Supporting actionable science for environmental policy: advice from researchers and decision makers to Canadian funding agencies

DRAFT – NSERC NSE REPORT

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Abstract

Environmental conservation and the management of natural resources require rapid and precise knowledge exchange between scientific researchers and environmental decision makers. However, successful incorporation of scientific knowledge into environmental policy remains a significant challenge. Although studies on how to bridge the so called 'knowledge-action gap' have grown rapidly over the last decade, very few have investigated the roles and responsibilities of funding agencies in overcoming this challenge through soliciting and selecting proposals, deciding on proposal requirements, and promoting specific research themes. Here, we present a set of criteria gleaned from interviews with experts across Canada that can be used by funding agencies to evaluate grant proposals for their potential to produce actionable knowledge for environmental policy. We interviewed 84 individuals with extensive experience at the science-policy interface working for environmentally-focused federal and provincial government bodies and non-governmental organizations. The interview elicited suggestions on characteristics of research proposals that indicate that a given project is likely to be useful in a policy context, and asked for any further advice to funding bodies on how to improve the impact of the research that they sponsor. Suggestions for proposal characteristics centered on four main topics including having 1) a well-developed research plan, 2) a clear and demonstrable link to policy, 3) a thoughtfully assembled research team, and 4) a communication plan for reaching diverse audiences. Participants also suggested several internal changes to funding models including 1) using diverse expertise during award adjudication, 2) incentivising co-production and interdisciplinary research, and 3) following up on and rewarding information sharing. The set of recommendations presented here can guide both funding agencies and research teams who wish to change how applied science is conducted, and improve its connection to policy and practice.

Introduction

Lack of effective knowledge mobilization (KMb) among scientists and decision makers is a primary barrier to integrating scientific evidence into policy and practice in environmental arenas (Cvitanovic et al. 2016). The last decade has seen a steady stream of scholarship dedicated to understanding and narrowing this so-called "knowledge-action gap" (Nguyen et al. 2017), with the aim of supporting evidence-informed decision making, and reducing the waste of resources allocated to the production of policy-relevant scientific knowledge. In environmental fields, much of the KMb literature has focused on the responsibilities of scientists to change their research approach, improve communication skills, and be aware of policy windows (Seidl et al. 2013; 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 and Knight 2004; Cvitanovic 2014). Far less attention has been directed toward the roles and responsibilities of funding agencies in soliciting and selecting research that is likely to promote evidence-informed decision making, and in following up on funded projects (Matso and Becker 2014; Arnott 2019). Here, we present a set of criteria gleaned from interviews with experts across Canada that can be used by funding agencies (Canadian or otherwise) to evaluate grant proposals for their potential to produce actionable knowledge for environmental policy.

Funding agencies play a unique role within the scientific community, and have the capacity to encourage and influence practices that can bridge the gap between science and environmental policy (Holmes et al. 2012; Mach et al. 2020). Within Canada, public funding bodies (e.g., NSERC, SSHRC) and other granting agencies distribute tens of millions of dollars in research funds, annually. In applied conservation fields, this research often has the stated goal of understanding and solving environmental problems. Indeed, some would suggest that there is an obligation to the public for it to do so (Lubchenco 1998; Gibbons 1999). However, the extent to which this research is actually 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 transfer (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 an important responsibility to ensure that the work they support has a high probability of success (here defined as knowledge being integrated into policy and practice) if that is the stated goal of the research. However, predicting which proposals, research plans, and research teams will have the highest likelihood of producing usable knowledge is not always straightforward.

Studies investigating strategies for funding agencies to support more actionable science are needed to develop strong selection procedures, and to identify possible internal changes to the granting process (Arnott 2019). For example, there is a small (but growing) body of evidence that 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). Some funding bodies have begun to focus deliberate efforts on promoting interdisciplinary engagement and incorporating follow-up programs to move away from a 'fund and forget' model of granting (Holmes et al. 2012; Arnott et al. 2019). Recent work has demonstrated that such changes can indeed amplify how influential science can be (e.g., Trueblood et al., 2019). Less well understood is how to evaluate research proposals for their likelihood of success (as defined above) before the projects are officially underway. Knowing which factors contribute to bridging the knowledge-action gap and identifying indicators of project success can provide granting agencies with the information they need to better align research funding with projects that will produce relevant and timely knowledge for environmental policy (Matso and Becker 2014). This

information is also valuable to research teams whose goal is to produce actionable knowledge for conservation.

In this study, we developed a set of criteria to be used by researchers and funding agencies during the solicitation, application, and selection processes that can help to determine the likelihood that proposed research will be useful for policy and practice. We used semi-structured interviews to elicit the perspectives of individuals with extensive experience in both providing and receiving public or private funds for environmental research. We investigated views on which aspects of a research team (e.g., composition, diversity, expertise) and research process (e.g., methodology, timeline, extent of co-production) are associated with generating new knowledge that informs policy and practice. We draw lessons and recommendations from these findings for to assist funding agencies in supporting actionable research (if and when that is the stated purpose of the work).

Methods

Selection of participants

Participants in this study were recruited via directed sampling, due to the specialized nature of the knowledge and experience we sought to access. We selected participants who are currently employed in or recently retired from high-level positions in environmental bodies in Canadian federal, territorial, or provincial governments, and those working for high-profile environmental non-governmental organizations (ENGO) with an interest in advising or influencing policy. Federal government agencies included the Department of Fisheries and Oceans (DFO), Environment and Climate Change Canada (ECCC), Parks Canada, and Natural Resources Canada (NRCan). Participants were selected through prior knowledge based on past partnerships, and by performing web searches of relevant organizations to identify individuals in directorial or advisory roles. Additional participants were identified through recommendations from people on this initial list. Invitations were distributed to potential participants by email. A total of 135 people were contacted, and of these 84 individuals were interviewed over 82 sessions, with two interviews having two participants. The participants were all highly educated with a minimum of a Master's degree, although the majority held a PhD in a scientific field. Although our recruitment methods were directed, we selected our participants for a diversity of perspectives, and had good representation across gender (36 female, 49 male), sector (federal, territorial or provincial government, ENGO), and federal agency (DFO, ECCC, Parks, NRCan), and included both early career and experienced individuals encompassing a range of experience from 8 – 30+ years in the field (not including years in academic graduate programs). Sample sizes of participants and their organizations are presented in Table 1.

Designing and conducting interviews

Interviews were semi-structured, following a set of scripted questions but allowing for digressions. They were comprised of 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, JT, TR, JFL, NY, JB, SJC), and was circulated to the other co-authors for comment. The interview guide was revised five times to incorporate these suggestions. Prior to finalization, the interview was tested on three individuals who were also participants in the study. Based on their feedback, several questions were removed to improve the flow and length of the interview process.

Because our test participants answered all of the questions in the interview, their responses were retained in the analysis.

In this article we report findings from two key questions, both of which asked participants about elements of proposals that indicate a high likelihood that the proposed research will useful in a policy context. First, we asked an open-ended question where participants could describe characteristics of grant proposals that indicate that the research is likely to be actionable. A follow-up question was used to probe whether the respondents had any further advice for how funding agencies can improve the impact of the research supported by their agency. Second, we asked a closed-ended question where participants were presented with a list of proposal characteristics that our research team had determined to be important. Respondents were asked to check boxes next to this list, first selecting all that apply, and then narrowing down their selection to the top three choices. This list included options for 'other' where participants could add something potentially missed, and 'unsure' if they could not answer the question. Participants received one of three different versions of this list, with options presented in different orders to prevent selection bias. Due to time constraints during some of the interviews, only about 30% of all respondents (n = 25) were able to complete the closed-ended portion of the interview; however, there was still good representation across sectors. Sample sizes for both the open- and closed-ended question are presented in Table 1. 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 (list) was printed and filled out by hand by the participant. For the telephone interviews, the list was emailed in an excel spreadsheet and participants were instructed to open the tab only when it was time to respond. Full interviews lasted for one hour (on average), with ~10 minutes of that time dedicated to answering the questions pertinent to this paper. All interviews were audio recorded, transcribed in full using Trint Automated Transcription software, and error checked by three transcribers to ensure accuracy. Hand written notes taken during the interviews were also transcribed. Consent was obtained from all interviewees prior to the interview occurring, and all personal information of the participants was kept strictly confidential as per Carleton University Research Ethics Board file #12486.

Data analysis

Both qualitative and quantitative analyses were conducted. Responses to the closed-ended (list) question were entered in a database along with the participants' affiliation (i.e., federal, territorial, or provincial government, federal government agency, ENGO). We examined the frequency of responses of all respondents together, and separated by affiliation. We combined answers to 'check all that apply' and 'top three' into one analysis by weighting the 'top three' selections more heavily than 'check all that apply'. We conducted the frequency analysis in two ways. First we assessed the total number of responses to each characteristic for each affiliation group. Second, in order to make the number of characteristics more manageable for analysis, we aggregated several characteristics into larger groupings of closely related characteristics (see Appendix A, closed-ended question), and analyzed the frequency of responses based on the percentage of all respondents who selected each characteristic / group of characteristics.

Interview transcripts were systematically analysed using NVivo (version 12) software to produce a database of suggestions for characteristics of proposals that give high confidence that the funded research is likely to be impactful. For this analysis, a code book was developed through a combination of

inductive and deductive processes by EAN and NH, the two researchers primarily involved in the qualitative analysis. This codebook was shared and discussed with the co-authors before coding began in earnest. We coded interview texts for statements that pertained to two central themes including: 1) characteristics of proposals leading to 'successful' research, and 2) advice on operational changes that could be made by funding agencies to improve their impact.

Results

Closed-ended questions: characteristics of successful proposals selected from a pre-determined list

Results of the closed-ended questions revealed that the top five most selected elements to look for in proposals (based on the aggregated analysis) are: i) a clearly articulated communication plan to ensure that the message is getting into the hands of the correct people; ii) a team that is socially and culturally diverse, including representation from Indigenous groups and other stakeholders; 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 solve the problem 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 (ENGO, federal, territorial and provincial governments) in what stood out as most important (Figure 1, Table 2). Respondents from the ENGO sector largely drove the push for social and cultural diversity, and also had a strong voice for promoting the inclusion of social scientists on research teams (Figure 1, Table 2). Respondents from federal government agencies pushed for strong communication plans, and recommended that there should be a clearly stated policy need within the proposal and a demonstration of the relevance of the results to fill that need (Figure 1). Provincial and territorial government responses strongly supported peer review, appropriate methodological approaches, the importance of a multi- or trans-disciplinary team, and the need for flexibility in research design (Figure 1, Table 2).

Open-ended questions: characteristics of successful proposals and operational advice

Responses to the open-ended interview questions echoed many of the survey results, but also uncovered several novel insights. These responses have been categorized into broad topics under the two themes mentioned above (see Methods), and are described in detail in the following sections. Responses are summarized in Table 3, and assigned to one of three categories (strong support, medium support, or some support) based on the number of participants that suggested each item.

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

Participants' suggestions for proposal characteristics that can serve as indicators for probable actionable research were grouped into four broad topics. These included: 1) Having a well-developed research plan, 2) Having a clear and demonstrable link to a relevant policy issue, 3) Having a thoughtfully selected research team with diverse and relevant expertise, and 4) Having a well-defined communication plan that goes beyond peer-review. We discuss each topic below. Several challenges associated with the suggestions are considered in the discussion.

1. Well-developed research plan

One of the most broadly supported characteristics of a solid research plan was careful consideration of the feasibility and timeliness of the proposed project. Participants suggested that applicants should be

able to convince the reviewers that their team has the ability to produce the promised results in the necessary period of time. As one respondent from ECCC 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 timeframe [is important]. Oftentimes when I've seen grants, you know, people put so much in there and it's like, this is not realistic in the timeframe that is being proposed and in the timeframe necessary for this decision"* (female, ENGO [AB]). Such sentiments were expressed by the majority of respondents in the study (Table 3).

A second suggestion that received broad support among participants was that applicants should be able to clearly demonstrate how the methods proposed will address the policy issue at hand. This requires a clear articulation of the policy need (discussed further below), but also a good understanding of how the methods will arrive at a useful conclusion. Several respondents specifically suggested evaluating proposals based on the planned use of innovative techniques and tools (where appropriate), and on evidence that applicants had considered the most appropriate spatial and temporal scales. Scales should be selected to ensure that the research will be relevant to the specific issue at hand, but could be applied to other circumstances and situations. For example, a participant from Parks Canada mentioned: "*The other thing to look at is, what is the gain? Is it regional? Is it local? Is it national? Is it a particular species or ecosystem process? What is the ecological reach of that? If it is research that has absolutely no relevance beyond a very small subject matter, then it's really not all that useful"* (male, federal [BC]), and one respondent from the DFO suggested: *It is important to look at: Is this the same approach that's been used forever? Or are there new, more efficient ways? Has the latest technology been adopted or adapted to this situation? Are we just kind of going back and turning the crank in a way we've been doing for the last 30 years expecting a different result? These [are questions that] should come into play* (female, federal [NS]).

Finally, there was an interesting suggestion about flexibility needing to be worked into the plan. As articulated by a researcher in the Ontario Ministry of Natural Resources and Forestry:

> *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 all of a sudden that research or that product is showing not exactly what is expected or isn't coming true to what the research goal was, there has to be that flexibility to make adjustments to find out exactly what the research is pointing to* (male, provincial [ON]).

Planning for flexibility from the outset is necessary to successful products. Time for mid-project evaluations and contingency plans or alternative approaches should be in place from the outset.

2. Clear and demonstrable link to policy

Having a clear and demonstrable link to a relevant policy issue emerged as a top priority when evaluating proposals for the likelihood of producing actionable research. First, there should be a clearly stated policy objective to the work and a demonstrated need for environmental research to influence that given policy development. Second, there was strong support that there should be evidence that the information provided by the study will be appropriate for filling that knowledge gap. In other words, the proposal should identify a knowledge gap and demonstrate that the information that will be generated

by the study is required by the end user. Each of these points was supported across sectors, but the following statement by a scientist from Alberta Environment and Parks summarizes these points succinctly:

> *I think at the onset you'd 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 done 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])*.*

A mechanism for success mentioned during the interviews was using a Theory of Change (ToC) approach. Stated simply, this involves starting with clearly-defined desired outcomes, and then using a graphical visualization (i.e., a ToC map) to guide the process of working backwards to decide on the types of interventions required to achieve those outcomes (James, 2011; DeSilva et al., 2014). Such decisions are based on theory, and are open to discussion, reflection, and re-evaluation by all stakeholders throughout the process (DeSilva et al., 2014). In addition, there should be careful consideration of how different outcomes will influence policy in one direction or the other. As stated by a participant from ECCC: "*So, 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])*.*

3. Thoughtfully assembled research team

Arguably the most important element of a proposal that is predictive of success according to the participants of this study is the composition of the research team. The most common recommendation in this area was that policy makers are at the table to guide the research at all stages of the process. The term 'policy maker' (above) is used to encompass various wording used by participants to make this point, and refers broadly to individuals that have a high level of experience and expertise in advising or writing environmental policy, knowledge of current policy windows, and a clear understanding of the type of scientific information needed to aid in decision making.

There was likewise strong support for assembling a team with a high level of diversity and expertise in relevant areas. This is to ensure that a diversity of perspectives and experiences are heard and to ensure consideration of multiple sources of knowledge in developing, conducting and sharing research projects. These points are summed nicely by a retired DFO employee with extensive transdisciplinary and policy making 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. An in-depth knowledge in each of the key perspectives that contributes to it"* (male, federal [ON])*.* There is an enormous amount of scholarship indicating that co-production of knowledge is effective for producing actionable research (Karl et al., 2007; Nel et al., 2016; Posner et al., 2016). To that end, teams should include government and academic scientists, and relevant representatives from Indigenous groups, resource users, practitioners, and other stakeholder groups, all of whom contribute to the research from conception to reporting. Mechanisms suggested for ensuring that co-production is occurring included requiring a letter of support from the research partners, incorporating checks and balances during the research process to demonstrate that

collaboration are ongoing (i.e., not just lip service), and/or requiring in-kind donations from end-user partners.

A final consideration regarding the team composition is that members of the team should have a proven track record of successful co-production (i.e., they are good collaborators) and have proven record of success in integrating science into policy, with a clear understanding of the policy instruments at hand. This being said, it is also essential that there is a focus on training the next generation of researchers to ensure that early career researchers are poised to move into these spaces in the future.

4. Communication plan for reaching a diverse audience

Participants strongly suggested that appropriate communication plans should be outlined early on in the research process. As suggested by a participant from NRCan: "*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. I think that has the highest likelihood of informing environmental policy"* (female, federal [ON]). In order to achieve this, participants suggested that a proposal must include a clear pathway for communication. This includes knowing who the audience is, who the specific people are that need the information, and the best format and forum for knowledge dissemination. In general, having a diversity of outputs planned (policy briefs, peer reviewed papers, seminars, presentations, videos, etc.) was recommended to facilitate this process.

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

Although the questionnaire did not explicitly ask for advice on operational changes from within granting agencies, participants had several relevant remarks that emerged from multiple interviews. We outline three major topics below, including 1) Drawing on diversity of expertise during award adjudication, 2) Incentivising co-production and interdisciplinary research, and 3) Following up on and rewarding information sharing. We discuss each in turn below, and expand more fully in the discussion.

1. Use diverse expertise during award adjudication

Similar to valuing diversity on the research team, including a diversity of experts on review panels can help to decide whether proposed research projects are likely to be successful. As stated by a participant from Alberta Environment and Parks: "*You know, 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 body"* (male, provincial [AB]).

2. Incentivising co-production and interdisciplinary research

A common point raised by respondents is that funders should encourage, and possibly even require, co-production of knowledge and interdisciplinary work in applied conservation fields, and work towards breaking down barriers between siloed social and natural science research (e.g., lack of wiggle room within NSERC and SSHRC to conduct boundary-spanning research). 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 done. A good example of that is the dearth of Indigenous participation in research. The absence of the inclusion of Indigenous*

voices is wrong. So there needs to be explicit funding for partnerships among researchers, departments, policymakers, and resource users or other stakeholders (male, ENGO [ON]).

3. Following up on and rewarding information sharing

A point raised by several respondents centered on the need to ensure that research that is meant to influence policy is actually conducted and shared through appropriate channels. Having a communication plan in place is key (as per Theme 1, Topic 4), however it is equally important to ensure that researchers follow up on this plan. Several respondents suggested that this can be done by incentivising data sharing by providing funds for this process (e.g., funds to run workshops, create communication tools, employ a knowledge broker, etc.) or by creating and (better) enforcing data sharing policies.

Discussion

Making complex policy decisions for environmental and natural resource management requires integration of the best available knowledge sources (Dicks et al. 2014). However, evidence suggests that successful incorporation of scientific research into environmental policy remains challenging (Cvitanovic 2014). Over the past decade, studies and opinion pieces diagnosing the problem have proliferated (Rose et al., 2018), as have recommendations for scientists and policy makers on how to bridge the knowledge-action gap (Laurance et al. 2012; Cook et al. 2013; Posner and Cvitanovic 2019; Rose et al. 2019). However, mobilizing scientific research at the pace and scale required to meet policy needs requires systemic change from all players in the scientific arena (Arnott 2019). Funding agencies and their program directors play a key role in guiding trajectories of scientific scholarship by selecting which research to fund, deciding on proposal requirements, developing proposal calls, and promoting specific research themes (Matso 2012; Holmes et al. 2012). Science funding bodies therefore carry a great deal of responsibility in solidifying linkages at the science-policy interface. Funding bodies could drive transformative change by ensuring that the research they fund has the highest chance of being actionable, and by promoting scientific approaches that are most likely produce actionable knowledge.

The results of this study provide suggestions from Canadian science-policy experts on important considerations for funding bodies looking to support actionable scientific research. This guidance is grouped under two major themes, the first exploring factors to take into account during grant selection, and the second highlighting internal changes to the funding process that can contribute to improved evidence-informed decision making.

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

Results of both the open- and closed-ended questions produced a list of proposal characteristics that indicate high a likelihood of research 'success' (i.e., findings will be used to inform environmental policy or practice). Although some of the criteria mentioned /selected by participants were not very different from those that would normally be used to evaluate a proposal (e.g., researcher track record in terms of typical outputs such as peer-reviewed papers in high impact journals; clear, understandable, and up-to-date methodologies; appropriate spatial and temporal scales), several suggestions emerged that relate specifically to selecting actionable research. Results from the closed ended question were closely aligned with answers to the open-ended portion, and are therefore discussed together.

A key suggestion was having a well-developed research plan (topic 1), which encompassed the need for a reasonable and useful timeframe and evidence of the feasibility of proposed research. A common barrier to using research in policy is a mismatch of timeframes, where research results are not available during critical policy windows (defined by Kingdon (2003) as 'windows of opportunity for policy change that periodically create situations for the sudden uptake of knowledge'; Rose et al. 2017). Mapping out achievable timelines and matching team members to specific tasks are two approaches that can ensure projects are finished on time, and can be assessed during proposal review. An interesting (although less common) suggestion was the idea of having built-in contingency plans in case the project needs to be adjusted to accommodate sudden changes in the policy landscape. Related to this was the suggestion to adopt a Theory of Change (ToC) approach, which has proven successful in the medical research field (DeSilva et al. 2014). Conceptual maps with contingency plans for reaching a desired outcome could be an important way forward, and could be an element that is required in applications for funds intended for policy-relevant projects. Many federal environmental programs are based on ToC and/or logic model approaches (see ECCC 2017; NRCan 2017; 2019 for examples). Using such tactics to guide research can help to identify specific points in the larger problem-solving picture where findings can be applied.

A second suggestion that emerged for evaluating proposals was evidence of a clear link of the proposed research to a specific policy issue (topic 2). In order for researchers to identify a policy knowledge gap and demonstrate that the proposed project will fill this gap, research teams (i.e., proposal writers) must have the capacity to accurately anticipate (or create) policy windows (Reed et al. 2014, Cook et al. 2014, Rose et al. 2017). Although several strategies have been suggested for scientists to accomplish this (Cook et al. 2014; Moon et al. 2014; Rose et al. 2017), a key approach is to build solid partnerships with individuals who are on the inside of the policy making sphere. This was the central point of topic 3: having a thoughtfully assembled research team. Team composition was an important element that emerged from this study, and there were several suggestions and opinions on how this should be realized. One must recognize, however, that these suggestions are highly context specific, and should be evaluated on a case-by-case basis. Suggestions included that the team that be led (or co-led) by an individual with in-depth knowledge of the policy issue at hand, that the team be composed of individuals from all relevant stakeholder groups and thus encompass a diversity of perspectives and expertise, and that the team include members with a track record of success in collaborative projects and in producing actionable science. Of course, building such teams can be challenging, particularly for early career researchers (ECRs) who lack diverse and expansive networks of collaborators. ECRs also typically lack established track records of successful collaborations. Mentoring of ECRs by experienced (later career) researchers can facilitate relationship building and expand/maintain productive partnerships. Apart from challenges faced by ECRs, there are several interacting barriers that come with working in complex teams, which have been discussed at length in other studies and are outside of the scope of this paper (see Oliver et al., 2019; Rose et al. 2019; Young et al., 2020).

The final topic under Theme 1 was having a well-planned communication strategy (topic 4) to ensure that the information gathered during the research project lands in the necessary hands. Gaps in communication are commonly identified as critical barriers to bridging the science-policy divide (Cook et al. 2013; Reed et al. 2014; Cvitanovic 2015). Important mechanisms for overcoming this barrier include knowing your audience, being flexible on the method of delivery of findings, and incorporating communication activities as a central component to the research program (Shanely and Lopez 2009; Cvitanovic et al. 2015). This can be evaluated in proposals by requesting proof of communication

outputs such as policy briefs, public seminars, videos, and other alternative communication pieces (discussed further below).

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

While all of the above measures are important considerations when selecting proposals, this list leaves many unanswered questions on how to implement the mechanisms required to achieve these recommendations. From the perspective of the scientific community, each of the suggested proposal characteristics requires time, financial support, broad inter- and trans-disciplinary networks, and the ability to predict and recognize policy windows. For example, co-production of knowledge often involves working with large teams of people with different priorities and perspectives. Such work, although it can be rewarding, is often time consuming, expensive, stressful and emotionally draining, and can come at the cost of overall productivity of the group (Olivier et al. 2019; Rose et al. 2019, Young et al. 2020). The divide between stating that actions will occur (i.e., in a proposal) and actually carrying them out on the ground was recognized by several participants, and recommendations for operational changes to funding agencies that can reduce or remove barriers to successful knowledge transfer formed Theme 2.

Participants in this study indicated that 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). Indeed, funders have the potential to have impact at all stages of the research process from solicitation, to proposal requirements and funding selection, to follow up and evaluation (Arnott 2019). For funding selection, there has been some argument to include information users on the grant selection committees, and several program directors of funding bodies have implemented such measures (Matso 2012, Trueblood et al. 2019). However, the best processes for including non-scientists on peer-review grant selection panels continues to be an area of debate (Arnott 2019). In another example, given that there are increasing calls for co-production, and evidence that co-produced knowledge tends to be the most effective at influencing policy (Kirchhoff et al. 2013; Jaganathan et al. 2020; Mach et al. 2020), it is intuitive that funding bodies could and should develop mechanisms that incentivize this kind of work. This can be achieved by helping to cultivate diverse partnerships (e.g., provide seed funding; Arnott et al. 2019), soliciting, funding, and possibly requiring interdisciplinary projects (as opposed to forcing proposals into silos that separate natural and social sciences; Matso et al. 2008), and providing allowances for the extra cost and time associated with co-production (Oliver et al. 2019). A growing body of work has shown that funding agencies that support and reward collaborative and interdisciplinary research have a strong track record of backing actionable research (Riley et al. 2011; Matso and Becker 2014; Arnott et al. 2019).

Participants further suggested that funding agencies should incorporate check-ins and incentives throughout the research process to ensure that collaborations remain strong and communication goals are achieved. Part of the selection process can involve giving 'points' to individuals who can prove that they have carried out successful communication missions; rewarding researchers for information sharing and communication will encourage more frequent and higher quality efforts (Arnott 2019). Recent studies have shown that funding models that provide support for carrying out communication plans (Shanely and Lopez 2009; Riley et al. 2011; Matso and Becker 2014) and that mandate interaction between researchers and potential users of the knowledge throughout the research process (Riley et al. 2011; DeLorme et al. 2016; Hunter 2016; Moser 2016; Arnott et al. 2019) have a higher probability of producing research that is used in a policy context.

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), and is growing in environmental fields (Matso and Becker 2014; DeLorme et al. 2016; Arnott 2019). In Canada, there are a number of funding programs that have used some of these principles. For example, several programs encourage academic researchers to collaborate with external partners in business, policy, or industry (e.g., Mitacs Accelrate Fellowship, Mitacs Canadian Science Policy Fellowship, SSHRC Partnership, NSERC Alliance, Liber Ero Fellowship). These programs have been highly effective in forming long-lasting collaborations, indicating that several of the suggestions from this study are likely to be fruitful if implemented. Such programs can be used as a model for other organizations to follow. However, it is important to acknowledge these changes may challenge the fundamental structure of many funding bodies, and therefore may be difficult to implement.

Conclusion

Funding agencies are powerful, but understudied actors at the science-policy interface. This study provided advice to funding agencies on how to select research proposals with the highest likelihood of producing actionable science, and provided pointers on how funding programs can be more proactive in encouraging and supporting research teams to engage in approaches to science that are known to result in higher policy uptake. The inventory of proposal characteristics 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.

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

Overall sample sizes	**N – open-ended**	**N – closed-ended**
Federal Government	49	11
Parks Canada	*12*	*1*
Environment and Climate Change Canada	*13*	*4*
Department of Fisheries and Oceans	*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*	-
Canadian Council of Academies	*1*	*1*
Canadian Parks and Wilderness Society	*2*	*1*
Canadian Wildlife Federation	*2*	-
David Suzuki Foundation	*1*	*1*
Evidence 4 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	*2*	-
World Wildlife Fund	*1*	-
Yellowstone 2 Yukon	*2*	-
Yukon Conservation Society	*1*	-
TOTAL	84	25

Table 2. Top six responses from the entire list provided for the closed-ended question answering 'elements of proposals that increase the likelihood the research produced will be impactful' selected overall, and within federal government organizations (FED), environmental non-governmental organizations (ENGO), and territorial / provincial government organizations (TERR/PROV). Each selection is colour coded to easily see differences in ranking among groups. Rankings are based on total counts of non-aggregated proposal characteristic data.

Rank	Overall	FED	ENGO	TERR/PROV
1	Study will be summarized in a digestible manner	Study will be summarized in a digestible manner	Proposed team is multidisciplinary	Plan in place to present work to policymakers
2	Proposed team is multidisciplinary	Proposed team is multidisciplinary	Indigenous team members	Understand needs of the user
3	Plan in place to present work to policymakers	Study aims to be published in peer-reviewed journal	Institutionally diverse team	Study will be summarized in a digestible manner
4	Institutionally diverse team	Appropriate spatial / temporal scale selected	Plan in place to present work to policymakers	Feasibility of study
5	Appropriate spatial / temporal scale selected	Relevance of the results	Understand implications of the study	Flexibility of research design
6	Understand implications of the study / relevance of the results	Plan in place to present work to policymakers	team members with social / cultural history	Culturally diverse team

Table 3. 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' >30%, 'medium' = 10-30%, and 'some' <10%.

Theme	Topic	Support	Characteristic
Elements of proposals	**Research plan**	Strong	Feasibility and timeliness of project
		Medium	Appropriate methodology to address the question
		Medium	Appropriate spatial and temporal scale
		Some	Innovation of techniques and tools
		Some	Flexibility in research design
	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
	Research team	Strong	Policy makers 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 wo
		Medium	Diversity of perspectives and experiences relevant to the question at hand
		Some	Training of the next generation
	Communication and reach	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
Internal changes	**Adjudication**	Medium	Include a diversity of expert voices on review panels
	Incentivize co-production	Strong	Explicit funding for partnerships among researchers and policy
		Strong	Extra time and funding allotment for coproduction
		Strong	Make partnerships a requirement (e.g., genome Canada)
	Data sharing	Strong	Work funded should be publicly available
		Medium	Ensure researchers follow up on communication plans
		Some	Provide funding for this process
		Some	Create and enforce data sharing principles

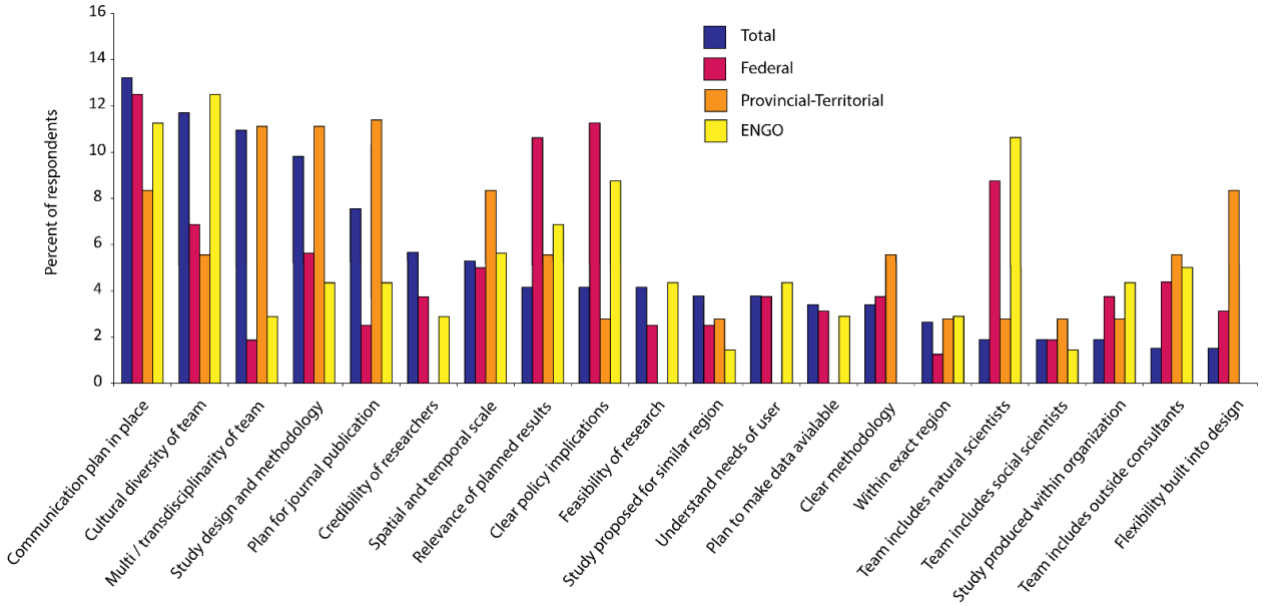

Figure 1.

Percent of all responses for each option from the aggregated list provided for the closed-ended question answering 'elements of proposals that increase the likelihood the research produced will be impactful'. Responses are presented as percent of all responses for each group, and are based on aggregated proposal characteristic data.

Appendix A.

Open-ended question:

- *In environmental research there are many considerations that make proposed studies or research programs more or less likely to be reliable, rigorous, and useable for integration in policy and decision-making. Thinking about this from the perspective of a funding body looking to fund actionable research, what should funders look for in proposals that will ensure the research is relevant and useful?*
- *Do you have any further advice for decision makers within these funding bodies to allocate funding appropriately in order to achieve this goal*

Closed-ended question:

- *Please read through this list and select a) all that apply, and b) the top 3 most important elements of a proposed study that will increase the likelihood that findings will be actionable for policy/practice.*

Funder consideration	Aggregated for analysis	Examples	all that apply	Top 3
Study design	Spatial and temporal scale'	Appropriate spatial scale Appropriate temporal scale Specificity of proposed study		
	Research methodology	Based on theoretical model Based on field data Based on experimental evidence Understandable/up-to-date study design and methodology		
		Relevance and interpretability of results		
		Rapidity and feasibility of the study		
		Don't know / other (specify)		
Time and Place	Context	Study will be produced within the exact region of concern		
		Study will be produced in regions similar to the region of concern		
		Study will be produced within Canada		
		Don't know / other (specify)		
Teams / individuals who produced the knowledge	Credibility	Proposed researchers / laboratories that are known and trusted Proposed researcher are from recognized academic institutions		
		Natural scientists		
		Social scientists		
		Proposed researchers from within gov't body / NGO		
		Proposed researchers from outside environmental consultancies		
		Proposed researchers indigenous groups		
		Academically diverse (multidisciplinary) team (e.g., includes natural scientists, social scientists, economists, political scientists)		
		Institutionally diverse team (e.g., cross-sector team includes academics, NGO, end-users, government, stakeholders, and/or Indigenous peoples)		
	Socially/culturally diverse team	People with social history / cultural background in the region of concern Culturally diverse team (e.g., includes diverse nationalities, ethnicities, cultural backgrounds) Cultural literacy of research team (understanding views and ideologies of local cultures)		
		Don't know / other (specify)		
Accessibility	Peer-reviewed journal	Study will be published in a peer-reviewed scientific journal Study will be published in a high impact factor journal Study will be published in open access journal		
		Raw data will be made available		
		Don't know / other (specify)		
Communication /Literacy	Communication	Evidence will be summarized in a simple, digestible manner Evidence will be presented to policy makers		
		Understand the implications of the proposed findings		
		Have a 'knowledge translator' to ensure messages are shared appropriately		
		Don't know / other (specify)		