SUPPORTING ACTIONABLE SCIENCE FOR ENVIRONMENTAL POLICY: ADVICE FOR FUNDING AGENCIES FROM DECISION MAKERS

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ABSTRACT

Successful incorporation of scientific knowledge into environmental policy and decisions is a significant challenge. Although studies on how to bridge the knowledge-action gap have grown rapidly over the last decade, few have investigated the roles, responsibilities, and opportunities for funding bodies to meet this challenge. In this study we present a set of criteria gleaned from interviews with experts across Canada that can be used by funding bodies to evaluate the potential for proposed research to produce actionable knowledge for environmental policy and practice. We also provide recommendations for how funding bodies can design funding calls and foster the skills required to bridge the knowledge-action gap. We interviewed 84 individuals with extensive experience as knowledge users at the science-policy interface who work for environmentally focused federal and provincial/territorial government bodies and non-governmental organizations. Respondents were asked to describe elements of research proposals that indicate that the resulting research is likely to be useful in a policy context, and what advice they would give to funding bodies to increase the potential impact of sponsored research. Twenty-five individuals also completed a closed-ended survey that followed up on these questions. Research proposals that demonstrated 1) a team with diverse expertise and experience in co-production, 2) a flexible research plan that aligns timelines and spatial scale with policy needs, 3) a clear and demonstrable link to a policy issue, and 4) a detailed and diverse knowledge exchange plan for reaching relevant stakeholders were seen as more promising for producing actionable knowledge. Suggested changes to funding models to enhance utility of funded research included 1) using diverse expertise to adjudicate awards, 2) supporting co-production and interdisciplinary research through longer grant durations and integrated reward structures, and 3) following-up on and rewarding knowledge exchange by conducting impact evaluation. The set of recommendations presented here can guide both funding agencies and research teams who wish to change how applied environmental science is conducted and improve its connection to policy and practice.

1. INTRODUCTION

The last decade has seen a steady stream of scholarship dedicated to understanding and narrowing the knowledge-action gap by, among other strategies, improving knowledge mobilization and exchange among scientists and decision makers (Box 1; Cvitanovic et al. 2016; Nguyen et al. 2017). In environmental fields, much of the literature has focused on the responsibilities of scientists to modify their research approach, improve their communication skills, and amplify their awareness of policy issues (Bednarek et al. 2016; Safford and Brown 2019); or else on decision makers to engage more effectively with the scientific community and rely less on informal knowledge sources (Pullin et al. 2004; Cvitanovic et al. 2014). Far less attention has been directed toward the roles, responsibilities, and opportunities for funding agencies to solicit, encourage, and support research that is likely to promote evidence-informed decision-making (Matso and Becker 2014; Arnott et al. 2020a). Here, we present a set of criteria gleaned from interviews with knowledge users working at the science-policy interface across Canada that can be used by funding agencies (Canadian or otherwise) to evaluate research proposals for their potential to produce actionable knowledge for environmental policy (Box 1).

Funding agencies play a unique role within the scientific community. They have substantial influence on the direction of and intention behind funding calls, and on the evaluation of proposals and decisions on funding allocation (Lyall et al. 2013; Coutinho and Young 2016). In turn, funding decisions shape research programs (Smits and Denis 2014), particularly in relatively young and/or interdisciplinary fields that lack dedicated funding bodies (Lyall et al. 2013). Research funders thus have capacity to encourage and influence practices that can bridge the gap between science and environmental policy and practice (Bozeman and Youtie 2017; Mach et al. 2020). A small (but growing) body of evidence has documented how innovative funding models can stimulate approaches to research that are known to amplify its impact (Bednarek et al. 2016; Boaz et al. 2018; Trueblood et al. 2019). Research in the medical field has

identified funding agencies as key players in the process of integrating science into policy and practice (Holmes et al. 2012) with several funders deliberately promoting interdisciplinary engagement and incorporating follow-up programs to improve knowledge exchange (Sibbald et al. 2014).

In an applied conservation setting, research often has the stated goal of understanding and solving environmental problems. However, the extent to which this research is mobilized to inform policy and practice is much lower than would be ideal (Sutherland and Wordley 2017). Although much work has been done to identify barriers to effective knowledge exchange (Rose et al. 2018), suggested solutions are often difficult to implement (Rose et al. 2019), and support is needed from all players in the research arena. Funding bodies have a responsibility to ensure that the work they support has a high probability of being integrated into policy and practice if that is the stated goal of the research or the funding call (Fisher et al. 2001). However, predicting which proposals have the highest likelihood of producing usable knowledge can be a daunting task for grant selection committees. Being able to foresee which research projects are likely to produce useable knowledge *before* the research is underway can prevent waste of important research resources (Buxton et al., 2021). However, most of the nascent research in this sphere has focused on evaluating study utility *after* the research has been conducted by monitoring the policy and practice impact in the months or years following publication (Bozeman and Youtie 2017). We are unaware of studies that have investigated steps that can be taken during the grant selection stage based on insights obtained from knowledge users.

The goals of this study are therefore to 1. provide a set of general criteria that can be used by funding agencies to determine whether a given proposal is likely to produce usable knowledge and 2. provide recommendations on operational aspects of funding agencies that promote production of usable knowledge. We used semi-structured interviews to elicit the perspectives of individuals with extensive experience as knowledge users at the science-policy interface on how funding agencies can solicit and

select research proposals that are likely to be useful for policy and practice. We draw lessons and recommendations from these findings to assist funding agencies in identifying and supporting actionable research.

2. METHODS

2.1 Selection of participants

Participants for this study were recruited via directed sampling due to the specialized nature of the knowledge we sought to access. We selected participants who are currently employed in or recently retired from senior-level positions (e.g., senior science advisors, program directors) in environmental departments in Canadian federal, territorial, or provincial governments, and those working for environmental non-governmental organizations (ENGO) with an interest in environmental policy. We targeted this demographic because of their experience using applied research to advise or inform environmental policy. Some of our participants also have experience on grant selection committees and as recipients of grants and are thus familiar with the process of applying for, adjudicating, and taking up grants. Although we were primarily interested in participants' perspectives as knowledge users, this diversity of experience situates them well to provide advice on judging or predicting research utility at the proposal stage. Most on-the-ground environmental managers or practitioners are focused on a given region or issue and are not typically involved with development of strategic funding programs, hence our focus on individuals who hold senior positions. We acknowledge that targeting senior-level professionals might overlook valuable perspectives from practitioners and encourage future studies to focus on that demographic.

Participants were selected through prior knowledge and past partnerships (n = 53), and by performing web searches of relevant organizations to identify individuals in leadership or advisory roles (n = 23).

Additional participants were identified through recommendations from people on this initial list (n = 8). Invitations were distributed to potential participants by email. A total of 135 people were contacted. Of these, 84 were interviewed over 82 sessions, with two interviews having two participants. The participants all had post-secondary education with the majority (75%) holding an Master's or a PhD in a scientific field. Participants had experience either primarily in policy (n = 8), primarily in scientific research (n=9), or in both (n=67), with the majority (80%) gaining policy experience on-the-job rather than through formal training. Of participants working for a federal department, 30 were based out of headquarters in Canada's capital city of Ottawa, and 19 were attached to regional offices in various provinces. Participants included 36 female and 48 male respondents and included both early, mid, and later-career individuals encompassing a range from 8 – 30+ years experience. We had representation from federal government bodies (including Fisheries and Oceans Canada [DFO], Environment and Climate Change Canada [ECCC], Parks Canada, and Natural Resources Canada [NRCan]), territorial/provincial governments, and ENGOs. Sample sizes of participants and their organizations are presented in Table 1. This study was conducted with Canadian professionals. Although our findings are likely to be applicable to regions with highly developed research and funding systems (e.g., Europe, Australia, the United States) they may not apply as seamlessly to regions where these systems are less developed (e.g., much of the Global South).

2.2 Designing and conducting interviews

Interviews were semi-structured, following a set of scripted questions but allowing for digressions. They were a mix of closed-ended and open-ended questions, thus generating quantitative and qualitative responses. The interview guide was written collaboratively by several members of the research team (EAN, JJT, TR, JFL, NY, JB, SJC), and was circulated to all 17 co-authors for comment. The interview questionnaire was extensively revised over a three-month period. Prior to finalization, the interview was

tested on six individuals: three non-participants and three participants in the study. Based on their feedback, several questions were removed or revised.

The full interview questionnaire comprised 14 questions that, in addition to funders roles, covered definitions of evidence and usable knowledge, barriers and solutions to using evidence in policy and practice, and experiences with co-production. In this article, we report findings from two key questions that asked participants about elements of research proposals that indicate a high likelihood that the proposed research will be useful in a policy context. First, we asked an open-ended question that requested participants to describe characteristics of grant proposals that indicate that the research is likely to be actionable based on definitions of usable knowledge discussed earlier in the questionnaire (see Box 1). The respondents were then prompted for further advice on how funding agencies can support the production of actionable knowledge. Second, we asked a closed-ended question whereby participants were presented with a list of 33 study characteristics that our team had determined might be important based on our collective experience as researchers and knowledge users and on literature review from both medical and environmental fields (Holmes et al., 2012; Matso and Becker, 2014; Arnott et al., 2020ab). Respondents were asked to check boxes next to this list, first selecting all items they deemed to enhance utility ('all that apply'), and second narrowing down their selection to the top three choices. This list included options for 'other' where participants could add an option, and 'unsure' if they could not answer the question. Participants received one of three different versions of this list with characteristics presented in different orders to prevent selection bias. The different versions were offered to participants at random. Due to time constraints during some of the interviews, only ~30% of all respondents (n = 25) were able to complete the closed-ended portion of the interview; however, all sectors were still represented (Table 1). We chose to focus only on these two questions for this study because the story that emerged was cohesive, impactful, and timely, and responded to a request for this

information from Canada's primary science funding body – the Natural Sciences and Engineering Research Council (NSERC). The questions used in this study are presented in Appendix A.

Interviews were conducted in person or via telephone by JFL. For the in-person interviews, the closed-ended question was printed and filled out by hand by the participant. For the telephone interviews, it was emailed in a spreadsheet and participants were instructed to open the tab only when it was time to respond. All interviews were audio recorded, transcribed in full using Trint Automated Transcription software, and error checked by one of three transcribers to ensure accuracy. Consent to participate in the study was obtained from all interviewees prior to the interview, and all personal information was kept strictly confidential per Carleton University Research Ethics Board file #12486.

2.3 Data analysis

Qualitative analyses were conducted on responses to the open-ended question using NVIVO software (version 12). A codebook was developed through a combination of inductive and deductive processes by EAN and NH (Appendix B). Coders conducted two inter-rater reliability tests to ensure consistency of coding. The first test resulted in an average Cohen's K-value of 0.37 indicating low agreement. Coders thus conducted four meetings over two months to manually compare and discuss coding choices, and a second test resulted in an average K-value of 0.52 indicating fair agreement. Interviews were coded under two central themes including: 1) characteristics of proposals leading to useful research, and 2) advice on operational changes for funding agencies (Appendix B).

Quantitative analyses were conducted on responses to the closed-ended question. We tested whether the list order of characteristics in the three different versions of the closed-ended question affected participants' selections by comparing binary responses among the three groups using Kruskal-Wallis tests and Holm's sequential Bonferroni procedure to adjust alpha levels for multiple testing. We

conducted a frequency analysis to assess trends in participants' responses to the 'check all that apply' and 'top three' survey questions, and compared responses among sectors (federal, provincial/territorial, and ENGO). To conduct the frequency analysis, we aggregated the 33 characteristics into 18 categories of closely related characteristics, based on our judgement (Appendix A). These groupings were formed to make the number of characteristics more manageable for analysis and graphical presentation.

3. RESULTS AND DISCUSSION

3.1 Open-ended questions: characteristics of successful proposals

Theme 1: Elements of proposals that indicate potential for actionable research

Participants' responses about proposal characteristics that are indicators of actionable research were grouped into four topics. These included having: 1A) a research team with diverse perspectives and appropriate expertise, 1B) a research plan that is comprehensive, feasible, and flexible, 1C) a clear and demonstrable link to policy, and 1D) a plan for knowledge exchange with diverse audiences. In the following text, suggestions emerging directly from participants' responses are underlined. Mechanisms to achieve the various recommendations, support from the literature, and potential challenges are considered alongside each suggestion. Connections among themes and responses are illustrated in Figure 2 and summarized in Table 2.

1A. Research team comprises diverse perspectives and expertise appropriate to the problem at hand

According to participants in this study, the most important element of a proposal that is predictive of useful research outputs is the composition of the research team. Specifically, it was emphasized that proposals should indicate that a <u>policy practitioner and/or advisor will be at the table to guide the program at all stages of the research process</u> (Box 1). There was likewise strong support for assembling a

team with a high level of diversity and expertise in relevant areas. Participants suggested that diverse research teams increase the likelihood that multiple perspectives and knowledge sources will be considered at all stages of the research process (Figure 2). These points are summarized by a retired federal employee with extensive transdisciplinary and policy experience: "*[Review panels] must look for a team made of people who are individually expert in the diverse range of things. Especially for a policy question with broad scope. You will want a team where you have an expert in each of the major perspectives"* (male, federal [ON]). To that end, teams should include government and academic scientists, and relevant representatives from Indigenous groups, resource users, and practitioners with individual areas of expertise and potential contributions stated clearly in the proposal.

Having a research team with diverse perspectives and expertise is crucial because the team provides the foundation for success in all other aspects of the research (Figure 2). For example, having varied sectoral and cultural representation has been shown to facilitate knowledge exchange with end users (Howarth and Monasterolo, 2016), and having team members with in-depth knowledge of pertinent policy issues helps to keep policy-related information needs in focus (Cooke et al., 2020). Network maps have been suggested as tools to identify groups that should be included in a study, and to select individuals who can fill necessary roles (Cooke et al., 2020), and could be integrated into proposals to demonstrate how the team will be effective at carrying out the proposed research. Inter-sectoral and trans-disciplinary partnerships should ideally be formed by following rigorous models of co-production (Box 1; Beier et al. 2017*,* Norström et al., 2020) as a great deal of scholarship has indicated that co-production is effective for producing actionable knowledge (Karl et al. 2007; Nel et al. 2016; Posner et al. 2016) and driving research use (Fujitani et al 2017; Nguyen et al. 2019; Mach et al. 2020). myraid

Participants further recommended that members (especially leaders) of policy-oriented research teams should be able to demonstrate a track record of successful co-production and provide evidence of

success in integrating science into policy within the proposal. Mechanisms suggested for predicting that co-production will occur included requiring letters of support or in-kind contributions from research partners at the proposal stage. This can provide evidence that the knowledge end-users are invested in the findings of the proposed work (Figure 2). Requiring evidence of support from partners has been implemented by some funding agencies (e.g., Genome Canada) and other collaborative grants (e.g., NSERC Alliance). However, the degree to which such requirements have led to lasting relationships among partners has not been formally quantified. Even though such documents might be useful to indicate partnerships at the proposal stage, it often happens that letters of support are requested just days before application deadlines (Cooke et al., 2020), and the demanding schedules of most practitioners presents challenges to their long-term engagement. Thus, participants recommended that such letters should be required for proposal evaluation only if follow-ups and support of these relationships by funders are planned (Figure 2, expanded in Section 2A).

Building diverse, interdisciplinary teams and garnering support from external partners can be challenging, particularly for researchers who are new to the science-policy sphere (e.g., early- or mid-career researchers [ECRs, MCRs]). Such individuals often lack diverse networks of collaborators outside of academia and have not yet established track records of successful collaboration with Indigenous groups, policy advisors/practitioners, or other end-users (Chapman et al. 2015; Kelly et al. 2019). In addition, there are several barriers to working in complex teams that have been discussed at length in other studies (see Lemos et al., 2018; Oliver et al., 2019; Rose et al. 2019; Young et al., 2020). Internal changes to funding agencies that support and encourage co-production can lower such barriers (Figure 2, expanded in Section 2A), but mentoring of ECRs and MCRs by more experienced researchers and practitioners can facilitate relationship building and expand/maintain productive partnerships (see Haider et al., 2018 and Kelly et al., 2019 for further discussion). Participants in this study suggested that it is essential to ensure that early and mid-career researchers are included on teams so that the next

generation of researchers are prepared to move into collaborative spaces (Figure 2). Several studies have suggested that the capacity of leaders of diverse, interdisciplinary teams is of ultimate importance when considering the potential success of a project and should be given more weight than in conventional grant applications (Lyall and Meagher 2012; Lyall et al. 2013; Smits and Denis 2014).

1B. Research plan that is comprehensive, feasible and flexible

Participants in this study identified several elements of research plans that are uniquely important for proposals that intend to produce actionable knowledge. One of the most broadly supported characteristics was careful consideration of the feasibility and timeliness of the proposed project (Figure 2, Table 2). Participants suggested that applicants should be able to convince the reviewers that their team can produce the promised results in the necessary period. As one federal government employee suggested: "*A big consideration is: Is the project doable? Do they actually have the skills to deliver? Do they have the gear to deliver? Do they have the relationships in place to deliver?" (female, federal [ON]),* and another from the ENGO sector: *"The time frame is important. Often people put so much in their proposals and it's like, this is not realistic in the time frame that is being proposed and in the time frame necessary for this decision*" (female, ENGO [AB]). Participants thus suggested that funding bodies look for evidence of whether teams have mapped achievable timelines and matched various team members to specific tasks based on their expertise (see Section 1A). Some studies have shown that such approaches can be effective in ensuring projects are finished successfully (Gevers et al. 2001; Henderson et al. 2016).

An interesting suggestion from participants was the idea of having built-in contingency plans or flexibility in research design in case the project must be adjusted to accommodate sudden changes in the policy landscape. As articulated by a provincial/territorial government employee:

> *The more flexibility that you can build into proposals the better they can be. Often proposals from external sources are very focused, and in some cases that could be exactly what is needed. But in other cases, if suddenly that research or that product is not exactly what is expected or isn't fulfilling the research goal, there has to be flexibility to make adjustments* (male, provincial [ON]).

Planning for flexibility is necessary to successful products (Meng et al., 2020). Time for mid-project evaluations (i.e., formative evaluation; McGowan et al. 2008) and contingency plans or alternative approaches should be in place from the outset. Formative evaluation recognizes that, while project trajectories can be well-planned, surprising challenges and opportunities may present themselves and require teams to adjust goals (McGowan et al. 2008). Conceptual maps with outlines for reaching a desired outcome and possible alternative routes could be required in applications for funds intended for policy-relevant projects (De Silva et al. 2014). Incorporating flexibility into a research program has been shown to promote successful collaboration and encourage cross-institutional and interdisciplinary learning (Beier et al. 2017) and can thus increase the likelihood that a given project will meet a policy information need.

1C. Clear and demonstrable link to policy

Having a clear link to a relevant policy issue emerged as a high priority for determining whether proposed research is likely to produce actionable knowledge. First, there should be a clearly stated policy objective and a demonstrated need for environmental research to inform that objective. Second, there should be evidence that the information produced by the study is likely to be appropriate for filling a given knowledge gap through endorsement by a policy expert (Figure 2). Each of these points was supported across sectors, but the following statement by a provincial/territorial government scientist summarized these points succinctly:

> *I think at the onset you would have to know, from the perspective of the policy makers, what are the knowledge gaps or information needs that people have identified? And then the experimental design and hypotheses would have to clearly show how the outcomes of that work are feeding into those knowledge gaps. I think that link needs to be made explicitly at the onset, and the proponents of the work need to demonstrate how they expect the outcomes of their work be exactly related to that process* (male, provincial [AB])

In addition, participants suggested that proposals should demonstrate careful consideration of how different outcomes will inform policy in one direction or the other. As stated by a federal employee: "*The proponent of the project should first identify what decisions need to be made, and then think about how the decision would be influenced by the outcome of the project. Preferably, they would have identified: If the outcome is this, the decision should go this way and if the outcome is that, the decision should go a different way*" (male, federal [ON]). This requires a clear articulation of the policy need, but also a definitive statement on how the proposed methods will produce appropriate and conclusive data.

To fulfil the above recommendations, researchers require a clear vision of the policy landscape (Reed et al. 2014, Cook et al. 2014, Rose et al. 2017), hence the participants' suggestion to have a policy practitioner on the team (Figure 2, Section 1A). On one hand, scientific knowledge can shape policy if appropriate research findings are available during critical policy windows (Box 1; Rose et al. 2017). However, this is rarely the case, and there are several other routes by which scientific research with appropriate and flexible research plans can inform policy (Figure 2, Section 1B). There can be incremental improvement to existing policies by filling knowledge gaps, questioning or falsification of a current policy approaches, or identification of new areas of environmental conservation that require policy action (Fiorino 1995; Holmes and Clark, 2008). Regardless of the situation, the research team

must identify the knowledge gaps that would inform a particular policy. Furthermore, if policy relevance is a goal of the research it is important that people with policy experience are included during the review process; funding agencies that include a diversity of experts on the adjudication panel can support these goals (Figure 2, expanded in Section 2A).

1D. Plan for knowledge exchange with diverse audiences

Participants suggested that appropriate plans for knowledge exchange should be outlined early in the research process. As suggested by a federal government employee: "*I would say it has to have two pieces. On the front end there needs to be evidence that [research objectives] are responsive to the current policy landscape. And then on the back end there must be a mechanism to feed the information back to that policy community*" (female, federal [ON]). To achieve this, participants suggested that proposals must include a clear pathway for knowledge exchange with appropriate audiences. This includes knowing who the audience is (e.g., stakeholder groups), who the specific people are that require the information (e.g., an individual public servant), time limitations, and the best format and forum for knowledge dissemination. In general, planning to share diverse outputs such as presentations, policy briefs, videos, concept maps, data, and manuscripts was recommended by participants to facilitate this process (Figure 2).

Lack of knowledge exchange is often a critical barrier to bridging the science-policy divide (Cook et al. 2013; Cvitanovic et al. 2015). Having a detailed plan to share information can therefore improve the likelihood that research will be linked to policy (Figure 2, Section 1C). This can be evaluated in proposals by requesting detailed strategies for knowledge exchange from researchers including timelines and identification of individuals or external communication bodies (e.g., boundary organizations) that will be involved with knowledge exchange activities (Shanely and Lòpez 2009; Micheals 2009). Although this might necessitate grant evaluators who are able to determine if a knowledge exchange strategy is

appropriate to the policy sphere (Baylis et al. 2016; Section 2A), such efforts are important when evaluating the potential utility of research proposals. In addition, proof of knowledge exchange outputs (i.e., policy briefs, etc.) from previous research projects can indicate the level of commitment a research team has to this process (Section 2C; Arnott, 2019). Several funding bodies have begun to require outreach and knowledge exchange plans to be included in the grant proposals (Cvitanovic et al. 2015). Crucially, funding agencies that allow researchers to budget funds explicitly for knowledge exchange have higher success in ensuring it occurs (Shanely and Lòpez 2009; Matso and Becker 2014; Cvitanovic et al. 2015).

3.2 Closed-ended questions: characteristics of successful proposals

Responses to the closed-ended survey question supported findings from the open-ended questions described above. The results of the quantitative analysis thus serve as a robustness check to the open-ended question. In addition, the variation in responses among sectors highlights the importance of considering context when interpreting the findings presented here. Connections among themes and responses are illustrated in Figure 2 and summarized in Table 2.

The list order in the three versions of the closed ended question had no effect on the frequency of participants' selections for any of the characteristics (Appendix C). The quantitative analysis revealed that the top five most common characteristics respondents sought in proposals were: i) a plan for knowledge exchange to facilitate the transfer of relevant information to the correct people; ii) a team that is socially and culturally diverse, including representation from Indigenous groups and stakeholders (where appropriate); iii) a team with representatives from different academic disciplines and professional backgrounds, including practitioners and decision makers; iv) an appropriate study design and methodology to address the policy issue at hand; and v) a plan to publish the findings of the study in a peer-reviewed journal (Figure 1). There was some variation among sectors in what stood out as most

377 important for evaluating proposals that are likely to produce actionable knowledge (Figure 1).
378 Respondents from the federal government pushed for strong knowledge exchange plans (emphasizing
379 peer review) and thorough consideration of research methods used (Figure 1). Provincial and territorial
380 government responses supported the need for knowledge exchange plans, feasibility and flexibility of
381 methodological approach, and cultural diversity within teams (Figure 1). They also emphasized the
382 importance of understanding the needs of the end-user more than the other sectors did (Figure 1).
383 Respondents from the ENGO sector chose social and cultural diversity and emphasized the need for
384 multi-disciplinary teams (Figure 1).

385 Differences in priorities among sectors likely reflect the scale and scope of work conducted by each
386 group. Federal government departments in Canada face national-level environmental challenges
387 affecting a vast country with diverse social, economic, and ecological needs (Cooke et al. 2016).
388 Knowledge to support such decisions must be precise yet generalizable, so it is logical that the priorities
389 of the federal government align with classic academic priorities such as peer review and consistent
390 methodology and reporting. Much of this support is also likely driven by the fact that most (82%) federal
391 employees interviewed had academic backgrounds. Such training is likely to influence their values
392 towards academic approaches to evaluation.

393 While federal government departments make national environmental decisions, most constitutional
394 powers for natural resources and environmental management reside with the provinces and territories
395 (Becklumb 2013). Participants from provincial and territorial governments indicated that they had
396 considerable hands-on experience with policy and practice. This group's insights are thus in tune with
397 the types of knowledge that are useful on the ground. Their choices also reflect the relatively smaller
398 geographic scale and context of policy decisions faced by provincial and territorial governments. The
399 reclamation and recognition of the roles and jurisdiction of Indigenous Peoples in environmental and

natural resource governance means that territorial and provincial settler governments frequently make decisions alongside Indigenous governments and partners (Cooke et al. 2016, Pasternak et al. 2019), which likely contributes to cultural representation being a high priority for this sector.

Participants from ENGOs had a strong focus on the social, cultural, institutional, and disciplinary diversity of the research teams. Many of the ENGOs represented in this study indicated that they have histories of engaging local and Indigenous communities in their research processes and incorporating diverse philosophies into conservation and management recommendations. Witnessing the benefits of these collaborations for promoting knowledge uptake and community cooperation likely motivates the emphasis on diversity-related qualities.

The quantitative analysis highlights the importance of understanding how various contexts might influence what is considered important in research proposals. Knowledge that is deemed usable is likely to change depending on the spatial and temporal scale, the stakeholders involved, and the policy issue at hand (Mach et al. 2020). Likewise, proposal calls and selection criteria set by different funding agencies are likely to vary depending on their jurisdiction and goals. The criteria outlined above for elements of proposals that are likely to result in usable knowledge are intended to be generalizable; however, funding agencies must carefully consider whether and how each recommendation applies to their specific goals, and to use these recommendations as general guidelines (not strict rules) to be used at their discretion.

3.3 Open-ended questions: operational advice to funders

Theme 2: Operational changes in prioritising research and managing fund distribution

Although the above suggestions are important considerations for selecting promising proposals, each suggestion demands time from researchers, increased financial support, and broad inter- and trans-

disciplinary networks (Lemos et al., 2018). These requirements represent potential barriers that, without institutional support, might prevent researchers from carrying out important policy-relevant work. Funding agencies' responsibilities should go beyond simply selecting the best proposals, and then hoping the work proceeds as planned (i.e., a 'fund and forget' model; Holmes et al. 2012). Several participants recommended ways that funding agencies could alter their internal operations to lower barriers to producing and communicating actionable knowledge. We outline three major topics including: 2A) drawing on a diversity of expertise during award adjudication; 2B) supporting co-production and interdisciplinary research; and 2C) following-up on and rewarding knowledge exchange.

2A. Reconfigure the award adjudication processes

Including a diversity of experts on review panels was suggested as an important action by funding agencies that can help determine whether proposed research projects are likely to be successful in producing actionable knowledge. As stated by a provincial/territorial government employee: "*…if it's forestry sector research, how is the forestry sector actually going to use this information to advance their practices? Those statements would have to come from the forestry sector, not from the researcher or the funding bod*y" (male, provincial [AB]). Participants suggested that including voices of knowledge end users and/or relevant cultural groups in the adjudication process can mean that project proposals are assessed not only for scientific excellence but also for the relevance of the results to policy issues. Having such diversity on adjudication committees can promote selection of proposals with appropriate and timely research plans (Figure 2, Section 1A) and provide insight into whether the proposed research has a clear link to policy (Figure 2, Section 1C). Furthermore, including a communications expert on the adjudication panel can help to determine whether a proposed knowledge exchange strategy is appropriate for the policy context (Figure 2, Section 1D). Several studies investigating the US-based National Estuarine Research Reserve System (NERRS) funding program have shown that diverse

adjudication panels increased the legitimacy, credibility, and salience of the funded research (Matso 2012; Trueblood et al. 2019). Further research into the tangible outcomes of soliciting expert opinion during the proposal review process and methods to ensure role clarity within diverse selection committees is necessary to determine how such committees should be assembled and how they should operate (Ly et al., 2018; Arnott et al. 2020a).

2B. Supporting co-production and interdisciplinary research

A common point raised by participants is that funders should rethink existing metrics used to evaluate and prioritize projects. Many suggested that academic funders should solicit, incentivize, and reward co-production and interdisciplinary work in applied conservation (Figure 2, Table 2). An important suggestion was that additional funding could be allocated to projects with diverse teams given the extra time required for co-produced projects, either through distinct funding calls or through additional funding funneled through existing streams. As mentioned by a scientist in the ENGO sector:

> *I think that funders need to think carefully about the importance of partnerships with civil society because that will help inform how the research is done. For example, look at the dearth of Indigenous participation in research right now. The absence of Indigenous voices needs to be addressed through explicit funding for partnerships among researchers, departments, policymakers, and resource users* (male, ENGO [ON]).

Given that there is increasing evidence that co-produced knowledge can be highly effective at influencing policy (Nel et al. 2016; Posner et al. 2016; Mach et al. 2020), it is intuitive that funding bodies could and should develop mechanisms that support this work (Lemos et al., 2018). Research has shown that funders who mandate and provide support for interactions between researchers and knowledge users are more successful in ensuring that knowledge exchange occurs and that the funded research

goes on to inform policy decisions (Riley et al. 2011; Matso and Becker 2013, 2014; DeLorme et al. 2016; Moser 2016).

Some funders support researchers in building diverse networks at the outset of a new research initiative, often resulting in synergy among collaborators (Lyall et al. 2013) which can lead to successful integration of the research findings into policy and practice (Matso and Becker 2013, 2014; Arnott et al., 2020b). This can be accomplished through providing seed funding for starting interdisciplinary projects, and by funding or offering workshops and/or courses to introduce, grow, and solidify partnerships (Lyall et al., 2013). In addition, funders must recognize that co-producing knowledge within diverse teams usually requires more time and funding than a typical project (Lemos et al., 2018). Providing allowances for the extra cost and time associated with co-production is therefore essential for 'true' co-production to occur (Beier et al. 2017; Oliver et al. 2019; Norström et al. 2020). Finally, funding agencies have a role to play in ensuring that such relationships are maintained throughout the entire research process (Sibbald et al. 2014). Participants suggested that funding agencies should incorporate check-ins and incentives throughout the research process to ensure that collaborations are ongoing. Lack of explicit guidance can lead to regulations being misinterpreted resulting in the failure to meet the intended goals of the project (Reale and Zinilli 2017).

The idea that funders should play a supporting role throughout the research process has been adopted by some medical funding bodies (Holmes et al. 2012; Smits and Denis 2014) and is growing in environmental fields (Matso and Becker 2014; DeLorme et al. 2016). In Canada, several programs require academic researchers to collaborate with external partners in business, policy, or industry (e.g., Mitacs Accelerate Fellowship, Canada's Social Sciences and Humanities Research Council (SSHRC) Partnership, NSERC Alliance, SSHRC New Frontiers, Liber Ero Fellowship). Anecdotal evidence suggests these programs have been effective in forming long-lasting collaborations (Mitacs Year in Review, 2015).

However, formal research is necessary to determine whether such patterns are systematic, and many funding bodies do not measure or track policy relevance, only have trivial reporting requirements, and use traditional metrics such as citation rates as opposed to policy impact (Coutinho and Young 2016). The incremental changes modeled by the NERRS funding system provides an example of how funding bodies can gradually implement change while checking to ensure the adjustments are having the desired outcomes (Trueblood et al. 2019).

2C. Following-up on and rewarding knowledge exchange

Several respondents discussed that research findings must be shared through appropriate channels. Having a plan for knowledge exchange is key (Figure 2, Section 1D); however, it is equally important to ensure that researchers follow up on knowledge exchange plans. Several respondents suggested that this can be done by incentivising knowledge sharing by providing funds for this process (e.g., to run workshops, create communication tools, etc.) or by creating and (better) enforcing data sharing policies (Figure 2). Several studies have shown that funding models with financial support for communication and knowledge exchange have a higher probability of knowledge being used in policy (Shanely and Lòpez 2009; Riley et al. 2011; Matso and Becker 2014). Such findings suggest that funds should be set aside to support engagement activities (Lavis et al. 2003; Lyall et al. 2013; Cvitanovic et al. 2016). In addition, even though a growing number of funding agencies are encouraging open access policies (Roche et al. 2014), better enforcement can improve their effectiveness (Sholler et al. 2019).

Rewarding researchers for information sharing through increased funding or peer recognition is likely to encourage more frequent and higher quality efforts (Provencal 2011). Scientists should be recognized for more than just peer-reviewed publications; production of alternative forms of communication should factor into their evaluation (Section 1D). There must also be impact evaluation to determine whether attempts at knowledge exchange reached the correct audiences in a timely manner (Baylis et

al. 2016). Funding agencies should develop guidelines to help evaluators recognize and value knowledge exchange. If funders recognized and valued these efforts equally with peer-reviewed papers, then academic institutions would not need to question the relevance and importance of such contributions (Lavis et al. 2003).

EMERGING CHALLENGES AND RECOMMENDATIONS

The results of this study provide recommendations from Canadian science-policy experts on important considerations for funding bodies looking to support policy-relevant research. These recommendations are designed to be actionable and some of the suggestions are already practiced by innovative Canadian and international funding bodies. However, new challenges to implementing these recommendations have arisen from this work. We discuss these challenges and suggest approaches to overcoming them.

An important consideration is **how to (re)structure the proposal evaluation process to account for the potential utility of the research to policy**. Given the complex interdisciplinary, cross-sectoral, and context-specific nature of policy-oriented research, an adaptive approach to proposal evaluation is required. Needs and priorities at the science-policy interface shift depending on changing political climates (Rose et al. 2017) and evolving stakeholder priorities (Scolobig and Lilliestam 2016). Models for adaptive evaluation of grant proposals or adaptive design of funding calls have yet to be developed; however, analogous systems have emerged from the human system dynamics literature, which suggests that evaluation criteria (and, by extension, priorities in proposal calls) should be reassessed for each new round of funding (Eoyang and Oakden 2016). Steps to adaptive evaluation modified from this literature include: 1. designing initial criteria; 2. collecting and analyzing data on the success of projects; 3. assessing social, scientific, or political changes; 4. adapting proposal calls and evaluation criteria; and 5. reporting the outcomes (Eoyang and Oakden 2016). These data could be used to inform initiatives or training offered by funding agencies to enhance research outcomes.

Related to restructuring the evaluation process is the suggestion to incorporate a diversity of perspectives on award adjudication committees. Such an approach requires funding bodies to use a co-production-like model when designing funding calls and deciding on selection criteria (Smits and Denis 2014). **The question thus arises as to how adjudication committees can incorporate a diversity of views without sacrificing the priorities of the stakeholders involved.** Based on recommendations from literature on approaches to team management, we recommend having clearly defined roles and responsibilities of various committee members so that everyone is assigned the section of the proposal most relevant to them (Henderson et al. 2016; Ly et al., 2018). Role clarity can streamline processes of complex teams (Ly et al., 2018). Training for committee members to understand different working practices and different priorities among sectors or disciplines and engaging in reflexive and considerate discourse to mutually decide on project goals early in the award solicitation process can also help to overcome barriers encountered by diverse adjudication committees (vom Brocke and Lippe 2015).

A third challenge emerged from the suggestion that research teams must include individuals with experience in co-production and a high level of expertise in each of the relevant spheres. This presents the conundrum of how to facilitate the entry of motivated but inexperienced academic researchers into collaborative work with practitioners (Kelly et al., 2019) and raises the question of **how funding agencies can best support the process of building interdisciplinary networks**. Based on participants' responses and literature review, we suggest that funders could play a more active role in developing collaborations by linking various actors and by facilitating training and mentorship opportunities for early and mid-career researchers (Haider et al., 2018; Sibbald et al. 2014). Funders and their program managers are often uniquely aware of individuals who could and should be linked (Arnott et al. 2020a) and can thus facilitate the development of new partnerships by connecting appropriate actors and fostering interactions among researchers or organizations with similar interests (Sibbald et al. 2014). Feedback

559 from mentors and mentees could be required to evaluate whether mentorship promises are being
560 realized (Hund et al. 2018).

561 In conclusion, participants in this study indicated that funding agencies' responsibilities should go
562 beyond simply selecting the best proposals, and then hoping the work proceeds as planned. There are
563 many diverse factors that influence whether research has a policy impact, and there are often political
564 realities that will prevail despite the scientific evidence that is supplied. However, this work has
565 advanced our understanding of the roles and responsibilities of funding agencies, which is a crucial area
566 where tangible improvements can be made. Funders have the potential to have impact at all stages of
567 research from solicitation to proposal requirements and funding selection, to follow up and evaluation.
568 Although our recommendations do not guarantee success in identifying proposals that will yield
569 actionable knowledge in all contexts, following these guidelines is likely to increase the utility of funded
570 research if that is the goal of the funding agency.

571

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Table 1. Numbers of participants from the federal government (Parks Canada, Environment and Climate Change Canada, Fisheries and Oceans Canada, and Natural Resources Canada), provincial/territorial governments, and environmental non-governmental organizations (ENGOs) that responded to the open-ended and closed-ended questions.

Agency, Organization, or Department	N – open-ended	N – closed-ended
Federal Government	49	11
Parks Canada	*12*	*1*
Environment and Climate Change Canada	*13*	*4*
Fisheries and Oceans Canada	*14*	*5*
Natural Resources Canada	*10*	*1*
Provincial / Territorial Governments	14	7
Alberta	*3*	*1*
British Columbia	*1*	*1*
New Brunswick	*1*	*1*
Nova Scotia	*1*	*1*
Nunavut	*2*	*1*
Northwest Territories	*2*	-
Ontario	*2*	*2*
Saskatchewan	*1*	-
Yukon	*1*	-
ENGO	21	7
BC Wildlife Federation	*1*	-
Council of Canadian Academies	*1*	*1*
Canadian Parks and Wilderness Society	*2*	*1*
Canadian Wildlife Federation	*2*	-
David Suzuki Foundation	*1*	*1*
Evidence for Democracy	*1*	*1*
Great Lakes Fisheries Commission	*1*	*1*
Island Nature Trust	*1*	-
Nature United	*1*	*1*
Nature Conservancy Canada	*2*	*1*
Trout Unlimited	*1*	-
Waterton Biosphere Reserve	*1*	-
Wildlife Conservation Society Canada	*2*	-
World Wildlife Fund Canada	*1*	-
Yellowstone to Yukon Conservation Initiative	*2*	-
Yukon Conservation Society	*1*	-
TOTAL	**84**	**25**

Table 2. Key recommendations gleaned from open-ended questions for ensuring that funded research is effective for informing policy in environmental fields. Different levels of support indicate the percentage of respondents that mentioned each characteristic with 'strong' >20%, 'medium' = 10-20%, and 'some' <10%.

Theme	Topic	Support	Characteristic
Theme 1: Elements of proposals	**1A. Research team**	Strong	Policy implementers/practitioners at the table
		Strong	Proven track record of success in co-production
		Strong	Integration of multiple knowledge sources
		Medium	Letter of support from partners
		Medium	Financial or in-kind contributions to the proposed work
		Medium	Diversity of perspectives and experiences relevant to the question at hand
		Some	Training of the next generation
	1B. Research plan	Medium	Appropriate methodology to address the question
		Medium	Appropriate spatial and temporal scale
		Some	Innovation of techniques and tools
		Some	Flexibility in research design
	1C. Clear link to policy	Strong	Clear policy objective
		Strong	Demonstrated need of research to influence policy development
		Medium	Demonstration of how the methods will achieve goals for policy
		Some	*Theory of Change* approach
	1D. Knowledge exchange plan	Strong	Appropriate communication plan
		Medium	Demonstrable track record of sharing
		Medium	Demonstrable pathway for communication: who, how, when, where
		Medium	Diversity of communication outputs
		Some	Broadly applicable findings
Theme 2: Operational changes	**2A. Reconfigure adjudication**	Medium	Include a diversity of expert voices on review panels
	2B. Support co-production	Strong	Explicit funding for partnerships among diverse partners
		Strong	Extra time and funding allotment for coproduction
		Strong	Make partnerships a requirement (e.g., Genome Canada)
	2C. Support knowledge exchange	Strong	Funded work should be publicly available (open access, data archived)
		Medium	Ensure researchers follow up on communication plans
		Some	Provide funding for this process
		Some	Create and enforce data sharing principles

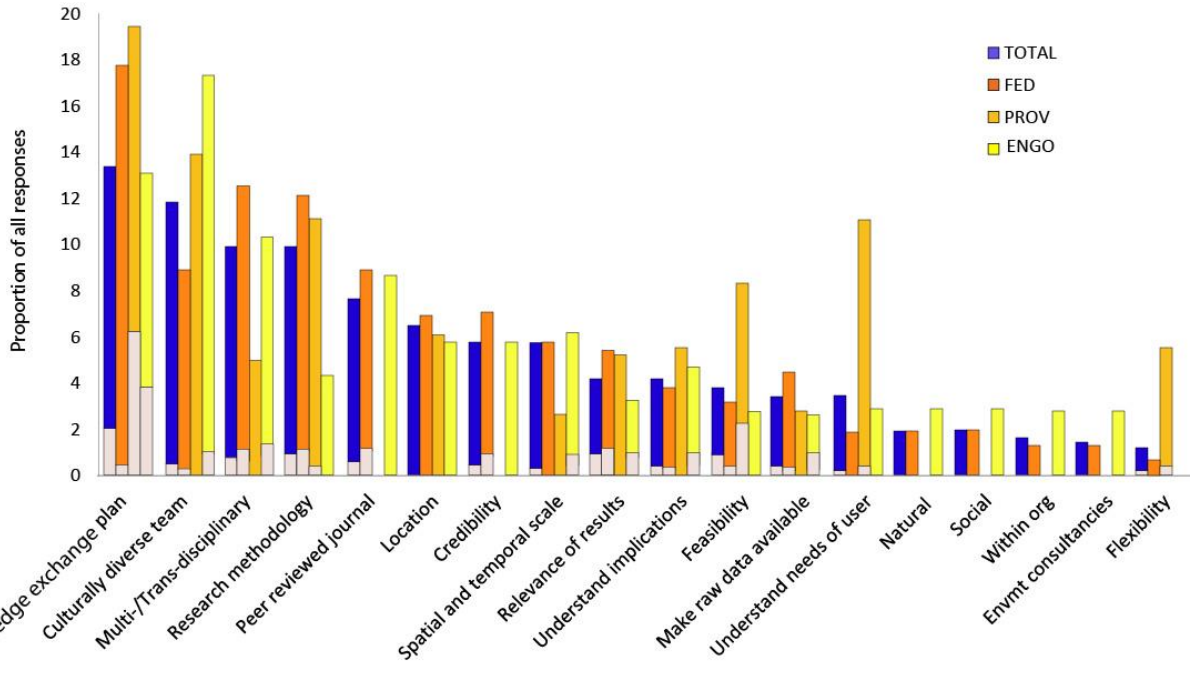

Figure 1.

Proportion of responses for each characteristic from the aggregated list (see appendix A) provided for the closed-ended question: “select elements of proposals that increase the likelihood that the research will be actionable”. Responses are presented as a proportion of all responses including selections for ‘all that apply’ and for ‘top 3’. Beige bars at the bottom represent the proportion of responses that came from the ‘top 3’ selection and the remainder represents the proportion of responses that came from the ‘all that apply’ selection.

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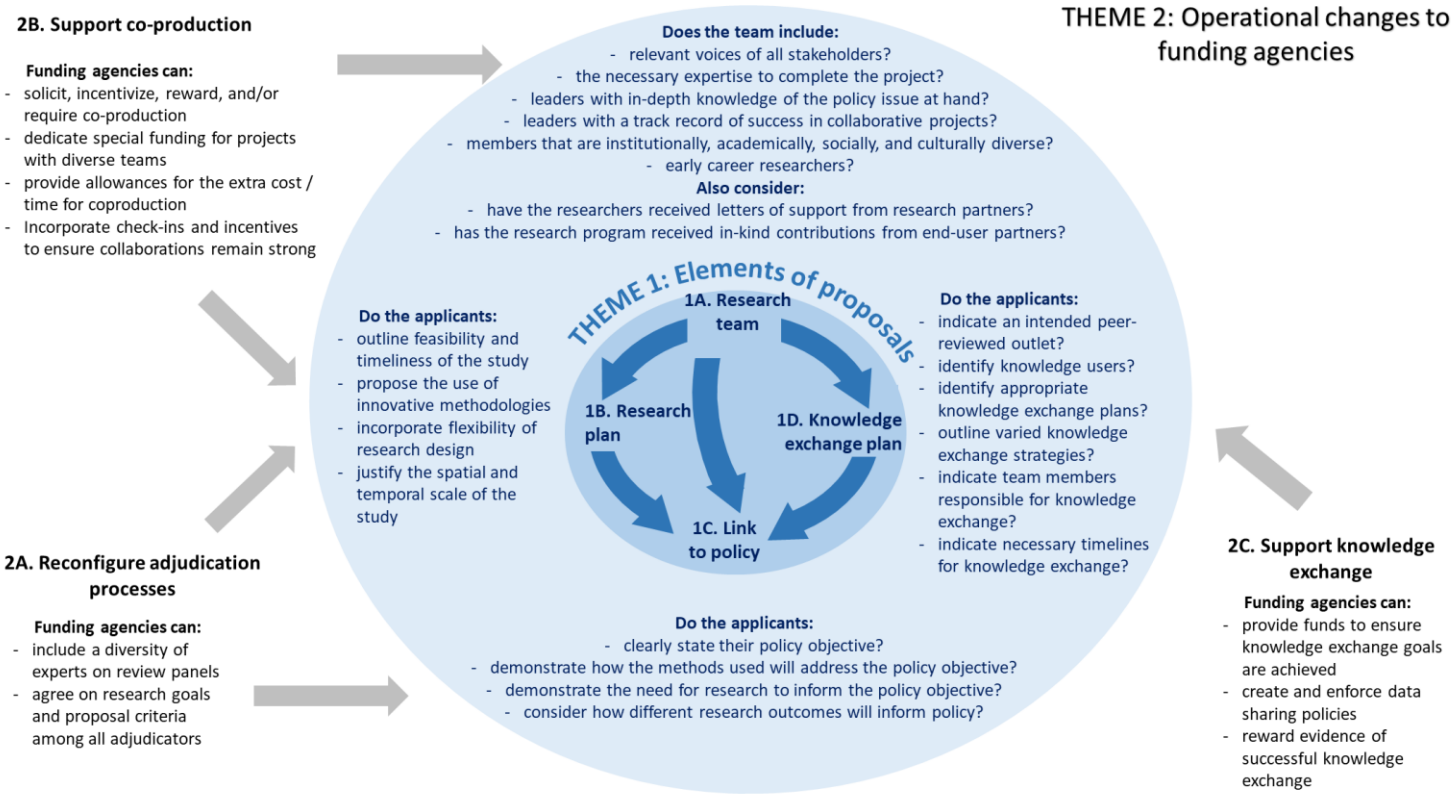

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805 **Figure 2.** Schematic diagram illustrating recommendations from participants for funders looking to
806 increase the impact of the research they sponsor. Recommendation in the blue circle include qualities
807 funders can seek in proposals to determine whether research will result in actionable knowledge. Blue
808 arrows indicate influence of categories on one another based on participant responses and literature
809 review. Recommendation outside of the blue circle represent internal changes to funding structures
810 that could allow for institutional change from within funding agencies. Grey arrows indicate elements
811 of research proposal requirements these requirements will facilitate.