000 by the federal government of Canada to promote research excellence and development in post-secondary institutions across the country (Government of Canada 2019). The program is a tri-agency initiative of the Social Sciences and Humanities Research Council (SSHRC), the Natural Sciences and Engineering Research Council (NSERC), and the Canadian Institute of Health Research (CIHR) and invests nearly \$300 million to attract and retain world-class scholars and scientists. Beyond contributing to Canadian knowledge and quality of life, CRC chairholders also help train the next generation of highly skilled people through teaching, student supervision, and research coordination. CRC chairs come in two forms: Tier II CRCs aimed at the best and brightest young researchers (i.e., within 10 years of their PhD conferral), and Tier I CRCs aimed at established world-class researchers. These CRCs have academic excellence as their first priority. Government research priorities are not the defining feature.

Multiple universities across the country have hosted CRC positions focusing on wildlife and habitat stewardship. In B.C., current CRC chairholders pursue research on terrestrial mammal conservation (Tier II, Dr. Cole Burton UBC), wildlife restoration ecology (Tier II, Dr. Adam Ford, UBC-Okanagan), climate change and marine fish (Tier II, Dr. William Cheung, UBC), and recently deep-sea ecology and biodiversity (Dr. Verena Tunnicliffe, UVic). Across Canada, the CRC funds researchers to conduct, for example, important research into boreal forest

management (Dr. Yves Bergeron, Université du Québec en Abitibi-Témiscamingue), northern biodiversity (Dominique Berteaux, Université du Québec à Rimouski), coastal habitats (Dr. Mark Mallory; Acadia University), amphibian and mammalian responses to habitat loss (Dr. Dennis Murray, Trent University), freshwater ecology and fisheries (Dr. Michael Rennie; Lakehead University), and arctic marine mammal populations (Dr. Melissa McKinney, McGill University). Multi-year funding from the CRC program has allowed these researchers to pursue world-class research on sensitive and important wildlife populations and the habitats that support them. CRC operating grants help support graduate student and post-doctoral fellow research, and the potential to leverage more research funds provided by the university, scholarships, and research grants. CRC funds are not enough to run a productive research lab and must be constantly supplemented by funds from other sources.

Beyond the federal CRC program, various academic research chairs have also been established by other government and non-government organizations to support research into Canadian wildlife and habitat management. Endowed chairholders receive funding to pursue research programs aligned with conservation and habitat management priorities of the funding body and present for collaboration with government, NGOs, First Nations, industry, and other organizations. Examples of government, NGO, and industry funding chairs with a research focus on wildlife and habitat include the Alberta Conservation Association (ACA), the Alberta Biodiversity Conservation Chairs Program, Ducks Unlimited Canada (DUC), Institut Nordique du Québec, Raincoast Conservation Foundation, and the BC Habitat Conservation Trust Foundation (HCTF). These programs may have a more targeted problem-solving focus compared to CRC chairs, with research priorities directed by the sponsoring agency.

Dr. Mark Boyce (Alberta Conservation Association Fish and Wildlife Chairholder, University of Alberta) leads a large academic research team to collect information on wildlife populations of identified management concern by the province and public stakeholders (Alberta Conservation Association 2021). Drs. Stan Boutin (U of A) and Scott Nielsen (U of A) are both appointed Alberta Biodiversity Conservation chairholders leading academic labs with many graduate students conducting research projects focused on key biodiversity challenges related to the energy sector (Alberta Biodiversity Conservation Chairs (n.d.)). The recently appointed DUC Endowed Chair in Wetland and Waterfowl Conservation, Dr. Mitch Weegman, will be tackling major challenges associated with wetland and waterfowl conservation (Ducks Unlimited Canada 2021). Dr. Murray Humphries' (Institute Nordique du Québec, McGill University) research is a collaboration with northern communities and partners to predict and monitor environmental change impacts on northern wildlife and traditional food security in Canada (Institute Nordique du Québec, 2020). Through multiple NGO and First Nation partnerships, Dr. Chris Darimont (Raincoast Conservation Foundation, University of Victoria) leads various applied conservation research programs with a geographic focus on Indigenous territories in the Great Bear Rainforest (Raincoast Conservation Foundation, 2021). Dr. Brian Starzomski (HCTF Ian McTaggart Cowan Professor, UVic) is a community ecologist and conservation biologist researching patterns of biodiversity across BC (University of Victoria, 2021). Dr. Peter Arcese (Forest Renewal BC Chair in Conservation Biology, UBC) leads various research programs studying vertebrate demography, biogeography of native plants and animal communities, and adaptive management of rare species and ecosystems (The University of British Columbia, n.d.). For some of these positions there is a steering committee-like structure to define priorities and

evaluate performance. In other cases there is no such structure. Most have a strong research focus though some have substantial teaching loads and less research.

Establishing a research chair at a university

Typically a research chair (university employee as a professor) is created at a university through 1 of 2 forms:

- A supported chair in multi-year (often 5 year, often twice to add to 10 years) increments. Examples include Canada Research Chairs
 - Open competition, university must either agree to the position for 5-10 years (term, after which position is terminated) or pick up a continuing faculty line after external funding has been exhausted (results in a position – which is in limited supply for each department/unit - having to be used at the university; this can cause controversy when other unit priorities cannot be met).
- Endowed chair established through an endowment to the university, in a defined area of research need/focus for the funder.
 - Typically endowed by an external funder in perpetuity, with an endowment currently on the order of \$7-8 million. The salary etc. for the chair comes from interest accrued on the endowment, thus allowing the university to host the chair in perpetuity.
 - Can be hired through an open or through a “waived search” process. The waived search is used when there is a candidate in mind
 - This is often a new “line”, and therefore may not impact other university hiring priorities (this can result in less controversy at the unit level, as this is a new position in addition to other positions in the unit)

Box 2. Steps in creating a sponsored chair/professorship at a British Columbia university.

Endowed Chairs and Fellows beyond Canada

Numerous endowed chairs have been established across US universities to support research into fish and wildlife and the habitats that support them. Some are focused on specific taxonomic groups or habitat types, such as the James C. Kennedy Endowed Chair in Waterfowl & Wetlands Conservation (Mississippi State University) (Mississippi State University., 2021), the G. Raveling Endowed Chair in Waterfowl Biology (University of California, Davis) (UC Davis 2015), the Redig Endowed Chair in Raptor and Ecosystem Health (University of Minnesota) (University of Minnesota, n.d.), and the Wild Sheep Foundation Endowed Chair in Wild Sheep Disease Research (Washington State University) (College of Veterinary Medicine, n.d.). Others encompass broader wildlife management objectives, such as the Boone and Crockett Endowed Chair in Wildlife Policy, Governance, and Leadership (Michigan State University) (University of Georgia , 2021) and the Bricker Chair Endowment in Wildlife Management (Texas Tech University) (Kaminski, 2017). Other examples include the Gordon W. Gullion Endowed Chair in Forest Wildlife Research and Education (University of Minnesota) (University of Minnesota, 2021), the Harte Research Institute endowed Chair for Conservation & Biodiversity (Texas A&M University), and the Wadsworth Endowed Chair in Conservation Science (University of Washington) (Center for Ecosystem Sentinels. 2016). There are further examples in places like the United Kingdom and South Africa.

Benefits and Challenges of Research Chairs

Chairholders in wildlife and habitat conservation science across Canada provide valuable information to federal and provincial policymakers. Moreover, they can engage with wide networks: partnerships listed by chairholders and their academic research teams include long lists

of funders and collaborators, including government and non-government bodies, corporate partnerships, not-for-profit organizations, charities, public groups, First Nation communities, other universities, international research councils, and individual donors.

Through their affiliation with post-secondary institutions, chairholders can leverage funds through access to various grants, bursaries, and scholarships for their research programs and graduate students. Beyond leveraging research funds, highly skilled graduate students and post-doctoral fellows provide the basis for large research programs collecting and translating data into meaningful information for policymakers. Host universities benefit from the Research Chair through the training and supervision of students, the knowledge of a leading expert, and access to the resources and collaborations with a wider network of organizations.

Depending on the funding body, research conducted by chairholders may not always be driven by local or regional wildlife management priorities. For example, the Canada Research Chair (CRC) program emphasizes theory and hypothesis-driven research with broad application, typically at the highest academic level. This sort of research may have global impact but does not necessarily lead to local solutions. Research programs that are too applied or specific to wildlife populations may not be supported by the CRC program, and CRC holders only work on projects of local/provincial concern when it aligns with their research interests and reward structures within the university (Goss Gilroy Inc., 2016). Chairs developed with a specific funder (e.g., the Alberta Conservation Association) can have a much more targeted research focus, and it is recommended that if FLNRORD pursues a research chair that it be done independent of the CRC program and with a targeted research focus and terms of reference (including a steering committee) that define a field of study.

Collaborative Networks of Supported Chairs

Another way to create targeted research is through supporting collaborative arrangements between multiple institutions that can be formalized into research networks. Research partnerships may be established between universities, government, industry, NGOs, and other institutions to establish a program addressing wildlife and habitat issues of mutual concern. Such multi-institutional research partnerships (hereafter “cooperatives”) can help foster active linkages, enhance student education and professional development, and lead to the development of proactive research programs providing information to help inform policy. In Canada and the United States, multiple research cooperatives have been developed between post-secondary and government institutions to address issues in wildlife and habitat management. Simple partnerships that start as informal joint projects on issues of mutual research interest can evolve into organized research cooperatives. By integrating teams from multiple partner organizations, cooperatives can be highly effective at producing and applying scientific knowledge on issues of wildlife management. Across Canada, several research cooperatives were established to address regional issues of wildlife management. Most cooperatives, such as the Atlantic Cooperative Wildlife Ecology Research Network (Acadia University, n.d.) are no longer active, but served to produce valuable information for wildlife and habitat management. Some have had success over time with significant support (e.g., Cooperative Freshwater Ecology Unit at Laurentian University and Ontario government), while others have largely failed from a lack of dedicated funding and vision (e.g., New Brunswick Cooperative Fish & Wildlife Research Unit where a chair was endowed but no continuing funding support was maintained). Here we use the Atlantic Cooperative Wildlife Ecology Research Network as an example of successes and challenges.

The Atlantic Cooperative Wildlife Ecology Research Network (1994-2008)

The Atlantic Cooperative Wildlife Ecology Research Network (ACWERN) was established in 1994 to enhance understanding of wildlife ecology in the Atlantic provinces (Acadia University, n.d.). ACWERN focused on the relationship between human activities and changing ecological patterns and processes, applying research results to problems in biodiversity conservation. Established as a partnership between three Atlantic universities (Memorial University – Dr. Ian Jones --, Acadia University –Dr. Phil Taylor--, and the University of New Brunswick –Dr. Tony Diamond, senior member) and the Canadian Wildlife Service (CWS), ACWERN also collaborated with Parks Canada and provincial wildlife agencies. The CWS and partner organizations benefited from ACWERN's research expertise in addressing priority wildlife research questions. This included peer-review in the design of research projects, support from high quality students and postdoctoral fellows, and opportunities to develop scientific skills and knowledge.

With a focus on migratory birds and species at risk, ACWERN addressed numerous wildlife ecology research questions in Atlantic Canada. Research programs included identifying and quantifying human disturbance and climate change effects on seabirds, mitigating industrial risks on endangered shorebirds, modeling wildlife population declines, and identifying essential foraging habitats for migrating birds.

ACWERN research chairs were tenure-track or tenured university faculty members. Chairholders developed research programs, supervised graduate and undergraduate students, and taught senior-level courses at the host university. They were linked to CWS through various collaborative projects and a management board. Dr. Tony Diamond chaired ACWERN at UNB (the Atlantic Laboratory for Avian Research) and provided research and training to graduate and

undergraduate students with over 60 peer-reviewed publications during ACWERN's lifespan (University of New Brunswick, n.d.). His research team received funding from non-profit organizations (e.g. Canadian Wildlife Federation, Ducks Unlimited Canada, Birds Canada), industry (e.g. Fraser Papers Inc.), and various federal (e.g. NSERC, Climate Action and Awareness Fund, Parks Canada) and provincial (NB Department of Natural Resources) funding bodies and grants.

ACWERN's annual operating budget exceeded \$1M by 2004-2005. The Canadian Wildlife Service contributed \$200K for research funding and student stipends, and supplementary contributions by partner universities of about \$450K supported ACWERN chair salaries, students, and research support. Partners in the industrial sector, NGOs, and other government granting agencies provided an additional \$650K in support for specific research projects. ACWERN achieved a funding leverage ratio of 1:6 after nine years of operation (Environment Canada, 2003). Note the success of partnering with multiple institutions to leverage seed funding into enough funds to run a successful program.

ACWERN was governed by a management board of two representatives from CWS, two senior representatives from each partner university, and one graduate student from each university. Each year, the board met to review programs, approve work plans and budgets, and provide support to the chairs. ACWERN was dissolved by Environment Canada in 2009 but Drs. Diamond, Jones, and Taylor continue research work at their original universities. Overall success included many collaborations and an excellent community for graduate training that built a large network for students from relatively small universities. In the end the Canadian Wildlife Service was concerned that not enough focus was being placed on CWS research priorities (as the

university researchers also needed to focus on “academic” research), and the administrative load of supporting researchers spread across multiple institutions was a burden.

Benefits and Challenges of government-sponsored academic positions

-Canada Research Chair program evaluation and university tenure processes are geared toward standard academic productivity measures and the academic literature, which are not always in line with what government needs for evidence-based wildlife stewardship and policy-relevant research. This is the same for any university-employee professor. These limitations in focus on government wildlife stewardship priorities can be overcome according to the interest of the individual, but there are no guarantees this will continue. Chairs supported by external funders (like the Alberta Conservation Association, for example) can construct terms of reference and steering committees that set research priorities, a format that is more in line with FLNRORD’s needs.

-Government support of networks of academic researchers, as in the Atlantic Co-operative Wildlife Ecology Research Network (ACWERN), can be successful, though the administrative load, and the academic reward system can mean that less focus on government priorities may be the outcome. University professor career-progress rewards are much more tied to the academic structure of funding outcomes and paper publishing than they are typically to government research priorities. This is due to the fact that professors are evaluated by international peers and thus have pressures to produce research that is significant and novel at international levels, and less tied to local government needs. To incentivize local research, some of these pressures would be best removed or reduced, or explicit instructions given that local questions are a high priority. Many of these issues can be avoided in a Co-operative model (see below) where assessment guidelines can be focused on local priorities.

Option 2A: University-affiliated scientists in extension/Co-operative models

In the extension or co-operative model government and other researchers engage between the academic and management/policy world through adjunct or affiliate status with universities. This benefits policymakers by providing access to an academic team of students and researchers that can conduct research of value towards wildlife stewardship policies. Similar to chairholders, government scientists supervising graduate students can leverage funds for their research program through application to various research grants and scholarships (e.g., NSERC) available

to academic institutions and students (though they may not be eligible for internal university funds that may be prioritized to regular faculty). Host universities benefit from the training and supervision of graduate students by adjunct professors, as well as access to government resources, technology, and information. Examples of cross-appointed environmental scientists in BC include Dr. Jason T. Fisher (formerly Innotech Alberta; UVic), Dr. Tyler Muhly (FLNRORD; UBC), Robin Steenweg (Canadian Wildlife Service; UBC-O), Dr. Eliot McIntire (Canadian Forest Service, UBC), Dr. Emma Hodgson (Department of Fisheries and Ocean; SFU), and Sarah Dudas (Department of Fisheries and Ocean; UVic). While adjunct status is not always clear on expected level of engagement (both to and from government and university), the best adjuncts are highly engaged and government scientists co-supervising graduate students can provide a direct link between policy and academia.

Cross-appointed partnerships are enhanced when individual government staff or facilities are co-located on a university campus, which deepens connection with the academic community. Strong examples of cross-appointed government scientists with a presence on campus and established academic research teams include scientists with the Ontario Ministry of Natural Resources and Forestry (OMNRF). Appointed as adjunct faculty with the Environmental & Life Sciences Graduate Program at Trent University, these researchers lead research teams of graduate students and post-doctoral fellows that focus on priority wildlife and habitat concerns. For example, Dr. Jeff Bowman leads a large team of OMNRF scientists and graduate students researching mammalian biodiversity in the temperate zone, supervising over 50 current and previous graduate students to date with over 130 peer-reviewed publications, and working on government-priority wildlife research (Bowman, 2021). Dr. Joseph Northrup's Wildlife Ecology and Conservation Lab studies human impact on wildlife, including animal movement through

human-modified landscapes, with a focus on multiple terrestrial mammals of provincial management interest including black bear, moose, polar bear, and mule and white-tailed deer (Northrup, 2021). Dr. Nicolas Jones leads a team of students and scientists in the Rivers and Streams Ecology Lab (Jones, 2021) which focused on the ecology and management of flowing waters, including developing a monitoring framework for the ecological influence of hydropower dams in Ontario. Dr. Glen Brown's Northern Animal Ecology Lab (Brown, 2021) focuses on wildlife inhabiting sub-arctic coastal ecosystems and the Hudson Bay Lowlands. In addition to supervising students and leading research programs, these researchers also provide courses on wildlife ecology at Trent University to train the next generation of leading scientists on wildlife research and management.

Benefits and Challenges of Cross-Appointed Adjunct Faculty

Benefits:

- Scientists can work toward 3 research priorities:
 - Long-term research on government priorities that is supported with base funding as the key research questions over a defined (5-10 year time span): the key ongoing issues for wildlife stewardship in a jurisdiction.
 - High-priority applied research that arises in response to a recent challenge: rapid response to challenges that have arisen in the past year, and are a current concern, and need to be solved immediately (i.e, in weeks to months) on direction from policy makers.
 - Discovery research that allows the scientists to stay engaged with current best practices and emerging wildlife stewardship issues, and develops novel research and solutions.
- Science can be focused on informing decision-making for wildlife management priorities
- There is an opportunity to enlist teams of students that can undertake more research than government scientists can accomplish on their own
- Cross-appointed faculty could bring policy into the academic world by developing applied courses as part of their teaching portfolio (or collaboratively developing course materials with a university employee).
- Prepare new generation of scientists in subjects with hands-on experience in policy-oriented research

Challenges:

- A large proportion of government employee time may be consumed by administrative/bureaucratic tasks that draw away from research
- Academic researchers are in a position where they can challenge established positions of the government, whereas those working within government cannot.
- Universities provide limited funding to adjunct faculty. Stipends for graduate students must therefore more often come from scholarships and other funding leveraging.

Option 2B: Examples from successful Cooperative Research Organizations: The United States Geological Survey Co-operative Extensions

In the United States, the US Geological Survey (USGS) Cooperative Fish and Wildlife Research Units Program consists of over 40 active cooperatives across the country. These cooperative research units provide perhaps the most effective example of a partnership that enables integrated research teams to conduct research on government-priority wildlife questions, leverage research funds, contribute to the training of graduate students, inform natural resource issues, and provide information to policymakers for improved wildlife and habitat management. Using details from the USGS Cooperative Research Units program, we provide an overview of how these units are established and function. We discuss the benefits and challenges associated with these types of partnerships.

USGS Fish and Wildlife Cooperative Research Units Program: government/university science for management priorities

The Fish and Wildlife Cooperative Research Unit program is a cooperative partnership among the United States Geological Survey (USGS), the Wildlife Management Institute (WMI), one or more State natural resource agencies, and a host university (United States Geological Survey, 2021). First established in 1935, a total of 40 cooperative research units (CRUs) have

since been created in 38 states (Figure 1). These units work to provide State fish and wildlife agencies and Federal natural resource agencies with the science used in management decisions to support sustainable fish and wildlife populations. The program's objectives also include developing the future workforce through graduate education and mentoring.

Each Cooperative Research Unit is staffed by 2 to 5 federal research scientists employed by the USGS and housed in an office on a university campus. Unit scientists hold faculty rank at their host university. The university extends all faculty privileges to unit employees except for tenure, and the university has no salary obligations towards professional unit personnel. Unit scientists may be teachers and researchers, contributing members of the graduate faculty, and well-integrated into the university system. Beyond leading their own research program, co-op scientists teach graduate-level courses, manage research labs, serve on university committees, help direct graduate curriculum development, supervise students, and serve as committee members of graduate students other than their own. Unit scientists provide extensive technical expertise to the university and also bring in Federal and State research funding. The presence of a unit and the professional stature of its employees also helps attract high-quality graduate students to the university: many world-class university wildlife research departments have affiliate CRUs, and these are a draw for high-quality graduate students. State wildlife managers benefit from the graduate student project support provided by the program, as well as the unit's expertise. The university benefits from the funding opportunities provided by State and Federal scientists, who in turn gain access to the expertise and research infrastructure of the host university.

Collectively, there are over 1000 research projects across the units, most of which are carried out by graduate students supervised by or working closely with unit staff. Graduate

students are advised by the unit scientists and conduct applied research projects on government natural resource priorities. Students benefit from the CRU program through opportunities to pursue a graduate degree, receive enhanced scientific training, and develop expertise on issues of government natural resource management, which gives excellent training to enter the wildlife stewardship workforce. Students help the program leverage further research funds through access to academic scholarships and research grants.

Funding for the CRU program comes largely from congressional appropriations. Between 2003 – 2019, congressional appropriations were approximately \$14-19 million (USD), with a significant increase in 2020 to approximately \$24 million. Unit scientists garner \$25-40 million USD in State and Federal research funding each year. Federal investments support over 1100 graduate students, post-doctoral fellows, and university staff members each year. In turn, universities provide over \$20 million USD through in-kind support, tuition, and overhead reductions. The model enables the program to leverage significant available resources, with federally allocated funds being matched at a 1:3 ratio by State and host university contributions and grants.



Figure 1. A total of 40 USGS Cooperative Research Units have been established across 38 states. Each unit focuses on fishery (fish icon), wildlife (deer icon), or both fishery and wildlife research (duck icon) in partnership with the USGS, the Wildlife Management Institute (WMI), one or more State natural resource agencies, and a host university. (Modified from The Cooperative Fish and Wildlife Research Unit Program report, Vohs, 2006).

The Coordinating Committee

Each CRU receives guidance from a coordinating committee, which is responsible for the functioning of the unit (Vohs 2006). The Coordinating Committee includes an official representative from each partner organization on the cooperative agreement. The university representative is often a dean, department head, or program director within whose department the CRU is assigned. The representative from the partner state agency is usually the research division director. Along with representatives from the WMI and USGS, these members must be

in a position to legally commit their organization to expenditures and in-kind support to support unit activities.

Each CRU operates under a general directional statement developed by the unit leader with input from engaged groups. This statement reflects the type of research the cooperators wish to have emphasized and is reviewed annually at a coordinating committee meeting to confirm that the direction is representative of all partners' needs and priorities. Any adjustments to the directional statement throughout the unit's development are negotiated among cooperators, with consensus being the desired outcome to avoid unit personnel having to split loyalties between cooperators.

Coordinating Committee Meetings are attended by representatives from each cooperator, as well as other interested parties such as collaborating university professors, students, and state agency staff and researchers. The general information session includes information about the budget status, summaries of research activities, statements of direction, as well as accomplishments over the past year. A major part of the Coordinating Committee Meeting is the presentation of planned activities for the upcoming year. Unit personnel present on the research projects they wish to conduct and their associated funding and student requirements. Following these meetings, the Coordinating Committee discusses whether to approve the proposed activities. The general information session often features a separate session where students can present on their research to interested faculty members, state biologists, and the coordinating committee. These sessions provide students with the opportunity to gain experience giving professional presentations and meet with prospective employers. Performance of the unit leader is evaluated in a separate session from evaluation of the unit's productivity and performance.

Cooperative Research Unit Organization and Function

Federal employees staffed at a CRU in an office on campus perform the range of tasks of typical government researchers. However, these scientists also perform the role of a university professor as biologists integrated into the university system. Unit personnel therefore perform all the duties of state and federal researchers while also acting as program administrators, research supervisors, and office managers. Keeping the administrative burden to a minimum is identified in all research and interviews as a key step to maximizing success.

3 recommendations from USGS co-operative/extension model

-This is a hybrid of government researchers and university researchers that draws on the best features of each for policy-relevant research. Policy-relevant research is conducted on government research priorities but at arm's length from government offices. The combination of research expertise and arm's-length research excellence has been identified as a feature that builds public trust in the co-operative units as honest brokers of research results.

-This form can clearly focus on the 3 key wildlife research themes needed for wildlife stewardship:

- Long-term applied research that is supported with base funding as the key research questions over a defined (5-10 year time span): the key ongoing issues for wildlife stewardship in British Columbia.
- High-priority applied research that arises in response to a recent challenge: rapid response to challenges that have arisen in the past year, and are a current concern and must be solved immediately at the request of policy makers.
- Discovery research that allows the scientists to stay engaged with current best practices and emerging wildlife stewardship issues, and developing novel solutions

-There are opportunities for many student projects and training for future expertise.

Option 3: Enhanced funding arrangements

Funding for wildlife stewardship and research has declined since 2000 (BC Public Accounts, N.D.). Ministries such as FLNRORD and the Ministry of Environment face critical funding

shortfalls for both research and the communication research findings. Increasing capacity for government science is a priority, and one strong way forward is to support funding for graduate student projects that can span the university-government divide. All graduate student projects in wildlife ecology and stewardship must be provided with a living wage stipend. Currently MSc and PhD student stipends come from NSERC funds (typically \$17,500 and \$21,000 per year, widely regarded as too low to live on and typically supplemented with other funding sources), MITACS, or Faculty of Graduate Studies funds at the host university. Wildlife stewardship management needs currently outstrip available scholarship funds, and as BC becomes one of the most expensive places to live in Canada, inadequate to support a student. Government funding of independent scientist research is currently very low, with some funds from HCTF, and recently, the BC Parks Living Lab program. HCTF was described in interviews as “high cost” funds because of the length of the application process, the vagaries of the selection process that was widely panned for being opaque and plagued by a feeling that funding was as likely to be allocated to “known quantities” as opposed to the best proposal. The Living Lab program was described as “refreshing, but the year-by-year model is frustrating. To get research projects off the ground where new data will be collected, there is a need for multi-year commitments to support graduate students and allow meaningful data collection and interpretation.” There is currently not enough funding to address these issues. While funding challenges were identified as an ongoing challenge for wildlife stewardship research across government and universities, *one strong way forward is the creation of a funding pool for graduate students at the MSc and PhD levels, as well as post-doctoral fellows, a funding pool that would be available to all wildlife stewardship researchers at all universities across the province.*

Graduate stipend funding at a university

Graduate students are usually funded in 3 (often combined) ways:

- Supported by funds given to the academic unit by the Faculty of Graduate Studies. These are then allocated by the unit to students. Typically only the students of regular faculty (i.e., not adjunct professor or other non-university employees) have access to these funds. As an example, a Faculty of Graduate Studies might move \$150,000 to a unit, which then makes decisions on how to allocate those funds to 12 students.
- The student applies for and receives a graduate award from an organization like NSERC (Natural Sciences and Engineering Research Council of Canada), MITACS (originally Mathematics of Information Technology and Complex Systems) or another funding agency. For MSc and PhD students these awards are in the range of \$15,000-25,000 annually, for 1 to 4 years.
- The supervising faculty member writes student stipend funding into a grant application and uses these funds to support the graduate student. Typical funding levels are in the range of \$17,500-25,000 annually, for 1 to 4 years, often pulled together from multiple sources.
- Students may also be offered opportunities like teaching Assistant or Research Assistant positions, which may form part of a stipend funding package. These are typically on the order of \$3000 to \$8000 per year.

Box 3. The typical forms of graduate student funding in universities.

Part 2: Supporting priority research for wildlife stewardship: Interviews

Over the course of interviews and discussions, the following related themes came up repeatedly.

Notably, a co-operative/extension-style model (i.e., the **BC Wildlife Co-operative Science Unit**) addresses and supports most of these.

Excellent wildlife research is already happening in BC: support it

It should not be forgotten that there are already excellent scientists working in BC. Generally there is a feeling that over the last 20 years BC has fallen behind other jurisdictions in North America in supporting wildlife science, at the same time as challenges in wildlife stewardship and management have increased. Some even described the period before 2000 as very successful, with a dramatic decline in available funding after the turn of the century. Funding is difficult to obtain in BC for work on government priorities, and the total amount of government funding is small. There is a feeling that historically BC did an excellent job communicating government wildlife science to the public, but has become much less effective in the last 20 years. This leads to the next point.

Trust in government wildlife stewardship has been eroded

This decline in funding and research was described as eroding public confidence in wildlife research and stewardship conducted by government. Partly as a consequence of the BC government stepping away from supporting and communicating wildlife science, trust in the provincial government's capacity to steward wildlife and solve complex environmental challenges is low. There was discussion of a lack of public-facing communication capacity within government, resulting in the public not having clear access to government research.

Further, wildlife stewards who are working directly with wildlife populations described a lack of learning opportunities with government: few outreach or extension products, few working groups, few field trips to learn new best practices from experts, and fewer resources for improving their skills. Some went so far as to make statements like “Government has abdicated its responsibility to public-facing communications”. Others within government agencies bemoan the lack of resources for translating government research to the public. There was a feeling that this left the public confused about who to trust for the best and most objective information on BC wildlife. It was noted that this has allowed communications around wildlife to become overly complicated and polarized.

To most effectively use the funds identified in Action 5, a co-operative/extension model has the most support. The co-op structure should be nimble and durable (i.e., have long-term funding), and be established in an area beyond the Lower Mainland/Victoria

This is the creation of a research arm of government wildlife stewardship, embedded at a university to deepen collaboration. It should be supported for a long period of time (e.g., 10 years), otherwise wildlife stewardship research will not be completed or deep. It should be able to be nimble and respond to research needs at 3 levels: rapidly (i.e., weeks-to-months response time), medium-term (1 to 3 years, the length of graduate student projects), and long-term (identifying and reacting to population trends in long-lived species). Though funds should be spread to projects around the province, the location of the co-operative should not be in the Lower Mainland or Victoria which A) already has lots of expertise and money, and B) is often far from the wildlife stewardship challenges and people who are most engaged in them. People outside of the Lower Mainland and Victoria felt very strongly about this: new wildlife stewardship opportunities should be in “rural” parts of the province where there are many

wildlife challenges and fewer opportunities than in “urban” settings. For discussants in the Lower Mainland and Victoria this was less of an issue, and there was some feeling that proximity to decision-makers and expertise was important.

In discussions wildlife stewardship models that provided excellent research, collaboration opportunities, and extension/outreach consistently came to the top, as they provide the best balance of ability to work on priority questions while doing excellence science. Interviewees described priority wildlife science topics as A) ecological science questions, and B) social dimensions of wildlife stewardship in BC.

Local capacity development

Any developed program should seek to create capacity at all levels, but notably there were calls to always leave expertise in local communities by engaging with, and deeply involving, local communities whenever possible. This should have First Nations capacity development as a priority.

Opportunities for government, industry, community wildlife scientists to upgrade skills

Universities are often on the cutting edge of training, techniques, and methods. Government, industry, and scientists and managers from communities around the province could benefit from training in these methods. There were calls for opportunities for upgrades in education (e.g., for government scientists to return to school on government-priority projects that could lead to MSc or PhD degrees), including for “micro-credentials” that might involve short courses or training. While there were concerns about whether micro-credentials would actually be recognized officially, most who were interested in this were less concerned about new credentials per se, and

more concerned with learning new best practices for wildlife stewardship. Further, many government, First Nations, and industry scientists would be very interested in spending short periods of time (weeks to months) embedded in academic institutions, even if not taking courses, but rather to facilitate conversations, collaboration, and partnerships. Similarly, students can learn a lot from conducting their research in collaboration with groups outside the university. A **BC Wildlife Co-operative Science Unit** would provide these opportunities.

Support students at universities around the province

Support for students at the MSc and PhD level was identified as one of the most efficient ways to do excellent wildlife science. It was even proposed that the development of a large graduate student support program could have outsized impact on wildlife stewardship and management, through the support of 10 student projects per year, which, over a trial period of 10 years for example, would lead to 100 theses or major projects. Currently MSc and PhD student stipends come primarily from sources like NSERC funds (typically \$17,500 and \$25,000 per year), MITACS, or Faculty of Graduate Studies funds at the host university. BC does not currently have a continuing program for support of graduate students, unlike other jurisdictions in Canada. While programs like this do not necessarily provide capacity for priority questions that need to be answered very quickly (for example in less than 6 months), they do provide for ongoing collection of population data, development and implementation of best wildlife research and stewardship methods, and create expertise and capacity for the province moving forward. Crucially, this follows the “more brains, more solutions” model where funds are also spread to researchers at all BC universities.

Spread money around: “more brains, more solutions”

Funds should not be concentrated in one place, or on one big project: spread funding around to facilitate many brains working on many solutions: this maximizes creativity and solutions, as well as develops expertise around the province. This is best supported with a new graduate student scholarship program that focuses on priority wildlife stewardship research questions. Funds would flow directly to a research supervisor (i.e., a university professor) who could use these funds to support a student stipend, and leverage against other research funds. A committee, composed of government scientists and managers, university professors, and interested community members could be convened to develop priority research topics for these scholarships, and assess applications.

Indigenous Knowledge documentation and engagement

Working with both western science and Indigenous Knowledge (IK) will require significant time and partnerships. The provincial government needs to be ready to give more responsibility to local communities for decision making. Working on wildlife stewardship using both forms of knowledge will be an ongoing project, but one way to support it is to fund the recording of IK in appropriate ways. This also develops and increases wildlife stewardship capacity. People are well aware that this is a complex task.

Public communication improvements

There was much discussion that there is far too little public communication of the results of wildlife science in BC, especially from government research. Even FLNRORD is far under-resourced to make their research findings available to the public. There were many successes in

the past: e.g., FORREX, the development of the BEC zones, and extension style notes. Public communication of wildlife research must be improved. This could even extend to having someone writing a weekly column in newspapers, etc. A **BC Wildlife Co-operative Science Unit** would have this as part of their mandate.

Open data, better data collection and storage

Data collected to date in BC using western science methods is too difficult for researchers to get. Data collection and storage needs to be vastly improved. This can lead to synthesis and better science. Effective and coordinated data collection and storage is needed. Open data (from all sources including industry) is the gold standard that promotes trust through independent analysis and review of the data.

Synthesis is often better than new research

Much work needs to be synthesized and publicly explained to provide support for actions. There are a lot of data already collected that can help with wildlife stewardship. Support for synthesizing already collected data is recommended, a project that can be part of the mandate of the **BC Wildlife Co-operative Science Unit**.

Moving funding from government to independent researchers is often difficult and a barrier to collaboration

Improving and regularizing funding from government to independent researchers is necessary: avoiding end-fiscal scrambles, reducing overhead complications, and related actions frees up partnerships between government and universities. Some of this can be avoided with co-operative organizations that straddle the boundary between government and universities.

Government often does not know what it wants. Researchers should seek to provide stewardship options

Government often does not know what questions to ask, what answers it wants, and how to get them. Examining and providing options should be one goal for scientists. Increased communications between all stakeholders can help prioritize questions through collaborative workshops, working groups, and steering committees for organizations like the **BC Wildlife Co-operative Science Unit**, or for an endowed university research chair.

Long-term funding

Wildlife stewardship science will only be successful if there is long-term funding. A 10 year commitment for a trial may be an effective way to start. Too many projects have started off strong and then faded because funding was not available for long enough periods of time. Many wildlife species of interest have generation times at or beyond the length of a typical funding cycle of two years.

More inventory and monitoring

We still don't have answers to many basic wildlife questions. We often don't even know where species are found and how many individuals there are. We need to vastly improve our inventory and monitoring. Community science may be one component of this. A **BC Wildlife Co-operative Science Unit** could have a mandate to track key wildlife populations around the province.

Table 1. Analysis of the ability of each proposed activity (right column; darker colours indicate stronger support) to address key challenges in British Columbia wildlife research and stewardship. Note that the proposed activities in blue text would have components of those in black text within them. Note, too, that the development of a co-operative style organization affiliated with a major BC university would best address most challenges. This analysis synthesizes both review and interview information.

	Establishing a new endowed research chair for a set term (e.g., in ecology or human dimensions)	Establishing US Geological Survey-style co-op positions at major Universities in B.C.	Supplementing existing research programs to specifically support partnerships with post-secondary institutions	Holding workshops to develop partnerships among researchers, managers and First Nations, and support co-development of research projects	Preparing "state of knowledge" reports on high priority issues to support decision-making	Increasing extension to the public and stakeholders on the current state of scientific knowledge and best practices for human activities (e.g., forestry)	Analysing existing data collected by government researchers and others (e.g., through post-docs), and publishing the results	Creating a communications portal so all researchers (academics, government, private) are aware of each other's work.
Is it good for wildlife?								
Is it cost effective and efficient?								
Is it good at leveraging further opportunities?								
Does it enhance and deepen current work?								
Can it respond to challenges and provide options?								
Does it effectively address multi-year priorities?								
Can it respond to priorities that arise?								
Can it address and stay abreast of scientific best practices and priorities?								
Is it creating new expertise, new capacity, new opportunities, new partnerships?								
Is it producing open data?								
Is it communicating the results in a way the public can access easily and understand?								
Is it increasing trust in government stewardship of BC's wildlife?								

Cost-benefit analysis

A cost benefit analysis was conducted of the options explored in scans and identified in interviews as the most preferable options. Financial costs are considered generally as comparing across jurisdictions may be problematic, and up-to-date financial information can be difficult to find. Details about some costs can be found at places like the Alberta Conservation Association website (<https://www.ab-conservation.com/>). Other costs are based on experience in British Columbia universities and the Canada Research Chairs program (<https://www.chairs-chaire.gc.ca/program-programme/index-eng.aspx>). There was a hint given that the total amount of funding available from FLNRORD for Action 5 might be on the order of \$400,000, though this was never stated explicitly. With that in mind, I explore all options as identified in surveys and interviews, and do recommend that the government look for strong partnerships with other agencies (universities or NGOs that might be able to leverage the funds creatively) to extend any amount. Table 1 provides a summary of the ability of each proposed activity to serve key parts of wildlife stewardship research in British Columbia.

Cost of an endowed chair (like those found in the Alberta Conservation Association, there may be other options for government to university chairs though)

- currently universities require \$7-8 million up front to endow each chair: money is invested and the annual cost of the chair is taken from the interest accrued on the endowment.
- there may be an opportunity to endow at ~ \$200,000 per year (this would cover university administrative costs as well as salary, plus a small annual fund for research) if an agreement can be reached with universities on this. This will require negotiations, however, as one university rationale behind endowing positions is that the position can persist indefinitely. Universities can be wary of short-term funding opportunities because these can end and the university would then be responsible for continuing funding for the position. Short-term position can be difficult for university to agree to. Sometimes 7-10 years of annual funding may be enough to convince the university to support the position beyond the expiration of funds, though this is rare.

Benefits:

- strong research focus on funder priorities, especially in combination with a Terms of Reference and steering committee to provide research and extension/outreach directions
- lots of opportunity for leveraging funding
- can happen quickly (i.e., less than 18 months)
- many student opportunities

Costs of Canada Research Chair Tier II

- funds from federal programs: \$100,000 per year per person, plus \$20,000 in annual research stipend for the first 5 years. Typically for two 5-year terms, after which the university must pick up the costs of the continuing position.
- must apply to the CRC program though, and is therefore not guaranteed. May take years to set up
- there are other programs that may allow government or industry sponsorship for setting up a chair, though they can take 2 or more years to apply for and set-up, and are by application so not guaranteed.

There are two types of Canada Research Chairs:

Tier 1 Chairs, tenable for seven years and renewable once, are for outstanding researchers acknowledged by their peers as world leaders in their fields. For each Tier 1 Chair, the institution receives \$200,000 annually for seven years.

Tier 2 Chairs, tenable for five years and renewable once, are for exceptional emerging researchers, acknowledged by their peers as having the potential to lead in their field. For each Tier 2 Chair, the institution receives \$100,000 annually for five years, with an additional \$20,000 annual research stipend for first-term Tier 2 Chairs.

Though these CRC positions may be relatively cost-effective (i.e., they receive funding from federal tri-council granting agencies) they are not recommended as a target for FLNRORD T4W Action 5 as the development time for them can be long, and success in the competition process for them is not guaranteed. With a longer view they may be a good target, though not for the short-term.

Benefits:

- strong research focus though primarily on academic priorities, if these positions work on government priorities that is secondary
- lots of opportunity for leveraging funding
- BC government could focus on providing student and operating funds rather than salary
- many student opportunities and increase BC wildlife stewardship expertise

Costs of co-operative/extension model

- In general, each scientist should be budgeted at \$200,000/year (includes salary, base operating funding, administrative costs): e.g., -\$110,00 annual salary per person to start (\$330,000 total for 3 scientists); base operating research funding of perhaps \$25,000 per researcher per year, scientists can leverage these funds and apply for other research funding; administration costs include space costs at the university, which may run to several \$10,000 per year.
- could be cost shared with university if negotiated: this model benefits both parties.
-
- \$100,000 outreach/communications individual salary per person to start
- \$100,000 administrator costs

Benefits:

- strong research, strong focus on FLNRORD priorities, ability to respond to priorities quickly
- partnership with university can share costs
- partnership with university can train students, wildlife stewards
- public facing communications can be a strong component and can lead to this structure being seen as a clear “go to” for wildlife information in British Columbia.

Costs of Course and Administration Buy-outs for current professors (similar to what was used as part of ACWERN model: buying university faculty out of teaching and administrative responsibilities so they can spend more time on research)

- \$10,000/course
- increased funding for research costs (perhaps at \$25,000 per person) to be leveraged against other research funds
- little ability to do public communications, though in a Terms of Reference this responsibility could be established
- little ability to respond to rapid research needs (i.e., on a less than one year timeline)

Benefits:

- can support people already in place, potentially to create a dispersed community of researchers that might work together to support researchers working on similar wildlife stewardship research around BC
- excellent research, though focus still driven by academic evaluations and may be difficult to ensure FLNRORD research priorities are met.

Costs of new graduate student scholarship/funding

MSc/MA Scholarship	4/year	\$25,000/yr X 2 years	\$200,000	\$20,000/year student stipend, plus \$5000/year research costs. Each scholarship covers 2 years.
PhD Scholarship	3/year	\$30,000/yr X 3 years	\$270,000	\$25,000/year student stipend, plus \$5000/year research costs. Each scholarship covers 3 years.
Post-doctoral fellowship	2/year	\$50,000/yr X 2 years	\$200,000	Cutting edge research and synthesis

Benefits:

- excellent research on funder priorities
- development of new capacity
- many projects quickly off the ground

-administrative costs fairly low as these flow directly to the university or to a wildlife research committee to decide on allocation strategies.

Total annual costs for **BC Wildlife Co-operative Science Unit and new graduate student/post-doctoral fellow scholarships**: \$1,270,000 to \$1,470,000 per year

Recommendations

Building on research and interviews, we present a cost-benefit analysis (Table 1) and recommend the following 2 specific and 2 general targets:

Specific

1. **The creation of a BC Wildlife Co-operative Science Unit, supported with long-term funding.** This is a research arm of government wildlife stewardship based at, supported by, and integrated into a university. This is a unit embedded with a Department of Biology/School of Environmental Studies. It is at once arm's-length from government and part of government— that is, working on a long-term provincial government funding structure and evaluated by both government and academic colleagues. The research and outreach focus of the BC Wildlife Co-operative Science Unit will be BC community and government wildlife stewardship priorities. This unit should focus on research and communications at 3 scales:

- **Long-term research that addresses long term and ongoing management goals and objectives for British Columbia (2-10 year scale)**
- **Research on pressures: problems that arise and must be solved right away (responses needed in weeks to months or sooner)**
- **Discovery research: the scientifically most important questions to stay on top of and contribute to cutting-edge science and methods (often completed in 2-3 years or less, or the length of a graduate student project)**

A steering committee, composed of government managers, scientists, and community members (e.g., First Nations, industry) can provide clear research priority direction. This will ensure the BC Wildlife Co-operative Science Unit will be nimble (can quickly respond to wildlife stewardship problems) and durable (will be supported by long-term funding). First Nations voices should be centered as scientists and on the steering committee: this could be a model for the world, and it focuses on

producing excellent research and stewardship options/solutions. The structure could be based on successful examples in the United States, with 3 scientist topics recommended: two natural scientists and one social scientist of wildlife stewardship. The researchers would have excellent study design and analysis skills, and a demonstrated ability to supervise students. Each co-op scientist should have a PhD and postdoctoral experience, and will be appointed in some form as Affiliated Faculty (e.g., Adjunct Professors) within the partnering unit and the partner university.

The BC Wildlife Co-operative Science Unit should be outside the Lower Mainland.

There are concerns about the current concentration of expertise and funding in the Lower Mainland and Victoria, and the relative lower density of expertise and opportunities outside of these areas. Many people described how most wildlife stewardship issues occur outside of southwestern BC, yet few of the research and management opportunities exist there. Many described how a BC Wildlife Co-operative Science Unit could create local expertise and provide more opportunities for training outside of southwestern BC if it was affiliated with, for example, the University of British Columbia-Okanagan or the University of Northern British Columbia where it can be engaged with, and build on, the expertise that already exists at these universities. It was recognized that hosting the co-operative science unit in the Lower Mainland or Victoria could provide access to other expertise and perhaps to policy development, but it was felt that addressing rural funding, challenges, and expertise issues outweighed these advantages.

The BC Wildlife Co-operative Science Unit should work on synthesis as well as new field research, and should play a role in improving BC’s data collection and management. Data are hard to get, there are few data standards, and there is a need for these to be created. All data should be open and easily available, as should all data collected in the province over the past few decades. A single hub for all government wildlife stewardship data is warranted.

The BC Wildlife Co-operative Science Unit should play a strong role in hosting working groups and outreach activities to bring people together to work on priority wildlife stewardship solutions. Further, recent improvements to video-conferencing and other communications tools make “visiting” Lower Mainland and Victoria colleagues much easier than a decade ago.

There should be clear public facing communications to report on science to build public trust and support, with a lean administrative structure. In addition to the 2-3 scientists, there should be a public communications expert.

2. **A new MSc and PhD scholarship in wildlife science should be created**, with up to 10 new students per year. Two post-doctoral fellowships should be created. This is a program to support research at all universities in British Columbia. A clear *terms of reference* for the research and communication needs supported by the scholarships would be created. A selection committee of government scientists and managers, and academic researchers (i.e., university faculty), could receive applications from students or research

supervisors, and assess the applications against criteria laid out in the terms of reference. These scholarships should be spread around to all universities in BC: more brains and more diverse methods lead to better overall science for wildlife. Some scholarships may go to students working within the BC Wildlife Co-operative Science Unit, while other could be spread around to all universities in BC, and potentially beyond, if the project was on a priority topic to the selection committee in the year of application. While the students holding these scholarships will not be able to respond to the most pressing short-timeline wildlife research needs, they do provide significant expertise for short- and medium-term goals. Further, training students in wildlife research provides the wildlife managers of tomorrow.

General

3. **Create and deepen capacity beyond the co-operative science unit.** Science work should be done on priority questions across the province, involving local community members and stewards wherever possible. A goal should be to leave expertise in communities. Programs to work with Indigenous Knowledge holders and even a program to record this knowledge should be prioritized. Indigenous knowledge must be included deeply and respectfully, recognizing differences in western science and traditional methods of knowledge gathering and holding. Increasing capacity in Indigenous communities should be a priority. Programs to bring people together, across sectors and communities, for working groups, knowledge creation and sharing, and outreach should be priorities.

4. **Continue, and extend, current science and communication funding initiatives** within and outside of government through increases in funding pots in places like those from the Habitat Conservation Trust Foundation and the Living Lab program of BC Parks.

Funding for government-priority science in BC remains too low, and operating funds to support science also supports grad students and builds wildlife stewardship capacity for the province.

Table 2. General annual costs for the creation of a BC Cooperative Wildlife Science Unit and associated funded projects. To be done annually for 10 years.

Position	Number	Annual cost per	Total cost	Role
BC Cooperative Wildlife Stewardship Scientists	2-3	\$200,000	\$400,000 - \$600,000	The lead scientists within the unit. This includes salary plus base annual research costs, and administrative costs.
BC Cooperative Wildlife Stewardship Communication Specialist	1	\$100,000	\$100,000	The Communications lead for the unit. Turns research results into public-facing communications, organizes extension activities like field trips etc. Salary.
BC Cooperative Administrator	1	\$100,000	\$100,000	The unit administrator. Salary.
MSc/MA Scholarship	4/year	\$25,000/yr X 2 years	\$200,000	\$20,000/year student stipend, plus \$5000/year research costs. Each scholarship covers 2 years.
PhD Scholarship	3/year	\$30,000/yr X 3 years	\$270,000	\$25,000/year student stipend, plus \$5000/year research costs. Each scholarship covers 3 years.
Post-doctoral fellowship	2/year	\$50,000/yr X 2 years	\$200,000	Cutting edge research and synthesis
Total annual costs			\$1,270,000 to \$1,470,000 per year	

Recommendations for Action 5

Develop a USGS Co-operative/extension style centre with 2 or 3 scientists, an outreach/communications specialist, and administrative support. Integrated into a university. The

Not in the Lower Mainland/Victoria: likely affiliated with UBC-Okanagan or the University of Northern British Columbia

The unit must be supported with long-term funding (e.g., 10 years)

The unit should always seek to build capacity in communities

The unit should support opportunities and activities for BC wildlife stewardship research, with a strong focus on working groups and outreach to provide solutions to, and trusted information on, BC's most difficult wildlife stewardship challenges

The unit should lead open data and data standards for BC wildlife stewardship

Further funding, spread around the province, especially new graduate student and post-doctoral fellow scholarship funding. More brains working on more problems yields more solutions: this is creation of current and future expertise, these people become wildlife stewards of tomorrow in BC

Public communication of research results and policy implications and development

Wildlife stewardship activities should focus on partnerships maintained, deepened, extended, including with First Nations

Work with a university to partner/support/host this position, to share costs and administration

Box 4. 10 recommendations for Action 5.

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Appendix 1. Case Studies of successful wildlife stewardship research

Case Study. *Dr. Adam Ford, Canada Research Chair in Wildlife Restoration Ecology*

As Tier II Canada Research Chair in Wildlife Restoration Ecology at the University of BC-Okanagan, Dr. Adam Ford's research focuses on bringing scientific information into the wildlife management decision-making process (Government of Canada 2021). Dr. Ford and his team of graduate students in the UBC-Okanagan Department of Biology conduct multiple research projects examining the impacts of human activity on the interactions of large predators (wolves, bears, cougars), their ungulate prey, and plans in human-modified landscapes (Ford, n.d.). Specifically, these projects investigate the impacts of forestry, urban growth, and highways on species' abundance, movement, and interactions throughout BC. Information collected from these studies is aimed at informing management strategies and policies seeking to protect and restore Canada's landscape and help stabilize and recover wildlife populations.

Research projects are largely funded by NSERC and the BC Habitat Conservation Trust Foundation, with a number of other research grants and partnerships providing further support for individual projects (e.g. Fish and Wildlife Compensation Program, BC Conservation Foundation, Columbia Basin Trust, Wild Sheep Society of BC). Students and post-doctoral fellows further leverage research funds through various grants and scholarships, such as the NSERC/SSHRC Vanier Graduate Scholarship, Mitacs Accelerate Internships, NSERC Canada Graduate Scholarships, and Liber Ero Fellowships. Research projects are also conducted in partnership and collaborations with a number of government and non-government agencies (e.g. Wildlife Conservation Society), as well as First Nations governments such as the Okanagan Nation Alliance.

Over the past 4 years, Dr. Ford's team has produced over 30 peer-reviewed publications with a further 10 under review. As Associate Professor, Dr. Ford teaches an undergraduate course on animal ecology. He engages in multiple university and professional services, acting as member of the Minister's Wildlife Advisory Council, Faculty Advisor for the UBC-O Student Chapter of the Backcountry Hunters and Anglers, Faculty Advisor for the UBC-O Student Chapter of the Wildlife Society, member of the Institute for Biodiversity, Resilience, and Ecosystem Services, and member of the UBC Biodiversity Research Centre.

Case Study. *Dr. Mark Boyce, Alberta Conservation Association Chair in Fisheries and Wildlife*

The Alberta Conservation Association (ACA) is a unique partnership between the Ministry of Alberta Environment and Parks (AEP), Alberta Fish and Wildlife Division, and the University of Alberta (Alberta Conservation Association, 2021). First established in 1997, the ACA's mission is to "conserve, protect, and enhance fish and wildlife populations and their habitats for Albertans to enjoy, value and use". The ACA holds special status as a delegated administrative organization (DAO), undertaking research projects and programs addressing AEP priorities for fish and wildlife management and conservation. As a DAO, results from the ACA's fish and wildlife surveys, assessments, and research feed directly into AEP management plans, providing the basis for fishing and hunting regulation changes.

The ACA works in science, research, and education. The ACA runs an extensive grants program to support projects benefiting Alberta's fish and wildlife populations. To date, approximately \$20.6 million has been granted to conservation-related projects throughout Alberta by the ACA's Grants Program⁴². Since the inception of the ACA Grant Programs, 567

graduate students have been awarded a total of \$5.8 million. In 2020/2021, the ACA funded 16 student research projects with a total of nearly \$330,000.

The ACA endows a tenured chair position in Fisheries and in the Department of Biological Sciences at the University of Alberta, and student activities through teaching and research. Dr. Mark Boyce has been the ACA Chair since 1999, conducting scientific research on priority wildlife populations across Alberta (Boyce, n.d.).

Research projects undertaken by the Boyce Lab support the ACA's identified goals for long-term sustainable fisheries and wildlife resources, providing findings and recommendations to guide the future direction of wildlife research in the province. Results from their wildlife population studies, surveys, and assessments feed directly into AEP management plans and form the basis of fishing and hunting regulation changes and evaluations of new management strategies for the province. Dr. Boyce's research has identified the impacts of energy developments in Alberta and Saskatchewan on sage-grouse populations, who continue to decline and are at risk of total extirpation in Canada. In an example of research directly translating to government action, in 2019 Dr. Boyce was retained by the Department of Justice Canada to develop an affidavit supporting Emergency Protective Order by the Minister of Environment and Climate Change for the Greater Sage Grouse (Boyce, 2020). The lab's research program on grazing management on Canada's grasslands contributes to public policy, engaging federal and provincial governments on strategies for strategic investment of carbon tax revenues (Boyce, n.d.). Moreover, their work contributes to a formal protocol in Climate Action Reserve to support the investment in carbon credits in Canadian grasslands for grassland conservation. This research program is a collaboration with multiple researchers from the University of Alberta and elsewhere and is funded by federal Agricultural Greenhouse Gas Program (Boyce, n.d.). Dr. Boyce's contributions to research into ungulate management and the consequences of harvest management led to his appointment by Alberta Environment and Parks to a scientific advisory panel for bighorn sheep management in Alberta.

To date, Dr. Boyce and his lab have produced over 350 peer-reviewed and technical publications, with more than 40 post-doctoral fellows and graduate students supervised. Numerous research projects to date have looked at habitat selection, distribution, and population ecology across multiple species, taxa, and ecosystems, and their responses to human and natural disturbances. Their work covers a diversity of species of management concern, including caribou, wolverine, elk, cougar, grizzly and black bear, mule deer, white-tailed deer, and waterfowl.

Current graduate students are working with Alberta Environment and Parks staff to build models to help inform and evaluate harvest policies for elk and mountain sheep. Two ongoing projects collaborate with the Provincial Carnivore Specialist to evaluate the efficacy of extended cougar hunting seasons in western Alberta. Other current students include a biologist with the Wildlife Department of the Government of Nunavut on leave to pursue a Ph.D. evaluating population declines of arctic caribou. Focusing on priority conservation issues in the province, the Boyce Lab provides a direct bridge between government, academia, and public stakeholders interests through their research.

Case Study. *Dr. Glen Brown, Trent University and Ontario Ministry of Natural Resources and Forestry*

Dr. Glen Brown's research group at Trent University is comprised of fellow OMNRF scientists and technicians and a team of graduate students conducting research on animal ecology in northern terrestrial ecosystems (Brown, 2021). Although appointed as adjunct professor across three Ontario universities, Dr. Brown's office and research lab is based on campus at Trent University.

His Northern Animal Ecology Lab focuses on addressing current issues facing resource management agencies. The lab's work uses science to help natural resource agencies, organizations, and the public. A main objective is to integrate wildlife biology into decision-making processes for conservation and sustainable resource management. Main research interests include mammalian and avian ecology, predator-prey relationships, wetland ecology, and sustainable resource management. The research program is supported through base funding, as well as contracts and grants from provincial, federal, non-governmental and private organizations and agencies. Over the past 12 years, the lab has produced more than 40 peer-reviewed publications.

Dr. Brown's team focuses on wildlife populations and habitats of provincial and federal interest. One program addresses wildlife indicators for sustainable forest management to meet the objectives for sustainability and biodiversity conservation. This program is conducted with partners in the Ontario Ministry of Natural Resources and Forestry to research critical habitat relationships between forest-dependent wildlife, and to identify useful indicators for monitoring the effectiveness of management strategies, with special focus on woodland caribou. Another research program addresses moose population health in Ontario to better manage for this key species of interest to many stakeholders. Collaborations extend to the American Museum of Natural History, the universities of North Dakota and Rhode Island, Environment and Climate Change Canada, and Bird Studies Canada.

In addition to the research space on Trent University campus, facilities also include field camps in Polar Bear Provincial Park (Ontario), Akimiski Island (Nunavut), and staff houses in Moosonee and Peawanuck, Ontario.

Case Study: *The New York Cooperative Fish and Wildlife Research Unit*

The New York Cooperative Fish and Wildlife Research Unit was established at Cornell University in 1961 for the purpose of enhancing the management and conservation of U.S. natural resources (United States Geological Survey, 2021). This unit focuses on natural resource issues of interest to New York State. Cooperators include the USGS, NY State Department of Environmental Conservation, US Fish and Wildlife Service, the Wildlife Management Institute, and Cornell University. Its mission is to conduct research on natural resource issues, provide graduate level education and training, and technical assistance to cooperators. Dr. Angela Fuller is the current unit leader, and two additional federal scientists make up the unit along with administrative staff from the university and a large team of graduate students (United States Geological Survey, 2021). The coordinating committee is comprised of a USGS representative, NY State Department of Environmental Conservation representative, two Cornell representatives (Chair of the Department of Natural Resources and the College of Agricultural and Life Sciences Senior Associate Dean), two US Fish and Wildlife Service Representatives, and a Wildlife Management Institute representative.

The New York Cooperative Research Unit focuses on the resource problems of the Northeastern States, with an emphasis on New York. Based Cornell University's Department of Natural Resources, this unit's efforts are directed at maintaining productive research programs. It

also works to seek funds for coordinating the planning of other research and management faculty/staff at the University and within the New York State Department of Environmental Conservation and U. S. Fish and Wildlife Service's Northeast Regional Office.

Over the past 12 years, this unit has led 55 research projects, produced 11 graduate theses and dissertations, given over 200 research presentations, and published 96 peer-reviewed papers and 32 technical reports. Over this time, Dr. Angela Fuller and other USGS scientists have taught more than 20 graduate and undergraduate courses, 16 workshops, 19 invited seminars, 16 guest lectures, and been part of over 30 graduate committees. They have also provided extensive technical assistance, university service, professional service, and outreach in the form of panel membership, university committees, advisory boards, session moderation, school programs, and media interviews. In 2020, this unit produced 12 peer-reviewed publications, 1 technical report, 23 presentations and seminars, 1 MSc thesis, and taught three courses. Current graduate research projects focus on fish, bird, and mammal populations of conservation and research interest to the State and cooperators.

Dr. Angela Fuller's research lab focuses on collecting information to guide conservation and management of wildlife species and their habitats (United States Geological Survey, 2021). With a special emphasis on decision science, The Fuller Spatial Ecology and Decision Science Lab applies structured decision making and adaptive management strategies to evaluate how well alternative management strategies perform at achieving objectives identified by decision makers and stakeholders. Research projects include invasive species management in New York, monitoring sensitive populations of fur-bearing species, threats to moose populations in the northern U.S., integrating hunter values with duck migration data, and human-wildlife conflicts across the U.S. and beyond.

Case Study: *Wyoming Cooperative Fish and Wildlife Research Unit*

The Wyoming Cooperative Fish and Wildlife Research Unit was established in 1977 as a partnership between the USGS, Wildlife Management Institute, the University of Wyoming, and various State and Federal fish and wildlife agencies (United States Geological Survey, Wyoming Cooperative Fish and Wildlife Research Unit, 2021). Housed at the University of Wyoming's Zoology and Physiology Department, the unit hosts three federal researchers as well as 7 university staff including research scientists and administrators. At present, 26 graduate students and postdoctoral fellows are directly attached to the unit (Wyoming Cooperative Fish and Wildlife Research Unit., 2021).

The unit focuses on seeking general solutions to specific management and conservation challenges through an applied research program on fish and wildlife populations and communities central to Wyoming and the Rocky Mountain West. The process of identifying research needs and priorities involves a collaborative process with Wyoming Game and Fish Department (WGFD staff. This includes preparation of proposals for review by WGFD, development of work plans prior to funding, the preparation of quarterly reports for research projects in progress, and a detailed project report submitted at the completion of a project. In addition to conducting research, the unit also provides substantial research administrative services for projects funded by WGFD and Federal agencies, including budgeting, contracting, communications, and reporting. The unit's close collaboration with wildlife managers provides students with the opportunity to gain a comprehensive understanding of the interplay between management and research.

Research projects developed by the unit and carried out by a large body of graduate students have provided state managers with a better understanding of the ecology of the Western landscape. To date, the unit has conducted over 80 research projects lead by more than 200 graduate students advised or co-advised by unit scientists (United States Geological Survey, Wyoming Cooperative Fish and Wildlife Research Unit, 2021). In the past ~20 years, the unit has produced over 250 peer-reviewed publications and more than 60 technical reports, with 250+ research presentations delivered. This has been done in conjunction with the teaching, training, and development of the next generation of leading scientists and resource managers. Unit scientists have provided over 20 graduate courses over the last two decades, as well as extensive participation in invited seminars, guest lectures, and graduate committees. In addition to teaching, unit scientists have also provided substantial technical assistance, university service, professional service, and outreach.

The Wyoming Cooperative Fish and Wildlife Research Unit is led by Dr. Matthew Kauffman (Wyoming Cooperative Fish and Wildlife Research Unit. *Kauffman Lab*, , n.d.). His team of graduate students and post-doctoral fellows conduct extensive research on large mammal migration patterns, population dynamics, community interactions, and behaviour. Current research projects include mule deer, elk, and moose habitat-use and migration, impacts of wind energy on pronghorn, and habitat connectivity for ungulate populations. Previous research projects included wolf-livestock interactions, native sportfish conservation, and habitat fragmentation on bird communities. One of their collaborative projects, The Wyoming Mule Deer Initiative, was the largest mule deer study in Wyoming and one of the largest in the West directed at understanding mule deer migration and factors affecting deer survival (Wyoming Game and Fish Department. The Wyoming Range Mule Deer Initiative, 2021). This project was a partnership between the Wyoming Game and Fish Department and researchers from the University of Wyoming, including those from the unit. Approximately \$500,000 USD were directed to this research project, including funds provided by various government and conservation groups such as the Muley Fanatic Foundation of Rock Springs, the Boone and Crockett Club, and the Animal Damage Management Board. In addition to Dr. Kauffman's team, Assistant Unit Leaders Drs. Anna Chalfoun and Annika Walters also each lead a large team of graduate students pursuing research projects focused on addressing conservation concerns for the State's fish, bird, and wildlife populations⁵¹.

Case Study: *The National Wildlife Research Centre, Environment and Climate Change Canada and Carleton University Department of Biology*

The National Wildlife Research Centre (NWRC) moved its office to Carleton University campus in 2002 as a partnership between Environment and Climate Change Canada (ECCC) and Carleton University, Ontario (Environment Canada 2004). Deteriorating facilities coupled with reduced capacity following the elimination of many research and technician positions threatened the closure of the NWRC in the late 1990s. As an alternative option to expensive renovations or spreading the remaining 50 dedicated research staff across different Environment Canada departments, management proposed building a new NWRC office on a campus of a university that could be a potential partner in wildlife research.

This option not only reduced the cost of infrastructure through shared expenses, but more importantly, offered enhanced opportunities for collaboration to re-build research capacity at the NWRC. Through access to a variety of capital grants for building activities, Carleton University helped provide funds to cover construction expenses of the new NWRC building as part of a

satellite facility of its biology building, encouraging the free movement of people and ideas between the university and NWRC staff. The new NWRC facility included work space to house up to 24 student work stations, with over half filled within the first year of NWRC's opening on campus. Physical proximity and close collaboration between Carleton students and professors with NWRC researchers would facilitate flow of knowledge, expertise, and scientific ideas between the two communities. NWRC would be in a position to offer students extensive data resources from their huge wildlife databases and offer supervision of research projects, and students in turn could direct their research towards important wildlife issues. Initial plans also included the creation of a joint Institute for Wildlife Science with one or more endowed research chairs. Insufficient resources prevented these initiatives from being fully realized, the NWRC – Carleton partnership opened the door for government and university scientists to collaborate on science critical to wildlife conservation. The government-university partnerships deepen collaboration to produce excellent science, while also sharing costs.

The NWRC's mission statement is "to be the principal source of knowledge and expertise in the federal government on the impact of toxic substances on wildlife and the use of wildlife as indicators of environmental quality, and to conduct national surveys and research on migratory birds." Today, its office hosts 12 ECCC research scientists with adjunct professor status at the university (Government of Canada. National Wildlife Research Centre, n.d.). NWRC scientists are conducting research on, for example, the ecology population dynamics of endangered seabirds (Dr. Grant Gilchrist), adaptation strategies for terrestrial biodiversity conservation (Dr. Ilona Naujokaitis-Lewis), and critical habitat conservation for species at risk (Dr. Cheryl A. Johnson. These researchers are the direct thesis supervisors to many MSc and PhD graduate students as well as postdoctoral fellows (e.g. Dr. Robert Letcher) and act as thesis committee members for graduate students across multiple Ontario universities. NWRC scientists have leveraged further research funds through research grants such as the Canadian Foundation for Innovation, NSERC Discovery Grants, and the Postdoctoral Research Program (Health Canada) (Government of Canada, n.d.).

Appendix 2. List of Participants (does not include those who asked to contribute anonymously)

Name	Affiliation
Anderson, Morgan	BC government
Bowman, Jeff	Ontario government & Trent University
Boyce, Mark	University of Alberta
Burkhart, Tim	Yellowstone to Yukon Conservation Initiative
Burton, Cole	University of British Columbia
Cortini, Francesco	BC government
Costanzo, Brenda	BC government
Darimont, Chris	University of Victoria
Davis, Rod	former BC government
Dempsey, Jessica	University of British Columbia
Festa-Bianchet, Marco	Université de Sherbrooke
Fisher, Jason	University of Victoria
Forbes, Graham	University of New Brunswick
Ford, Adam	University of British Columbia-Okanagan
Govinarajalu, Purnima	BC government
Hanacek, Megan	Private Forest Landowners Association
Harrower, Bill	BC government
Heffelfinger, Jim	USGS
Jacob, Aerin	Yellowstone to Yukon Conservation Initiative
Johnson, Chris	University of Northern British Columbia
Kerr-Uppal, Manjit	BC government
Lamb, Clayton	University of British Columbia-Okanagan
Lampreau, Hunter	Qwelmínte Secwépemc Office
McAdam, Steve	BC government
Muhly, Tyler	BC government
MWAC group	
Otto, Sally	University of British Columbia
Psyllakis, Jen	BC government
Quayle, James	BC government
Reynolds, John	Simon Fraser University
Rosenfeld, Jordan	BC government
Shackelford, Nancy	University of Victoria
Straka, Jason	BC government
Stuart-Smith, Kari	CANFOR
Taylor, Phil	Acadia University (ACWERN)

Todd, Melissa

Turner, Nancy

Zeman, Jesse

BC government

University of Victoria

BC Wildlife Federation