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Interference in science: scientists' perspectives on their ability to communicate and conduct environmental research in Canada

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Abstract

When researchers are sufficiently resourced to conduct research and communicate their findings, the knowledge produced can benefit the environment and society through policy. However, interference with the research process and its subsequent knowledge mobilization ("interference in science") has been observed in several countries, particularly for environmental researchers. Using a mixed-methods approach, we surveyed environmental researchers in Canada ($n = 741$) to investigate the perceived prevalence, source, and effects of interference and considered whether these perceptions differ by region, career stage, research area, and membership in any scientific society. Although over half of researchers were not restricted from speaking to the media (54%), and most had never been asked to make "undue modifications" to their work (84%), the vast majority (92%) reported at least some degree of interference in their work during their careers. Consequences of interference were more prevalent among early-career researchers and included negative impacts on job satisfaction, mental health, and undue modification to work leading to inaccurate or incomplete science communication. Although environmental researchers in Canada deem themselves overall better able to conduct and communicate their work than under previous federal governments, reports of ongoing political interference remain concerning. We recommend increased support for researchers and further investigations into interference.

Key words: interference in science, scientific integrity, environmental studies and sciences, knowledge mobilization, Canadian research, science suppression

Introduction

Scientific evidence produced by researchers in the public sector, academia, and industry is linked to policy and management outcomes by raising awareness, defining problems, assessing policy options, and monitoring implementation (Engels 2005; McNie 2007; Douglas 2012). However, the best-available scientific research and evidence is often unused or underused in informing law and policy (Lubchenco 1998; Sutherland and Wordley 2017; Cvitanovic and Hobday 2018). During the last decade, environmental researchers' ability to access sufficient resourcing and their capability to communicate with decision-makers and the public for the purpose of informing law and policy have been called into question in several countries (Singh et al. 2014; Young et al. 2016; Carroll et al. 2017; Peters et al. 2018; Driscoll et al. 2021). Recent evidence from Australia suggests researchers working in environmental sciences, along with medicine and health sciences, are facing severe science suppression (Driscoll et al. 2021), censorship (Lewis 2020), and interference (Mannix 2022). In the United States, the Union of Concerned Scientists (USC) has been documenting interference and scientific integrity for more than a decade (USC and PEER 2005; USC 2006, 2008, 2018; Desikan and Carter 2023). More recently, the US federal government implemented new scientific integrity policies and launched a 120-day review to document instances of improper political interference (Malakoff 2021).

In Canada, the interference experienced by federal environmental researchers began drawing public attention with accounts of "muzzling" in 2012 and 2013 (Ghosh 2012; Gatehouse 2013). In 2013, Canadian author Chris Turner coined the phrase "the war on science" to describe increasing interference from the federal government towards

scientific researchers. Specifically, concerns about scientific integrity in the domain of environmental impact assessment were reported for both public-sector science and industry-led science (Turner 2013; Office of the Ombudsperson of British Columbia 2014; Smith et al. 2017; Haddock 2018; Jacob et al. 2018; Westwood et al. 2019).

Following the 2015 federal election in Canada, the elected Liberal government introduced a model policy on scientific integrity to enable researchers to conduct and communicate work free of political interference in over 20 federal departments and agencies (Treasury Board Secretariat 2018). The model policy has been adopted across the federal public service, but there are inconsistencies in application reported between departments and agencies (Legault 2018). Furthermore, these policies only directly apply to public sector scientists at the federal level. However, leadership from the 2015 (and 2019) elected federal government that introduced these policies (Kelly 2019) may have influenced researchers' capability to conduct and communicate research in non-government sectors. Since the formal implementation of these policies, no research has been conducted on the perceptions of interference among environmental researchers in the public sector. Research that speaks to the perceptions or experiences of environmental researchers in other sectors is also limited.

What is interference in science?

Not all restrictions on a researcher's resources are necessarily mal-intentioned; indeed, in some instances, the censoring of scientific evidence has been for the benefit of protected or endangered species (Turner 2013; Driscoll et al. 2021). However, more generally speaking, for decision-makers who draft, negotiate, and enact laws and policies, the best-available research and evidence are required to do so effectively. Effective mobilization of scientific knowledge, or science communication, enables informed decision-makers and also ideally leads to an informed public equipped with the information required to form opinions about laws, policies, and political actions they support (McNie 2007). As a result, citizen-voters are sufficiently informed to act on those opinions when it comes to their democratic vote (Lester and Foxwell-Norton 2020; Driscoll et al. 2021; Qaiser et al. 2022). Conversely, when there is interference (defined as "deliberate actions that result in both reduced funding or capacity for research activities to levels insufficient to generate knowledge and/or the inability of scientists to communicate their results to the public or engage in effective knowledge transfer to inform decision-making" (Robertson 2022), appropriate democratic processes are thwarted (McNie 2007; Douglas 2012; Hahn 2019; Lester and Foxwell-Norton 2020).

Beyond the negative consequences for democratic governance, interference in science can cause the environment to suffer via a lack of effective environmental management policy (Anbleyth-Evans and Lacy 2019; Westwood et al. 2019). For scientific researchers themselves, interference can lead to negative impacts on mental health, including anxiety, grief, or hopelessness (Gilford et al. 2019). When compounded with conflict in the workplace due to increased public contention and politicization of environmental work, adverse mental health consequences can worsen and impact job security, motivation, and sense of trust (Gilford et al. 2019; Driscoll et al. 2021). There have been many calls by producers and users of scientific research to protect scientific integrity and prevent political interference that could compromise researchers' ability to conduct scientific work or communicate their findings (de Kerckhove et al. 2015; Tides Canada et al. 2015; Westwood et al. 2017; Peters et al. 2018; Driscoll et al. 2021). In response to these calls, we surveyed Canadian environmental researchers' perceived capability to conduct and disseminate research to inform decision-making and engage in effective knowledge mobilization.

Informed by the history of interference in science in Canada, we used a survey to document (1) the prevalence of interference in science for researchers in environmental studies and sciences in Canada; (2) the sources of interference; (3) its impacts on environmental researchers job satisfaction and mental health; (4) whether the experience of interference differs based on location, career stage, research area, and membership in a scientific society; and (5) whether the implementation of the scientific integrity policies in federal government has impacted researchers' perceptions of interference.

Methods

We drew from methods employed by Driscoll et al. (2021) and PIPSC (2015, 2017) to survey self-identified researchers living in Canada and currently employed in the field of environmental studies or environmental sciences. Our sample included Canadian researchers from multiple sectors who work in the environmental sciences or in adjacent environmental studies that address social, political, and cultural relationships with the environment. Using closed (Likert scale, multiple choice, multiple checkboxes) and open-ended (text-fill) questions, respondents indicated their work-based demographic information, perceived freedom to communicate their scientific works, access to organizational resources, sources of interference, and experiences after the introduction of the federal scientific integrity policies in Canada in 2019 (see Appendix A for a full-length survey). We also asked participants about their social demographics (gender identity, sexual orientation, race, wearing of religious signifiers, and others), which are analyzed separately from this study (in Chu et al. 2023).

The online survey was hosted on Qualtrics (Qualtrics 2021) in English and consisted of 31 questions, including three screening questions that determined a participant's eligibility. Eligible participants were required to self-identify as researchers currently working in environmental studies or sciences and were asked to indicate the Canadian province or territory in which they predominantly work. The survey took an average of 25–30 min to complete. This survey received ethics clearance from the Dalhousie Research Ethics Board (REB#: 2021-5630; see Figure A1 in Appendix A). Per the approved ethics application, raw data are to be destroyed after 2 years, but the aggregated data are available as supplementary material.

Survey limitations

First, given the nature of the survey, self-selection bias may emerge: participants interested in the topic of interference may be more likely to complete the survey, while those with little interest or no experience of interference may opt out (Bethlehem 2010). This may result in an overrepresentation of those reporting experience with interference. However, some of those concerns can be attenuated, given that 8% of our sample reported no experience of interference. Second, due to limited resources for official translation services, an English-only version of this survey was circulated, which may engender non-response bias (i.e., underrepresenting non-English speakers in our survey) (Groves et al. 1992). Consequently, some scientific societies declined to participate in survey dissemination as the survey did not meet their bilingual (English/French) communications standards.

In addition, PIPSC surveyed only public-sector employees in Canada, and Driscoll et al. (2021) surveyed self-identifying ecologists and conservation biologists working in research, policy, or related areas in Australia. Our sample, in turn, does not capture the different sectors in which scientists may be working. It also includes research areas not captured in PIPSC and Driscoll (2021), thereby inhibiting our ability to directly compare these works. Finally, the survey questions we reproduced from PIPSC (2015, 2017) and Driscoll et al. (2021) do not specify a time frame upon which participants were directed to reflect. Therefore, respondents' answers regarding their experience with interference could be based on experiences before the 2015 Canadian federal election, when a Liberal government replaced the previous Conservative leadership, or on a time before the implementation of the scientific integrity policies in the federal public service.

Measures

Work demographics

Work demographics were each measured using one categorical variable. Respondents identified their province or territory, which we later grouped into regions (British Columbia, Prairies, Ontario, Atlantic Provinces, and Territories). Respondents' career stage was identified by selecting one of three options: early-career (first employed as a researcher, including post-docs, after 2015), established (first employed as a researcher before 2015), or retired. Participants were asked to "indicate the full names of all scientific societies where [they] hold membership" in an open-text field. Their responses were converted into a dichotomous variable ("affiliated" or "unaffiliated") to represent all researchers' who hold membership to any scientific society as "affiliated" and all researchers who do not hold membership as "unaffiliated". All research areas identified by participants in the open-text responses ($n = 277$) and the research areas mentioned in their responses were classified into one of the six broad disciplines categorized by the Canadian Research and Development Classification (CRDC) (i.e., Natural sciences, Engineering, Medicine, Agriculture and veterinary studies, Social sciences, Humanities, and the arts) (Statistics Canada 2020). Participants who mentioned multiple research areas falling under different CRDC disciplines were categorized as "Multidisciplinary".

Experience of interference

We assessed several aspects of respondents' experience of interference using scale, categorical, and open-ended questions. First, using a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5), participants indicated their perceived capability to freely communicate scientific work to the public by responding to (Q12) "I am allowed by my organization to speak freely and without constraints to the media about my research in the environmental studies or sciences" and (Q13) "I have received a question from the public or media that I have the expertise to answer but have been prevented from doing so by my organization". Next, using the same scale, participants also indicated which topic areas had been constrained (Q14) and what factors constrained their public commentary in areas where they are scientifically knowledgeable (Q16).

In two categorical questions, respondents were also asked to identify whether they had ever experienced (Q10) "undue modification" to their work and whether their (Q17) "job satisfaction [had] ever been affected by restraints on public commentary and peer communication" by selecting yes (1), no (2), or unsure (3)". Follow-up open-ended questions allowed participants to answer (Q11) "who asked you to make the modifications and for what reason?" and (Q18) "how [respondents'] job satisfaction was affected".

Sources of interference

Sources of interference were identified with one open-ended question where participants were asked to identify anyone who contributed to their experience of interference. (Q16). Next, using a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5), participants indicated the degree to which they experienced 14 sources of interference, including 9 internalized factors (e.g., concern about how they may be represented by the media, uncertainty of their expertise) and five external sources (e.g., workplace policy, middle management).

Using Cronbach's alpha (Holcomb and Cox 2017), we next aggregated items to reflect higher order factors representing these experiences of interference. We specifically identified externally-imposed sources of interference (e.g., factors 10–14; $a = 0.91$), fear of the media (e.g., factors 2, 3, and 6; $a = 0.78$), and fear of negative career consequences for engaging in public commentary (e.g., factors 7, 8, and 9; $a = 0.83$) (see Appendix A for a full list of items).

Perceptions of impacts

We assessed perceptions of the impacts of interference using a five-point Likert scale (ranging from strongly disagree (1) to strongly agree (5)). Participants were asked to indicate awareness of cases of interference that negatively impacted (Q7) "the health and safety of Canadians (or environmental

sustainability)". They were also asked to indicate whether their (Q8) "organization has suppressed or declined to release information, and where this led to incomplete, inaccurate, or misleading impressions by the public, regulated industry, the media, and/or government officials" and if (Q9) "the exchange or transfer of knowledge based on scientific evidence for the purpose of developing policy, law, and/or programs at my organization has been compromised by political interference".

Impacts of policy

The perception of impacts on interference due to the implementation of scientific integrity policies was assessed using categorical and open-ended questions. Participants were first asked to indicate whether they were aware (Q20) "of the scientific integrity policies implemented in Canadian federal government departments by in 2019?" by answering yes (1) or no (2)". Participants were subsequently asked (Q21) "If yes, do you feel that the implementation of these policies has had an impact on the ability of researchers in the environmental sciences and studies in Canada to conduct and communicate research? Please explain".

Data collection

The responses were collected through a two-phased approach using purposive sampling to target the population of interest. First, we identified Canadian scientific societies in environmental studies and sciences established for at least 5 years. We contacted the societies via their designated contact email and asked them to distribute the survey to their members by email or via their official newsletter. Of the 29 societies contacted, 15 agreed to participate. We asked the societies for the number of individuals who received the invitation, but since these numbers were unknown for many societies, we could not provide response rate estimates from this distribution phase.

In the second phase, we distributed the survey directly via email to corresponding authors with an institutional affiliation in Canada identified from environmental research papers published since 2008 and indexed in the Web of Science. We identified relevant journals by research areas covered by the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Social Sciences and Humanities Research Council of Canada (SSHRC) classification (NSERC 2010; SSHRC 2015). We only included journals classified in a SSHRC category with mention of the environment or one of the relevant NSERC categories in their titles to ensure their relevance to environment studies. Explicitly non-Canadian-focused journals and those with no English publications were excluded, along with any cross-listed or duplicate journals. We identified 3719 unique journals. Using a relational database version of the Web of Science hosted on a SQL server by the Observatoire des sciences et des technologies, we retrieved email addresses from corresponding authors of articles published in journals from our list on or after 2008. All the email addresses collected used a ".ca" suffix, indicating a Canadian domain registry. Qualtrics was used to distribute the survey invitation to 37,494 active email accounts between August 3 to August 22, 2021. The survey responses were kept anonymous by not linking to any email addresses or other identifying information. As an incentive, participants were given the option to enter a draw to win one of three $50 gift cards to an online store of their choice or to donate to a charity of their choice.

Data analysis

Quantitative analysis

All statistical analyses were completed in RStudio version 1.4.1717 (RStudio, 2021). We calculated descriptive statistics for participants' province, membership in a scientific society, research area, and career stage. We also reported the prevalence, sources, and impacts of interference in science for the entire sample. Next, we used parametric statistical testing to examine whether perceptions of interference differed across province/territory, career stage, research area, and membership in a scientific society. We used independent χ^2 tests to determine whether each demographic variable (i.e., province/territory, membership, research area, career stage) differed in their *experience of undue modification to work* (Q10) and *impacts on job satisfaction* (Q17), which were measured with dichotomous response options (yes = 1, no = 0). For continuous outcome variables (measured on the 5-point Likert scale), we used one-way ANOVAs to test for omnibus group differences, with significance determined by $p < 0.05$. When omnibus tests were significant, we probed between-group differences further using preplanned contrasts. Where contrasts were tested post-hoc, we corrected for family-wise error by dividing the significance value ($p = 0.05$) by the number of tests performed (Bonferroni correction). The results of all statistical tests are available in Appendix A.

Qualitative analysis

We adopted an approach to qualitative analyses similar to that of Driscoll et al. (2021). Open-text responses were manually coded for themes by the first and second authors. Each coder was trained on the codebook (see Appendix A) and conducted independent coding on 100% of the responses for inter-coder reliability assessment. The theme and codebook development process allowed for ongoing consensus building between the two manual coders on how to best represent the response themes (Roberts et al. 2019; O'Connor and Joffe 2020). Following independent coding, sufficient reliability (~75%) was established between the coders (Frey 2018). Where there was disagreement about how any response should be coded, the coders conferred to address an error or misinterpretation. A third co-author was asked to break the tie when there remained disagreement (Zade et al. 2018). The codes presented in the paper reflect 100% consensus for the highest possible trustworthiness in reporting (Nowell et al. 2017; Frey 2018; Roberts et al. 2019).

Fig. 1. Responses for Q3: In what Canadian Province or Territory do you predominantly conduct your work? Responses are reported in the figure ($n = 741$).

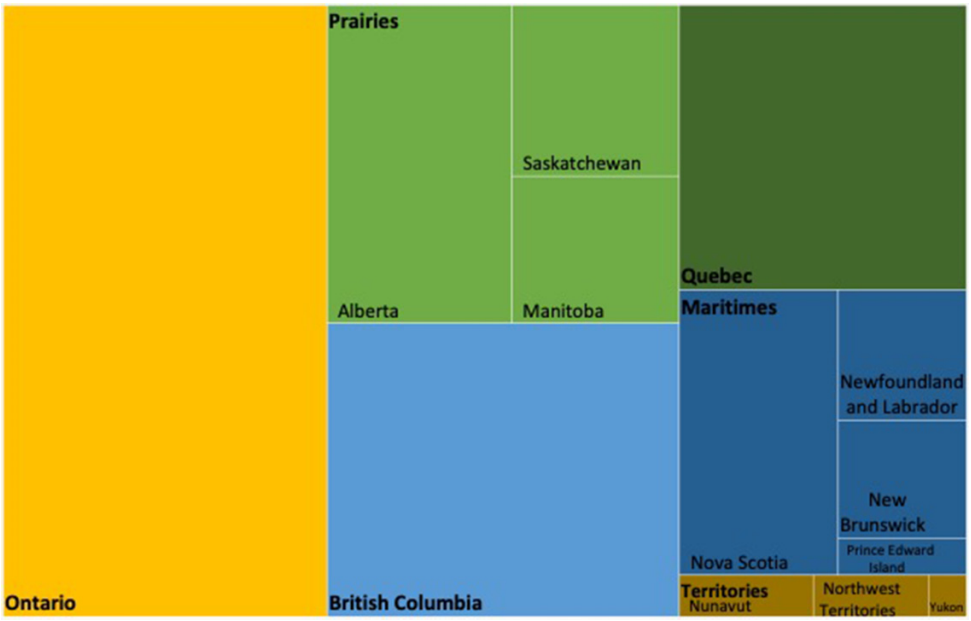
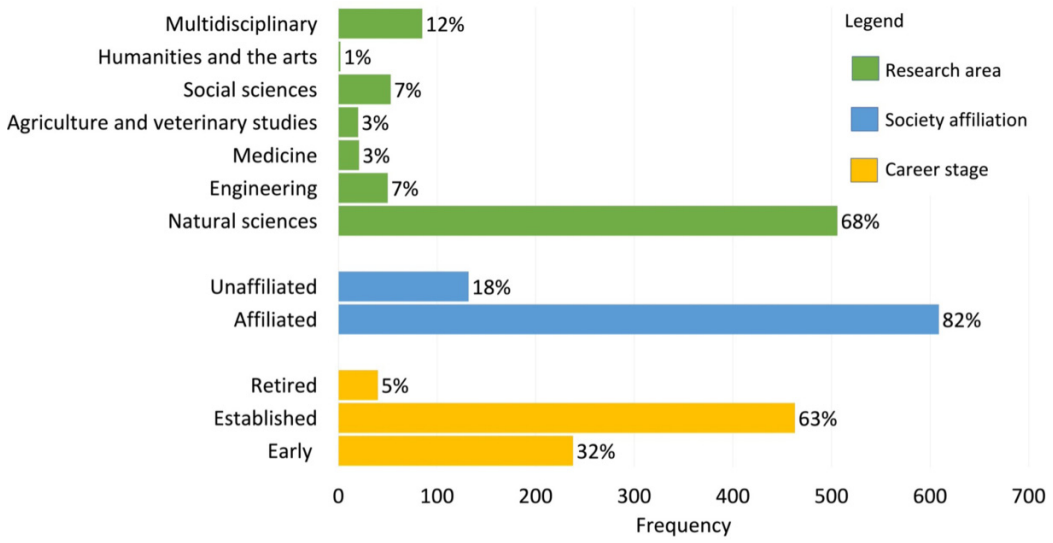


Fig. 2. Responses for Q4: Please indicate your primary areas of research or your discipline(s), Q5: Please indicate the full names of all the scientific societies where you hold membership (aggregated), and Q6: What career stage are you in. Responses are reported in the figure ($n = 741$).



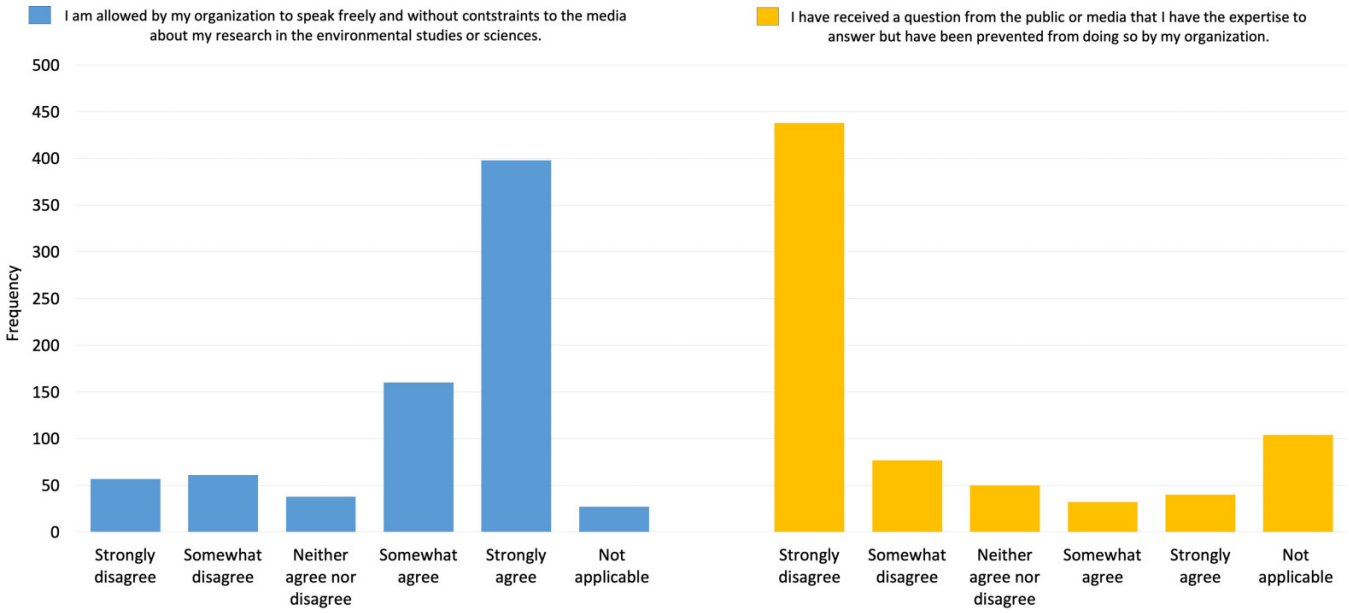
Results

A final sample of 741 survey responses was analyzed after excluding respondents who did not pass the screening questions ($n = 371$) or did not complete all parts of the survey ($n = 179$). Thirty-three percent of participants were located in Ontario, followed by 18% in British Columbia, 18% in the Prairies (Alberta, Saskatchewan, and Manitoba), 14% from Quebec, 13% from the Atlantic provinces (New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador), and 2% from the Territories (Yukon, Nunavut, and the Northwest Territories) (Fig. 1). In terms of career stage, established career researchers made up the majority of respondents (63%), 32% identified as early-career researchers, and the remaining 5% identified as retired and were included in analyses because they identified as "currently working/employed in the field of environmental studies or sciences". The majority of participants (82%) indicated membership in one or more scientific societies, including the Natural sciences (68%), multidisciplinary (12%), Social sciences (7%), Engineering (7%), Medicine (3%), Agriculture and veterinary sciences (3%), and the Humanities and the arts (<1%) (Fig. 2).

Table 1. Coded responses for Q11: undue modifications. Why were you asked to make modifications to your work? ($n = 67$).

Reasoning for modifications requested	Example	*N*	Percent
Downplay environmental risks or impacts	"Executive level directors and higher in government making changes to downplay environmental impacts"	12	27
Justify existing law or policy	"I am aware that some government environmental organizations have forced to release only part of the research results to support a concept/bylaw which they wanted to introduce"	8	18
Avoid contention	"University press office, because they thought it was too controversial"	6	13
Preserve partner/stakeholder relationships	"[research] was not conducive to future relationships or political goals"	5	11
Appease media	"Our Communications Officer has modified the content and the context of research findings…to simplify what's being said to get media interest (providing them with sexy sound bites)"	4	9
Avoid risk of affecting development plans	"Federal Government senior bureaucrats to avoid compromising a major development proposal"	3	7
Avoid risk to funding	"Managers & co-workers frequently asked me to downplay risks of oil and gas projects to increase the chances of projects being funded"	3	7
Protect an organization's reputation	"Industry, to protect their reputation and economy"	2	4
Total		**43**	**100**

Fig. 3. Responses to Q12: I am allowed by our organization to speak freely and without constraints to the media about our research in the environmental studies or sciences, and Q13: I have received a question from the public or media that we have the expertise to answer but have been prevented from doing so by my organization. Responses are reported in the figure ($n = 741$).

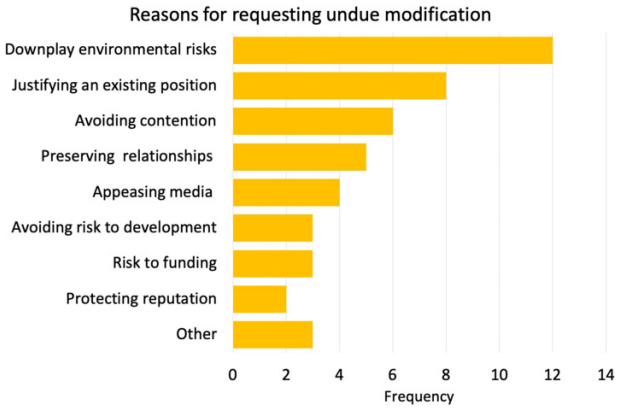


Perceptions of interference in science

Across the study sample, only 8% consistently reported that they had never experienced interference (by answering Q10 and Q17: "no", Q12: Somewhat or Strongly agree, Q13: Somewhat or Strongly disagree, and Q14: "I have not experienced any constraints"). The remaining 92% reported experiencing some degree of interference in their work, whether from externally imposed factors (e.g., management, workplace policy, research partners) or internalized factors (e.g., fear of the media, fear of negative career consequences). Most (84%) respondents said they had never been asked to make "undue modifications" (defined as substantive changes to a text or story that downplay, mask, or include misleading information about environmental impacts) to their work (Table 1). Nine percentage said they had (5% were unsure; Q10).

Fifty-four percentage of participants strongly agreed that they are allowed by their organization to speak freely and without constraints to the media about their research in environmental studies or sciences (22% somewhat agreed, 8% somewhat disagreed, 8% strongly disagreed, and 5% neither agreed nor disagreed) (Q12). Fifty-nine percentage strongly disagreed that their organization ever prevented them from answering a question from the public or media that fell within their expertise (10% somewhat disagreed, 7% neither

Fig. 4. Responses to Q11: Who asked you to make the modifications and for what reason? Responses are reported in the figure ($n = 46$).



agreed nor disagreed, 5% strongly agreed, and 4% somewhat agreed) (Q13) (Fig. 3).

Sources of interference in science

Respondents' reported requests for undue modification most frequently came from senior management (29%), middle management (24%), or communications personnel (14%). Government research partners (7%) were also reported, along with industry (8%) and other organizational research partners (9%). Workplace culture was only mentioned by three individuals (4%) (Q11).

The leading reason for requesting undue modifications to scientific work was to downplay environmental risks (26%). Other reasons included justifying an existing law, policy, or ministerial position (18%), preserving stakeholder or research partner relationships (11%), avoiding internal or public contention (13%), avoiding putting any development plans at risk (7%), and protecting an organization's (internal or external) reputation (4%). Appeasing media or communications staff was reported by 9% of respondents, and 7% mentioned the risk to current or future funding opportunities for publishing authentic research results (Q11) (Fig. 4). Externally-imposed factors constraining public commentary included senior management (11% strongly agreed), workplace policy (10% strongly agreed), the Minister's office (10% strongly agreed), and middle management (8% strongly agreed). Seven percentage strongly agreed their public commentary was constrained by workplace colleagues or work culture (Q16). Internalized factors constraining public commentary included concern about how they may be represented by the media (13% strongly agreed), fear of being drawn to comment beyond the boundaries of their expertise (14% strongly agreed), uncertainty about the boundaries of their expertise (5% strongly agreed), stress around discussing contentious issues (8% strongly agreed), fear of risking funding opportunities (8% strongly agreed), fear of reducing opportunities for advancement (8% strongly agreed), and fear of being made redundant (4% strongly agreed) (Q16) (Fig. 5).

Impacts of interference in science

Environmental impacts

Fourteen percentage strongly agreed they were aware of cases where the health and safety of Canadians (or environmental sustainability) have been compromised because of political interference with scientific work at their organization (18% somewhat agreed, 20% neither agreed nor disagreed, 12% somewhat disagreed, and 35% strongly disagreed) (Q7) (Fig. 6). Climate change (8%) and pollution (5%) were the research areas most often reported as constrained. Impacts of agriculture, impacts of mining, threatened species, and changes to legislation or policy were also reported as constrained topic areas by 3% of the sample, followed closely by land use planning, impacts of urban development, commercial fishing, and logging, all reported by 2% (Fig. 7). All other topic areas listed in Q14 were reported as constrained by 1% or less of the sample (see Appendix A for a comprehensive list).

Science communication

Eleven percentage strongly agreed they were aware of cases where their organization has suppressed or declined to release information and where this led to incomplete, inaccurate, or misleading impressions by the public, regulated industry, the media, and/or government officials (13% somewhat agreed, 14% neither agreed nor disagreed, 15% somewhat disagreed, and 40% strongly disagreed) (Q8).

Thirteen percentage strongly agreed they were aware of cases where the exchange or transfer of knowledge based on scientific evidence for the purpose of developing policy, law, and/or programs at their organization was compromised by political interference (16% somewhat agreed, 13% neither agreed nor disagreed, 13% somewhat disagreed, and 36% strongly disagreed) (Q9) (Fig. 6).

Researcher's job satisfaction

Nineteen percentage of respondents said that their job satisfaction has been affected by restraints on public commentary and peer communication (Q17). Of those, 30% cited muzzling, constraints, and restrictions in communicating scientific work, and 5% said they had insufficient resources to conduct work. Others described poor internal working conditions (26%), inability to express authentic views (10%), or feeling that their work was pointless or redundant (8%). Four percentage indicated that they had considered changing fields, and 7% felt they had lost professional development opportunities due to interference (Table 2). When asked to explain how their job satisfaction was affected, almost half of the respondents (48%) mentioned the 2006–2015 Conservative Party Leader and Prime Minister Stephen Harper or "the previous administration" ($n = 24$). Twenty-eight percentage referred to instances where an organization or industry development plan had been prioritized over environmental protection. Funding as a source of constraint was identified

Fig. 5. Responses to Q16: Our public commentary in areas where I am scientifically knowledgeable is constrained by; "Public commentary" refers to any information contributed in interviews with media and media statements or editorials, including social media (indicate your agreement with the following statements). Full statements available in Appendix. Responses are reported in the figure ($n = 741$).

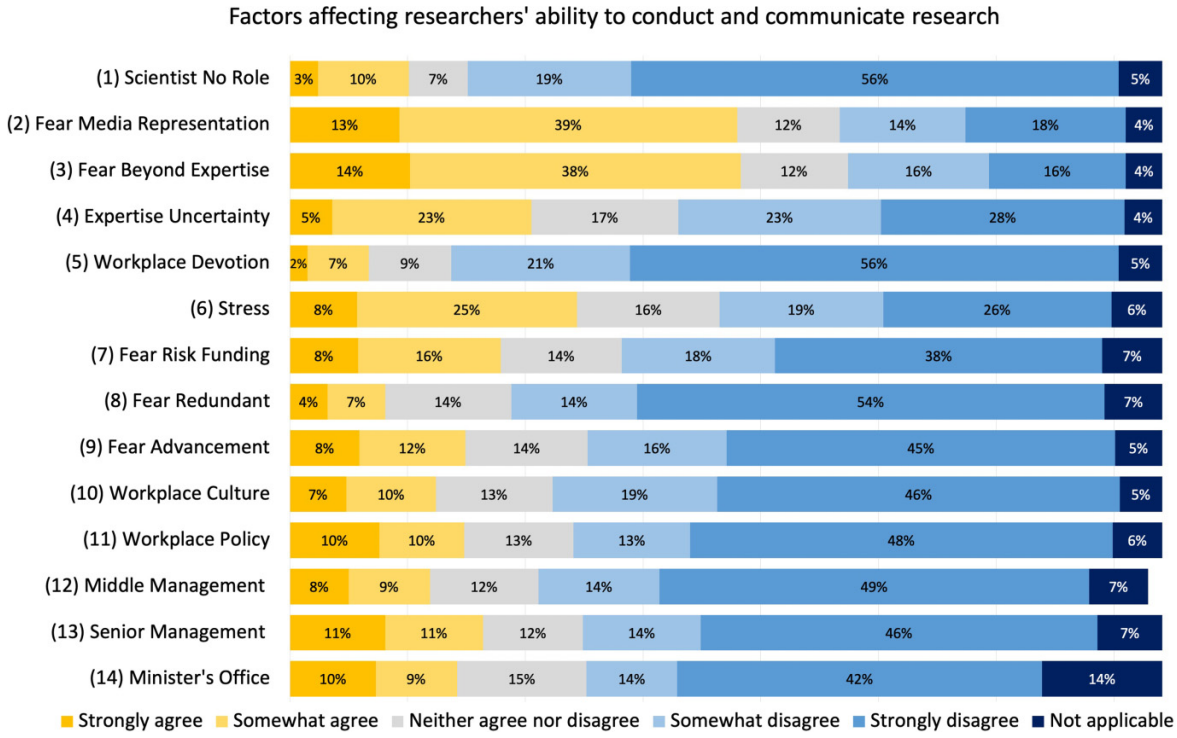


Fig. 6. Responses to Q7: I am aware of cases where the health and safety of Canadians (or environmental sustainability) has been compromised because of political interference with scientific work at our organization. ($n = 684$), Q8: I am aware of cases where our organization has suppressed or declined to release information, and where this led to incomplete, inaccurate, or misleading impressions by the public, regulated industry, the media and/or government officials. ($n = 692$), and Q9: I am aware of cases where the exchange or transfer of knowledge based on scientific evidence for the purpose of developing policy, law, and/or programs at our organization has been compromised by political interference. ($n = 696$). Responses are reported in the figure.

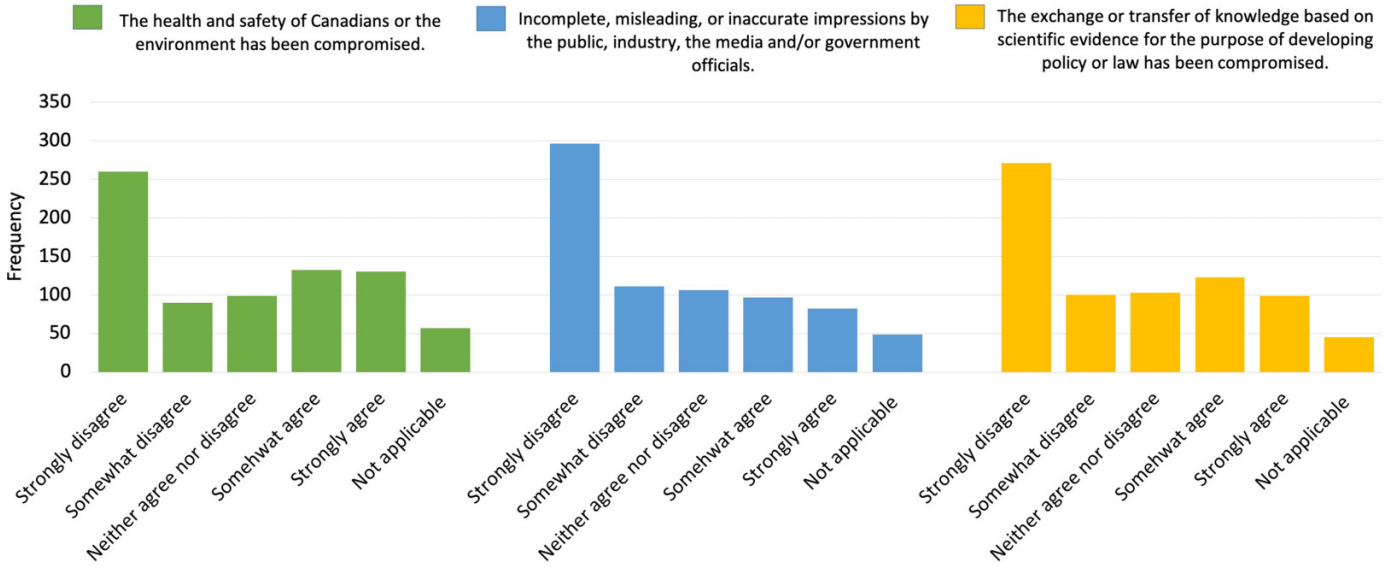


Fig. 7. Responses to Q14: Please indicate which topic areas you have experienced constraints on communication, in mainstream or social media, from your organization/present workplace. Responses are reported in the figure ($n = 449$).

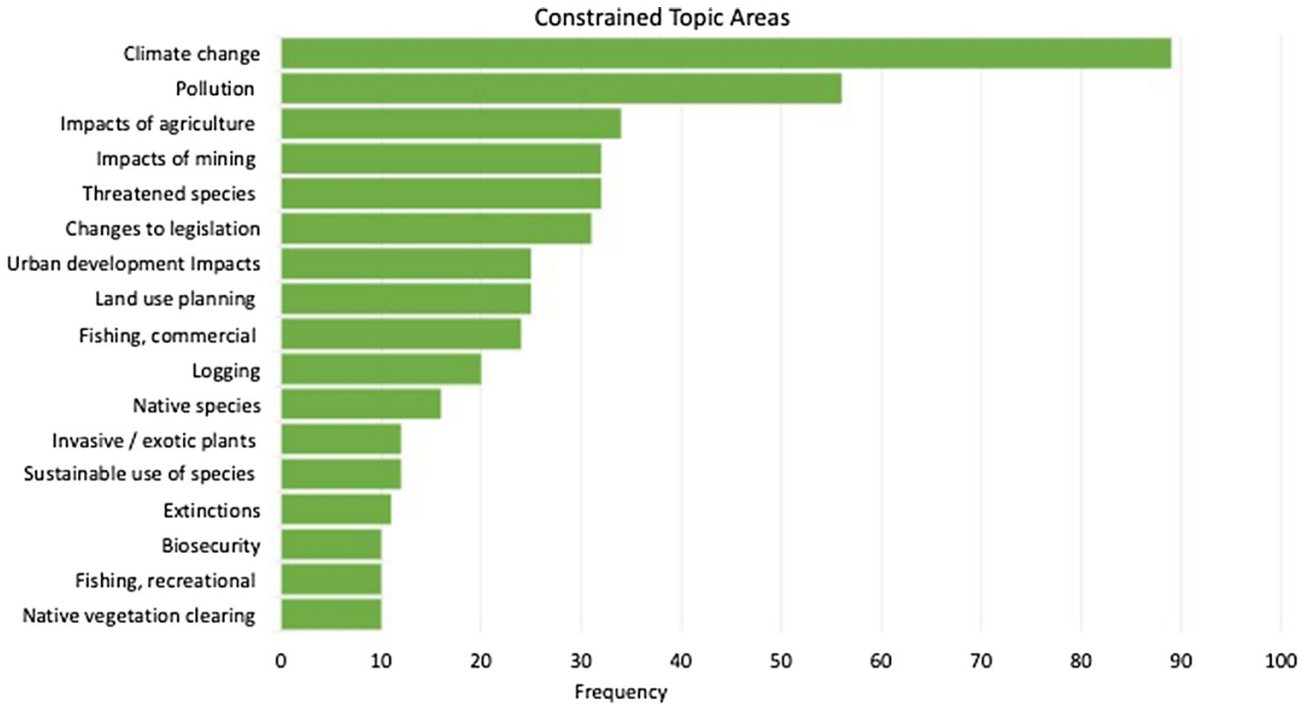


Table 2. Coded responses for Q18: job satisfaction. How was your job satisfaction affected by restraints on public commentary and peer communication? ($n = 129$).

Factors affecting researcher job satisfaction	Example	*N*	Percent
Muzzling (constraints or restrictions to communication)	"Unable to communicate directly with the public in many situations, including scientific data results (trends). Feel that this has led to mistrust in government scientists and programs from the public. Undermines the validity of science. Politics is more important than the data"	63	30
Poor internal working conditions	"I have experience bullying by a senior scientist for most of our tenure with the present organization. Middle and senior management, despite efforts via unofficial and official routes to solve the issue has lead to harassment from our middle management support/ignored by senior management"	56	26
Unable to express authentic views	"The fear of how our peers would judge me has limited our potential to speak about issues that we believe (and know) to be important to ecological processes"	22	10
Work is redundant, pointless, or invaluable	"Why am we here if no one cares enough to listen to our evidence, despite 10–25 years of research?"	18	8
Career development opportunities lost	"Career advancement as a scientist within our organization requires that we participate in media interviews and act as a provincial spokesperson on issues, both of which we are prevented from doing by ministerial policy and upper management"	15	7
Working conditions are good or better	"Prior to 2016, there was more fear around being critical of the government. Now there is an emphasis on open data and transparency. Publishing is more encouraged, supported, and funded"	11	5
Insufficient resourcing to conduct work	"[ability to] Conduct [work] is a question of resources (ppl doing the work, and paying people to do the work), and those have not risen for decades, even though the costs did"	10	5
Considered changing field/career/position	"I have taken leaves due to stress and have recently left our position at the government for this reason"	9	4
Undue modifications	"While researching with colleagues at Environment Canada, the publication of research was substantially…modified due to the levels of approval required by the federal government. This added undue stress and made publication more difficult"	5	2
Total		**209**	**100**

Table 3. Coded responses for Q21: policy impact. Has the implementation of the scientific integrity policies had an impact on researchers' ability to conduct and communicate research? ($n = 203$).

Impact of the implementation of the scientific-integrity policies	Example	*N*	Percent
Yes, our ability to conduct and communicate has improved	"Yes a very positive impact. Federal government scientists in particular are much better supported and protected in their ability to comment publicly on their work. Since these policies were implemented the instances of interference have greatly declined"	86	41
No, no impact	"Having nice lofty policies is one thing, but actual enforcement where the "rubber hits the road" is another. We have personally seen no change"	28	13
Unsure/we don't know/not that I am aware of	"I am not sure—we have not seen any data to support this one way or the other"	27	13
Political interference is ongoing	"No substantial effect at present. This was mainly a response to abuses that occurred during the Harper administration…"	26	12
	There are more subtle influences that constrain scientific communication that persist and have not been addressed: for example, the increased emphasis on partnership funding programs that give commercial interests a say in what is published or communicated to the broader public"		
Too soon to say	"I think it's still a bit early to determine the wider consequences of the policies, but we think in time it will have a significant impact on the ability of researchers to conduct and communicate research"	11	5
Funding as a source of constraint	"To some extent but not fully. The funding agencies control the ability to conduct research in Canada"	7	3
Uneven impact or application	"I don't know how the implementation of those policies has affected researchers who are working directly for the federal government (e.g., Fisheries & Oceans, ECCC, etc.), but it certainly hasn't prevented provincial governments from inhibiting environmental research"	6	3
Total		**191**	**100**

by 12%, and a further 12% mentioned having engaged in some form of self-censorship.

Impacts of scientific integrity policies on interference in science

The scientific integrity policy model introduced in 2018 likely only impacted researchers employed by the federal public service. The majority (69%) of our respondents were not aware of Canada's recently introduced federal Scientific Integrity Policies (Q20). Of the 31% who said they were aware of the policies, 41% indicated the policy improved researchers' ability to conduct and communicate scientific research; however, 12% identified ongoing political interference (Table 3). Open-text responses (Q21) indicate that perceptions of interference have changed since the change of federal governance in 2015 (from conservative to liberal leadership). Thirteen percentage of the respondents who were aware of the policies believed the policy had no impact or were unsure, while another 5% believe it is too soon to say (Table 3).

Difference of experience of interference in science

Results demonstrated that fear of the media differs by career stage ($F(689,2) = 5.81$, $p < 0.01$). Specifically, early-career researchers ($n = 220$, $m = 3.15$) reported significantly more fear of the media than retired researchers ($n = 36$, $m = 2.51$). Fear of negative career consequences for engaging in public commentary ($F(643,2) = 28.51$, $p < 0.01$) was also higher among early-career researchers ($n = 220$, $m = 2.56$) than it was for established career researchers ($n = 422$, $m = 1.91$). No significant differences were observed in the experience of fear of the media or negative career consequences for engaging in public commentary based on the province/territory, research area, or scientific society membership. Across all demographic comparisons (province/territory, research area, scientific society membership, and career stage), there were no significant differences observed in researchers' experiences of undue modification, ability to conduct or communicate research, sources of interference, or job satisfaction (see Appendix A).

Discussion

Our research documents the perceptions of environmental researchers living in Canada and working in environmental studies and environmental sciences several years after the end of the "war on science" (Ghosh 2012; Turner 2013). Since the election of a Liberal government in 2015, conditions for researchers have improved compared to the 2011–2014 period characterized by interference. However, survey responses indicate political interference with researchers' ability to conduct and communicate their work is ongoing to some degree, and environmental risks are sometimes masked to protect political and corporate interests. Respondents indicated that interference in science does have negative consequences for the environment and for science communication that could otherwise facilitate effective knowledge exchange between knowledge producers and users, including decision-makers and the public. This interference and the

associated environmental ramifications are perpetrated primarily by managerial bodies internal to the researchers' organization and research partners external to their organizations. However, our survey found the largest impacts reported by researchers in the survey were, in fact, on the researchers themselves. In particular, early-career researchers reported greater fear of the media and of negative career consequences for engaging in public commentary, which can lead to self-censoring behaviours and potentially widen the science–policy gap in Canada by preventing the free flow of information (Bar-Tal 2017).

A limitation of the study is that no data are available to objectively verify the motivation of those who are perceived by our population to be the "cause" of interference in the conduct or communication of science. Their motivations may be nefarious (e.g., intentional prevention of communication about politicized topics) or may be incidental (e.g., budget cutbacks resulted in reduced funding for research projects). In other words, it is likely that there are legitimate and illegitimate forms of interference reported in the survey, but our ability to distinguish between the two is limited because of the subjectivity of self-reported experiences. Distinguishing these factors would require investigating each alleged instance of interference from multiple sides, which we have not endeavoured to do. In interpreting the study's findings, it is important to understand these results as an example of how a wide array of environmental researchers have perceived interference in its many forms from a variety of sources. Given our methodological approach, our results may not generalize to all Canadian environmental researchers and may overrepresent individuals who have experienced interference.

Drivers of interference in science

Constraints on communication were defined as "any pressure applied to deter public or political engagement or provision of information or commentary in areas that you are scientifically knowledgeable". Respondents indicated that they experienced this type of constraint on communication on climate change, pollution, and the environmental impacts of a broad range of industries. These findings are consistent with reported concerns in Canada related to impact assessment for scientific research conducted in the public sector and industry-led research (Paskett et al. 2011; Office of the Ombudsperson of British Columbia 2014; Maclean et al. 2015; Smith et al. 2017; Haddock 2018; Jacob et al. 2018; Westwood et al. 2019). Constraints on related topics, including climate change, pollution, oil and gas extraction, natural resource development and reliance, energy, and species at risk (Q14), differ slightly from those most frequently mentioned in Driscoll et al. (2021) but are congruent with media reports in Canada from 2012 to 2013 (Ghosh 2012; May 2012; Turner 2013).

An explanation for the rejection of funding or change of research focus could be found in the democratization of science, which has increased the opportunity for the public to voice their opinion on which societal problems require an attention (Funtowicz and Ravetz 1993; McNie 2007; Douglas 2012). Our survey respondents who experienced undue modification to their work indicated that modifications were requested because of political motivations, for example, to justify existing laws, policies, and regulations that allow resource development to continue despite the negative environmental consequences (Q11). For example, one respondent stated (Table 1): "Managers & co-workers frequently asked me to downplay risks of oil and gas projects to increase the chances of projects being funded".

Similar reports emerging in Australia indicate that funding agencies may be exhibiting detrimental biases against researchers, particularly those working in "fundamental research areas" (Mannix 2022). Research laboratories and academic institutions in Australia and Canada rely substantially on federal funding agencies. The interests of these agencies were perceived by some in our study to be implicitly aligned with the federal government and industry. For instance, in response to Q18, one respondent said that in Canada (Table 2), "Public opinion or ideas other than scientific facts are taken/used by politicians, then became a policy or funding theme [that] constrains and affect[s] our research advancement steering [it] towards these ideas". Other survey respondents believe that funding agencies have rejected research proposals because they may uncover evidence contradicting industry-preferred findings on environmental impacts. For example, in response to Q11 (Table 1), one participant stated, "Department Chair… [and] Dean of Science… [interfered], because [their] findings were deemed too unflattering for the provincial government, which provides funding for [their] institution [and] because the findings were contrary to the claims made by the provincial government".

Navigating interference in science communication

Constraints and undue modification to scientific research and evidence result in an ill-informed public and ill-informed decision-makers (McNie 2007; Douglas 2012; Hahn 2019; Heer et al. 2021). Therefore, we deem it concerning that 24% of surveyed researchers agreed that they are aware of cases where their organization has suppressed or declined to release information and such actions led to incomplete, inaccurate, or misleading impressions by the public, regulated industry, the media, and/or government officials (Q8). In response to Q11, one researcher explained, "I am aware that some government environmental organizations have [been] forced to release only part of the research results to support a concept/bylaw which they wanted to introduce" (Table 2).

Issues with researchers' capability to communicate scientific work that is accurate and timely were more frequently anecdotally reported in Canadian media between 2012 and 2014 (Turner 2013; Learn 2017). However, issues may be ongoing for the 30% of surveyed researchers who described experiences with muzzling, restrictions on communication, and constraining factors that affected their job satisfaction. One respondent said they believe their inability to communicate directly "has led to mistrust [i]n government scientists…[and…undermines the validity of science" (Table 3). In the survey, 14% of respondents said that they had been asked to make undue modifications to their work by internal or external communications personnel (Q11). Several described

frustration with having to work with communications staff who did not share their expertise, which can result in the miscommunication of evidence to the public or to decision-makers who act upon it. For example, one respondent indicated, "Our Communications Officer has modified the content and the context of research findings for the purpose of external communications. Partly it's due to incompetence about what the research [that] myself (and [my] colleagues) do (and of course what our research actually means)".

Communications personnel may not be ill-intended when fulfilling their role to communicate scientific research in ways that are most relevant and accessible to a general audience. And yet, issues arise when findings are inaccurately presented, leading to misconceptions or the dissemination of misinformation. Differentiating this kind of miscommunication, or in some cases, the spread of disinformation, from politically motivated interference in science is not always an easy task.

Fear and self-censorship in environmental research

Incidents of self-censorship have been reported in the United States (Carter 2019) and Australia (Driscoll et al. 2021), where it is found to be a primary factor constraining scientists from offering public commentary. Consistent with findings from Carter (2019) and Driscoll et al. (2021), our survey respondents shared a fear of the media and of negative career consequences that lead to self-censoring of public commentary (e.g., response to Q18 (Table 2): "I have been publicly attacked because of our research and media experiences. Our student had to deactivate her Twitter account because of harassment"). Just over half of the sample (52%) agreed that fear of how they may be represented by the media was a factor constraining their public commentary (Q16). Specifically, participants indicated fear of being drawn to comment beyond the boundaries of their expertise and stress around discussing contentious issues, consistent with Australian respondents (Driscoll et al. 2021).

Our research reveals that early-career researchers in Canada experience the highest rates of fear and self-censoring behaviours. This was contrary to our expectation that higher rates of fear would be present among researchers working in the field before 2015, under a Conservative government infamous for inciting the "war on science" in Canada (Ghosh 2012; Turner 2013). However, it is also likely that the precarity of one's position as an early-career researcher, having held a position in the field for 5 years or less, could explain self-censoring behaviours. Another potential explanation for increased fear and self-censorship experienced by early-career researchers is the increasingly polarized media environment and the compounding effects of negative psychological impacts associated with working in the environmental research sciences, because of the exposure to difficult truths about the current sustainability and survivability of the planet, leading to researchers' environmental grief (Gilford et al. 2019).

Environmental and climate research is perceived by respondents from our survey (and by environmental professionals represented in Gilford et al. (2019)) as sometimes redundant or hopeless (Q18) because of the government's ineffectiveness in implementing adequate environmental protections through law, policy, and industry regulations. One survey respondent shared, "It was disheartening to learn that it was more important to some project partners to appear to have done a good job, then to actually do a good job—especially since this need for a positive spin would have come at a cost of Species at Risk protections if the data from the study was ignored or suppressed". Evidence suggests that the combined challenges of needing to engage in self-advocacy, conducting scientific work, and being responsible for effectively communicating the findings cause emotional strain on researchers (Gilford et al. 2019). In many cases, this stress can lead to increased environmental grief, anxiety, self-doubt, and negatively charged emotions (Gilford et al. 2019), potentially contributing to the sense of fear and uncertainty while engaging with public commentary (Q16) that then results in researchers' self-censoring. Conversely, the ability to make a difference and enjoying the experience are consistent predictors of the likelihood of scientists engaging with the public (Besley et al. 2018).

Evaluating federal policy

Almost half of the survey respondents who are aware of the scientific integrity policies (Q20) believe that their implementation has improved researchers' ability to conduct and communicate research (Q21) and indicated improvements for researchers (Q21) after the federal election in 2015. The elected Liberal government at the time promised to "ensure that government science is fully available to the public, that scientists can speak freely about their work, and that scientific analyses are considered when the government makes decisions" (Liberal Party of Canada 2019). It is evident that conditions for Canadian researchers have improved since the end of the "war on science", but there are competing opinions on the impact of the scientific integrity policies themselves. One respondent explained (Table 3) that "the ability of researchers to communicate research improved most notably between the Harper and Trudeau governments, less so from what I've seen with the implementation of any specific Trudeau government policy".

A way forward

Our results suggest that fear of the media is a substantial problem, especially for early-career researchers. This could be rectified by providing more comprehensive science communication training to early-career researchers, as well as more broad social efforts to combat the void, filled by fake news or misinformation, that impacts democratic decision-making (Driscoll et al. 2021; Heer et al. 2021). Training other organizational staff members on communicating scientific evidence in non-specialist terms (Lester and Foxwell-Norton 2020) could also reduce contentions with communications personnel reported by the researchers surveyed. We also concur with recommendations made by Gilford et al. (2019), who suggest that early-career researchers in environmental studies and sciences, in particular, should be supported by peers

and their institutions to mitigate environmental grief, anxiety, and hopelessness. This may preserve their motivation and engagement, which are vital to the continued production and sharing of knowledge (Gilford et al. 2019).

As recommended in previous research (Jacob et al. 2018; Westwood et al. 2019; Driscoll et al. 2021), authorities independent of government and industry could also be mandated to prevent interference in science and foster enhanced scientific integrity and science communication. The United States task force documenting instances of improper political interference in science (Malakoff 2021) is an example of how accountability can be increased. Overall, better communication and the involvement of unbiased authorities could help restore and maintain the trust in science needed to move forward.

Future research

In other parts of the world, more extreme cases of interference are being experienced than those documented in Canada. For example, environmental researchers in Iran have been arrested (Catanzaro 2019). In Brazil, researchers have experienced break-ins, theft of private property, and attempted kidnappings (Torres 2021). Reports of interference, albeit to lesser extremes, also increased in the United States in the past 5 years (Goldman et al. 2017; Lin 2018; USC 2018; Waters 2018; Carter 2019; Sullivan 2020; Desikan and Carter 2023) before investigations into political interference in science were initiated in 2021 (Malakoff 2021). In Australia, researchers have witnessed increased funding for engineering, technology, and experimental development research. In contrast, funding allocated to fundamental research and the natural sciences has taken a nosedive compared to 20 years ago (Mannix 2022). Still, little is known about the other forms and prevalence of scientific interference that occur in unstudied parts of the world.

In Canada, extreme and life-threatening consequences are not an imminent risk for environmental researchers, and there is more freedom for researchers to communicate their work. Still, interference—from both internal and external sources—is ongoing and has a range of undesirable consequences for researchers' well-being and environmental health. We recommend that interference in science be regularly studied using a bilingual survey and defined time frames. Future work should also consider how both the conduct of science and science communication can be constrained or otherwise affected. Workplace and social identity demographics (Chu et al. 2023) of environmental researchers should also be documented to provide more insight into the circumstances that lead to changes in the extent and severity of interference in science.

Conclusion

Our study demonstrates that interference in science occurs widely and comes from a variety of sources, affecting a broad array of scientists in different contexts. The perception of our survey respondents is that interference is ongoing in Canada and is particularly severe for early-career researchers. Some improvements have been made in the last decade to strengthen scientific integrity and free environmental researchers to communicate their results, particularly by Canada's federal government, through the scientific integrity policy model. However, the masking of environmental impacts to protect damaging policies and industries, as well as threats to researchers' careers, lingers. Environmental researchers contribute valuable information that can support decision-making on the part of the public and the elected officials responsible for representing public interests. Yet, fundamental research is not always prioritized, fully disclosed, or allowed to be conducted. Ongoing constraints leading to the erosion of democratic processes, environmental consequences, and negative impacts on researchers' mental health and job satisfaction are cause for concern. Historically, interference in science that erodes democratic processes (Turner 2013; Driscoll et al. 2021) can also result in poor environmental management decisions that can lead to further environmental degradation (Anbleyth-Evans and Lacy 2019), as well as personal consequences for the career progress and mental health of researchers. Researchers must be sufficiently resourced to meet research objectives and be supported when communicating their findings. We acknowledge that protecting scientific integrity and "freedom" for environmental researchers to conduct scientific work and communicate results does not ensure that knowledge exchange will be effective, nor does such protection guarantee pro-environmental decision-making in the future. What such protection can achieve, however, is support for democratic processes by enabling the public to form evidence-based opinions and influence government action.

Acknowledgements

This research study was predominately conducted at Dalhousie University, which occupies the unceded lands of K'jipuktuk, in Mi'kma'ki, the ancestral and contemporary land of the Mi'kmaq people. Significant support in project development was provided by Dr. Heather Cray, Dr. Alexander Engau, Dr. Bertrum MacDonald, and Dr. Kate Sherren, whose diverse disciplinary insights contributed to the interdisciplinary approach taken on this project. This research would not have been possible without the financial resourcing provided by the Partnership Engage Grant from the Social Sciences and Humanities Council of Canada (PI: Dr. Alana Westwood), internal funding from Dalhousie University (Dean's Collaboration Grant) (co-PIs Dr. Alana Westwood, Dr. Philippe Mongeon), and a Nova Scotia Graduate Scholarship fund allocated to Manjulika E. Robertson. Thank you to both the anonymous reviewers and the subject editor, whose thorough revisions and suggestions enabled us to present the best version of the research study. Per the approved ethics application, raw data are to be destroyed after 2 years, but the aggregated data are available as supplementary material.

Article information

Editor

Bethann Garramon Merkle

History dates
Received: 13 January 2023
Accepted: 17 July 2023
Version of record online: 30 November 2023

Notes
The article was originally published with minor errors (typographical error on page 6) that have now been corrected.
This paper is one of two companion papers published in this issue of FACETS. (Chu et al. 2023. FACETS. This issue. doi: doi.org/10.1139/facets-2023-0006).

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Competing interests
The authors have no competing interests to disclose.

Positionality statement of the lead author
As a young, mixed-race woman early in her career and as a researcher in environmental studies and science, I have personal experience in a number of the areas discussed in my research. I have lived in several provinces across Canada and worked in academia, the private sector, and as a federal civil servant. My background in political science, communication, and training in equity, diversity and inclusion has uniquely positioned me to take on this specific research project and contribute my expertise to the vital conversation on improving our methods of environmental protection and preservation with effective communication. This research was carried out in alignment with values stated on the Westwood Lab website (www.westwoodlab.ca).

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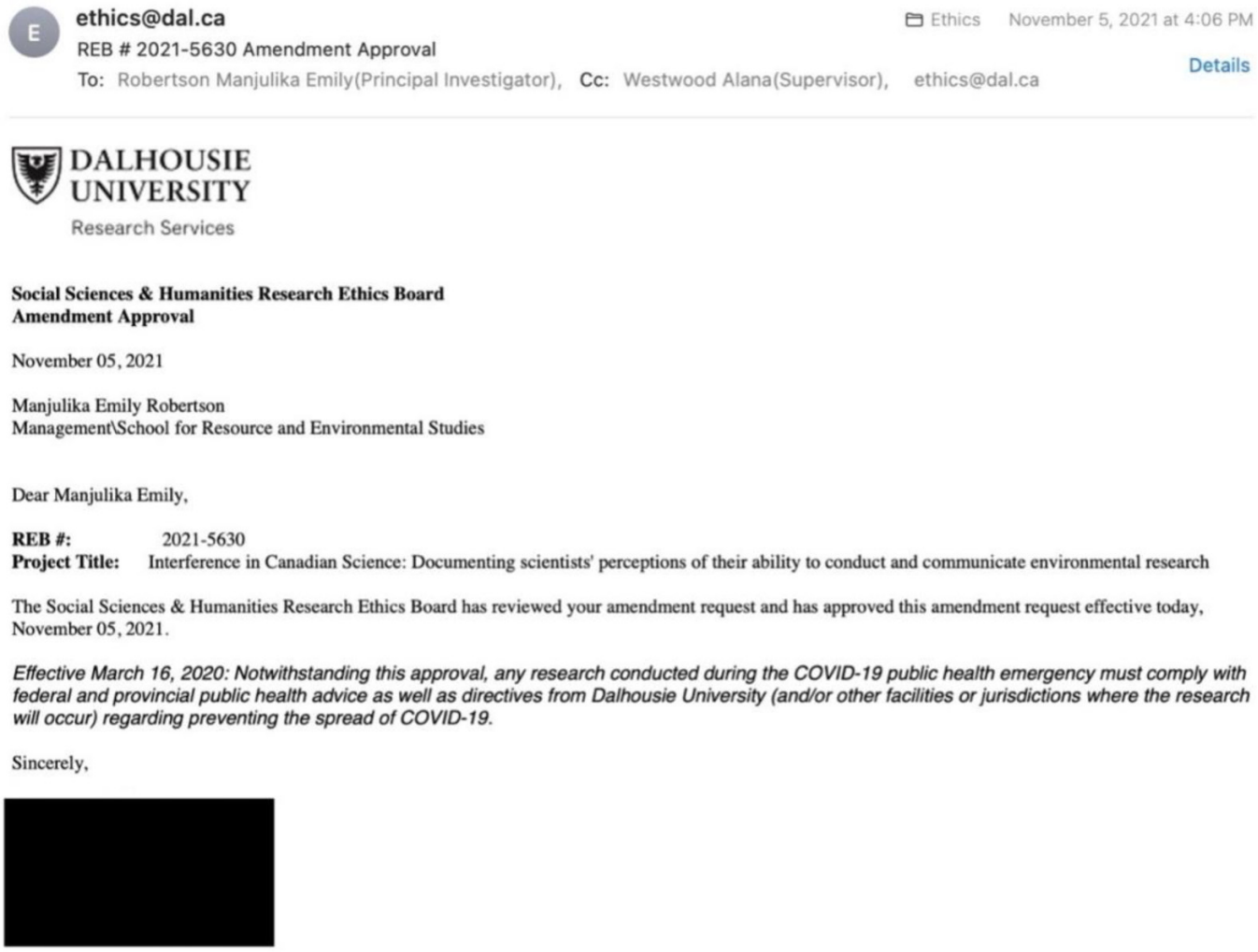
APPENDIX A

Ethics approval

Fig. A1

Fig. A1. Ethics approval from Dalhousie University, 2021.



ethics@dal.ca
Ethics November 5, 2021 at 4:06 PM
REB # 2021-5630 Amendment Approval
To: Robertson Manjulika Emily(Principal Investigator), Cc: Westwood Alana(Supervisor), ethics@dal.ca
Details

DALHOUSIE UNIVERSITY
Research Services

Social Sciences & Humanities Research Ethics Board
Amendment Approval

November 05, 2021

Manjulika Emily Robertson
Management\School for Resource and Environmental Studies

Dear Manjulika Emily,

REB #: 2021-5630
Project Title: Interference in Canadian Science: Documenting scientists' perceptions of their ability to conduct and communicate environmental research

The Social Sciences & Humanities Research Ethics Board has reviewed your amendment request and has approved this amendment request effective today, November 05, 2021.

Effective March 16, 2020: Notwithstanding this approval, any research conducted during the COVID-19 public health emergency must comply with federal and provincial public health advice as well as directives from Dalhousie University (and/or other facilities or jurisdictions where the research will occur) regarding preventing the spread of COVID-19.

Sincerely,

[redacted]

Research instruments

Consent form

DALHOUSIE UNIVERSITY

CONSENT FORM

[REB #2021-5630 v1.0. Approved June 23, 2021]

Who is conducting this study? This research study is being conducted by Manjulika E. Robertson (MES Candidate) and Dr. Alana Westwood (Assistant Professor) at the School of Resource and Environment Studies at Dalhousie University. The research is primarily funded by Dalhousie University through the Dean's Collaborative Research Grant.

What is the study about? The purpose of this study is to document the ability of researchers in environmental studies and sciences to conduct and communicate their scientific research. The study is funded by Dalhousie University.

What do we have to do? If you choose to participate, you will be asked to anonymously answer questions to inform the research team about your perspectives on interference with research in environmental sciences or studies. We will also ask for your demographic information.
All responses are anonymous.

Is our participation voluntary? Your participation in this research is entirely your choice. There are no right or wrong answers; our aim is to understand your perspective on the issue of interference. Excerpts from responses to long-form survey questions may be used in the report, but only if the information could not possibly reveal the identity of the response author. You may choose "prefer not to answer" where applicable, and may stop the survey at any time by closing the browser window. Recorded responses cannot be deleted after submitting the survey as they are anonymous. If you do not submit your responses by clicking "Submit" at the end of the survey, your responses will be deleted from the data set.
The survey should take approximately 25–30 min to complete.

What will happen to our responses? The findings of the research will be shared anonymously and in aggregate via theses, peer-reviewed papers, summary graphics for social media, news releases, and presentations. Your demographic data may also be shared with the scientific societies that you indicate membership in if they disseminated the survey to you and requested the data in exchange. Aggregate findings for particular identity groups will only be shared if there are a minimum of 10 respondents in that category. All data will be kept indefinitely in secure storage (locked hard drives) for the possibility of being re-analyzed in the future as part of longitudinal research.

Are there any risks? The risks associated with this study include potential emotional distress in recalling and recounting experiences with interference to your scientific work that may have been negative or traumatizing. If you experience this, we recommend reaching out to your organization's Employee Assistance Program if applicable, or using the following services to seek counselling and support.

Canadian Mental Health Association (613)-549-7027
Crises Help Line (CAN) 1-800-233-4357

What are the benefits? There will be no direct benefit to you from participating in this research. The research, however, might contribute to new knowledge on the prevalence and impacts of interference in science in Canada. Participating in the research study ensures that your perspective is included in the case that the research is successfully mobilized to impact the training, programs, and policy of science advocacy groups and governments. If you are interested in receiving direct communication about the results of the research or being involved in future research, you will have the option to confidentially provide your email address to the research team via an external form, which will be in no way connected to your survey responses.

What about compensation? To thank you for your time, you may choose to enter a draw for a chance to win one of three $50 gift cards to an online store of your choice or donate to the organization/charity of your choice upon completing and submitting the survey. Your contact information for the draw will not be linked in any way to your survey responses.

Where can we direct our questions? You should discuss any questions you have about this study with Dr. Alana Westwood and Manjulika E. Robertson. Please ask as many questions as you like before or after participating by contacting woodlab@dal.ca. If

you have any ethical concerns about your participation in this research, you may contact Research Ethics, Dalhousie University at (902) 494-3423, or email ethics@dal.ca (and reference REB file # 2021-5630)".

If you consent to participate, please click "I consent" below.

Consent to participate

- ○ I consent. (continue to initial survey)
- ○ I do not consent. (exit study)

Survey

Page 2: Screening questions

1. Do you identify as a researcher in environmental studies or sciences?
   - ○ Yes
   - ○ No
2. Are you currently working/employed in the field of environmental studies or sciences?
   - ○ Yes
   - ○ No
3. In what Canadian province or territory do you predominantly conduct your work?
   - ○ British Columbia
   - ○ Alberta
   - ○ Saskatchewan
   - ○ Manitoba
   - ○ Ontario
   - ○ Quebec
   - ○ New Brunswick
   - ○ Nova Scotia
   - ○ Prince Edward Island
   - ○ Newfoundland and Labrador s
   - ○ Northwest Territories
   - ○ Nunavut
   - ○ Yukon

Page 3: Scientific/Work demographics

4. Please indicate your primary areas of research or your discipline(s).
   You may select up to three of the following:
   - ☐ Civil, Industrial, and Systems Engineering
   - ☐ Chemical, Biomedical, and Materials Science Engineering
   - ☐ Mechanical Engineering
   - ☐ Electrical Engineering
   - ☐ Computing Sciences
   - ☐ Mathematical Sciences
   - ☐ Physics and Astronomy
   - ☐ Chemistry
   - ☐ Geosciences
   - ☐ Evolution and Ecology
   - ☐ Cellular and Molecular Biology
   - ☐ Plant and Animal Biology
   - ☐ Psychology
   - ☐ Other
5. Please indicate the full names of all the scientific societies where you hold membership. If there is more than one, separate the names using semi-colons.
   Open Text Response
6. What career stage are you in?

- Early-career researcher: first employed as a researcher (inclusive of postdocs) after 2015
- Established researcher: first employed as a researcher before 2015
- Retired

Page 4: Interference in Science Part 1: Political Interference in Conducting Research

Please indicate your agreement with the following statements on a scale of 1–5 (1: Strongly disagree, 2: Somewhat disagree, 3: Neither agree nor disagree, 4: Somewhat agree, 5: Strongly agree, 6: Not applicable).

7. I am aware of cases where the health and safety of Canadians (or environmental sustainability) have been compromised because of political interference with scientific work at our organization.
8. I am aware of cases where our organization has suppressed or declined to release information and where this has led to incomplete, inaccurate, or misleading impressions by the public, regulated industry, the media, and/or government officials.
9. I am aware of cases where the exchange or transfer of knowledge based on scientific evidence for the purpose of developing policy, law, and/or programs at our organization has been compromised by political interference.
10. Have you ever experienced "undue modification" to your work by your organization, such as substantive changes to a text or story that downplay, mask, or include misleading information about environmental impacts?
    - Yes
    - No
    - Unsure
11. If yes, who asked you to make the modifications and for what reason?
    Open Text Response

Page 5: Interference in Science, Part 2: Muzzling and communicating research

Please indicate your agreement with the following statements on a scale of 1–5 (1: Strongly disagree, 2: Somewhat disagree, 3: Neither agree nor disagree, 4: Somewhat agree, 5: Strongly agree, 6: Not applicable).

12. I am allowed by our organization to speak freely and without constraints to the media about our research in environmental studies or sciences.
13. I have received a question from the public or media that we have the expertise to answer but have been prevented from doing so by our organization.
14. Please indicate which topic areas you have experienced constraints on communication, in mainstream or social media, from your organization/present workplace. (check only those options that are applicable).
    "Constraints on communication" refers to any pressure applied to deter public or political engagement, or provision of information or commentary in areas that you are scientifically knowledgeable.

    ☐ 1 = Biosecurity
    ☐ 2 = Climate change
    ☐ 3 = Native species that some consider pests
    ☐ 4 = Extinctions
    ☐ 5 = Feral animals
    ☐ 6 = Invasive/exotic plants
    ☐ 7 = Firewood collection
    ☐ 8 = Fishing, commercial
    ☐ 9 = Fishing, recreational
    ☐ 10 = Hunting
    ☐ 11 = Impacts of agriculture
    ☐ 12 = Impacts of mining
    ☐ 13 = Impacts of urban development
    ☐ 14 = Indigenous land management
    ☐ 15 = Land use planning
    ☐ 16 = Logging
    ☐ 17 = Native vegetation clearing
    ☐ 18 = Pets

- ☐ 19 = Pollution
- ☐ 20 = Sustainable use of native species
- ☐ 21 = Threatened species
- ☐ 22 = Changes to legislation or policy
- ☐ 23 = Other (please list)
- ☐ 24 = We have not experienced any constraints

15. Please explain the nature of these constraints (optional).
Open Text Response

16. Please indicate your agreement with the following statements on a scale of 1–5 (1: Strongly disagree, 2: Somewhat disagree, 3: Neither agree nor disagree, 4: Somewhat agree, 5: Strongly agree, 6: Not applicable).
Our public commentary in areas where I am scientifically knowledgeable is constrained by.
"Public commentary" refers to any information contributed in interviews with media and media statements or editorials, including social media. By "knowledgeable", we mean having enough knowledge to be able to make a professionally informed contribution to public debate.]

1 = Our belief that scientists have no role in making public commentary beyond information provision
2 = Our concern about how we may be represented by the media
3 = Our fear of being drawn to comment beyond the boundaries of our expertise
4 = Our uncertainty about the boundaries of our expertise
5 = Our belief that our primary obligation is to our organization, rather than to the public
6 = Our stress around discussing contentious issues
7 = Our fear of risking funding opportunities
8 = Our fear of being made redundant
9 = Our fear of reducing opportunities for advancement
10 = Our workplace colleagues/peer pressure/work culture
11 = Our workplace policy
12 = Our middle management
13 = Our senior management
14 = The Minister's office

17. Has your job satisfaction ever been affected by restraints on public commentary and peer communication?
- ○ Yes
- ○ No
- ○ Unsure

18. If yes, please briefly explain how your job satisfaction was affected.
Open Text Response

Page 6: Interference in Science Part 3: policy changes and impacts

19. How would you define the term "interference in science"?
Open Text Response

20. Are you aware of the scientific integrity policies implemented in Canadian federal government departments by 2019?
- ○ Yes
- ○ No

21. If yes, do you feel that the implementation of these policies has had an impact on the ability of researchers in the environmental sciences and studies in Canada to conduct and communicate research? Please explain.
Open Text Response

Page 7: Demographics

22. How do you identify your gender?
- ○ Woman
- ○ Man
- ○ Non-binary
- ○ Prefer not to say
- ○ *Text Fill*

23. Would you describe yourself as transgender?
    - ○ Yes
    - ○ No
    - ○ Prefer not to say

24. Do you identify as a member of any marginalized group in terms of sexual orientation? (LGBQ2S+)
    - ○ Yes
    - ○ No
    - ○ Prefer not to say

25. How do you identify in terms of racial and ethnic identity (select all that apply)?
    - ☐ Black, African-Canadian, person of African descent
    - ☐ Indigenous (First Nations, Inuit, Metis)
    - ☐ East Asian (including Chinese, Japanese, Korean, etc.)
    - ☐ South Asian (including East Indian, Indian from India, Pakistani, Sri Lankan, Bangladesh, East Indian from Guyana, East Africa, Trinidad, etc.)
    - ☐ South East Asian (including Burmese, Cambodian, Filipino, Laotian, Thai, Vietnamese, etc.)
    - ☐ Non-White West Asian
    - ☐ North African or Arab (including Afghan, Armenian, Algerian, Egyptian, Iranian, Israeli, Lebanese, Libyan, Palestinian, Syrian, etc.)
    - ☐ Non-White Latin American (including indigenous persons from Central and South America, etc.)
    - ☐ Pacific Islander
    - ☐ White Canadian or of White European descent
    - ☐ Prefer not to disclose

26. How are you typically perceived in terms of racial and ethnic identity (select all that apply)?
    - ☐ Black, African-Canadian, person of African descent
    - ☐ Indigenous (First Nations, Inuit, Metis)
    - ☐ East Asian (including Chinese, Japanese, Korean, etc.)
    - ☐ South Asian (including East Indian, Indian from India, Pakistani, Sri Lankan, Bangladesh, East Indian from Guyana, East Africa, Trinidad, etc.)
    - ☐ South East Asian (including Burmese, Cambodian, Filipino, Laotian, Thai, Vietnamese, etc.)
    - ☐ Non-White West Asian
    - ☐ North African or Arab (including Afghan, Armenian, Algerian, Egyptian, Iranian, Israeli, Lebanese, Libyan, Palestinian, Syrian, etc.)
    - ☐ Non-White Latin American (including indigenous persons from Central and South America, etc.)
    - ☐ Pacific Islander
    - ☐ White Canadian or of White European descent
    - ☐ Prefer not to disclose

27. Do you identify as an individual living with a disability (select all that apply)?
    - ☐ Yes, visible
    - ☐ Yes, invisible
    - ☐ No
    - ☐ Prefer not to say

28. In your workplace do you wear a visible signifier of a religious affiliation (e.g., hijab, cross, kippah)?
    a. Yes
    b. No
    c. Prefer not to answer

29. Do you believe that your identity and/or demographics have influenced your experiences with interference in your research?
    - ○ Yes
    - ○ No
    - ○ Unsure

30. Please explain why or why not (optional).
    Open Text Response

31. Is there anything not covered in the survey questions that you would like us to know?
    Open Text Response

Submit

Page 8: Survey Debrief
Thank you for completing the survey.
If you are interested in entering a draw to win one of three $50 gift cards or to indicate interest in being informed of the research results, follow the link below to our follow-up survey.

[INSERT LINK TO FOLLOW-UP SURVEY]

If you found any of the survey content to be emotionally distressing, please consider contacting the Employee Assistance Program designated to you by your workplace or reaching out to either of the resources listed below.

Canadian Mental Health Association (613) 549-7027
Crises Help Line (CAN) 1-800-233-4357

If you have any further questions, you can reach out via email at woodlab@dal.ca
Sincerely,
Manjulika E. Robertson on behalf of the Westwood Lab
School for Resource and Environment Studies
Dalhousie University, Halifax (K'jipuktuk), Nova Scotia
www.westwoodlab.ca

Alternative survey ending

Thank you for your interest in the study. Unfortunately, your responses do not qualify you to further participate in the survey.

If you have any questions, you can reach out via email at woodlab@dal.ca

Sincerely,
Manjulika E. Robertson on behalf of the Westwood Lab
School for Resource and Environment Studies
Dalhousie University, Halifax (K'jipuktuk), Nova Scotia
www.westwoodlab.ca

Data analysis

Chi-squared tests

Q17 Job satisfaction

Variable *Group comparison*	*n*	X-squares	Degrees of freedom	*p*-Value
Q17. Job satisfaction		0.04	1	0.83
Early	236			
Established	469			
Q17. Job satisfaction		1.72	2	0.42
Early	215			
Established	425			
Retired	38			
Q17. Job satisfaction		19.24	12	0.08
British Columbia	133			
Alberta	73			
Saskatchewan	32			
Manitoba	29			
Ontario	240			
Quebec	99			
New Brunswick	20			
Nova Scotia	57			
Prince Edward Island	6			
Newfoundland and Labrador	19			
Northwest Territories	7			
Nunavut	6			
Yukon	2			
Q17. Job satisfaction		10.78	5	0.05
Ontario	227			
Prairies	124			
British Columbia	124			
Quebec	95			
Maritimes	95			
Territories	13			
Q17. Job satisfaction		0.08	1	0.76
Affiliated	558			
Unaffiliated	120			
Q17. Job satisfaction		4.88	6	0.55
Natural sciences	463			
Engineering	47			
Medicine	20			
Agriculture and veterinary sciences	15			
Social sciences	52			
Humanities and the arts	1			
Multidisciplinary	76			
Q17. Job satisfaction		3.46	5	0.62
Natural sciences	537			
Engineering	51			
Medicine	38			
Agriculture and veterinary sciences	24			
Social sciences	70			
Humanities and the arts	3			

Q10 Undue modification

Variable *Group comparison*	*n*	X-squares	Degrees of freedom	*p*-Value
Q10. Undue modification		0.74	1	0.38
Early	242			
Established	488			
Q10. Undue modification		1.11	2	0.57
Early	218			
Established	442			
Retired	38			
Q10. Undue modification		36.51	12	0.00
British Columbia	131			
Alberta	78			
Saskatchewan	35			
Manitoba	30			
Ontario	248			
Quebec	102			
New Brunswick	20			
Nova Scotia	60			
Prince Edward Island	6			
Newfoundland and Labrador	21			
Northwest Territories	7			
Nunavut	6			
Yukon	**2**			
Q10. Undue modification		4.27	5	0.51
Ontario	233			
Prairies	131			
British Columbia	122			
Quebec	99			
Maritimes	100			
Territories	13			
Q10. Undue modification		<0.01*	1	1
Affiliated	577			
Unaffiliated	121			
Q10. Undue modification		5.78	6	0.44
Natural sciences	475			
Engineering	48			
Medicine	21			
Agriculture and veterinary sciences	17			
Social sciences	52			
Humanities and the arts	2			
Multidisciplinary	79			
Q10. Undue modification		1.25	5	0.93
Natural sciences	552			
Engineering	56			
Medicine	36			
Agriculture and veterinary sciences	26			
Social sciences	73			
Humanities and the arts	3			

Cronbach's alpha reliability test

Question number "New Variable"	Raw alpha	Standardized alpha	Guttman's Lambda 6	Average	Signal– noise ratio	Alpha standard error	Mean	Standard deviation	Median
Q12 + Q13 "Comms"	0.59	0.59	0.42	0.42	1.5	0.03	1.8	1.1	0.42
Q16 (1–14) "External"	0.91	0.91	0.9	0.67	10	0.00	2.2	1.2	0.7
Q16 (1–9) "Internal"	0.82	0.82	0.84	0.34	4.6	0.00	2.4	0.8	0.29
Q16 (2, 3, 6) "Media"	0.78	0.78	0.71	0.54	3.6	0.01	3	1.1	0.56
Q16 (7, 8, 9) "Consequences"	0.83	0.83	0.78	0.62	5	0.01	2.1	1.1	0.66

t-Tests

Society affiliation

Variable *Comparison group*	*n*	Group means	*t*-Statistic	Confidence interval	Degrees of freedom	*p*-Value
Comms			−1.25	−0.39 0.08	134.96	0.21
Affiliated	590	1.75				
Unaffiliated	131	1.90				
External			−1.74	−0.48 0.03	154.3	0.08
Affiliated	515	2.08				
Unaffiliated	116	2.30				
Internal			−0.30	−0.19 0.14	156.23	0.76
Affiliated	532	2.36				
Unaffiliated	114	2.39				
Media			−0.46	−0.26 0.16	179.87	0.64
Affiliated	567	3.00				
Unaffiliated	125	3.05				
Consequences			0.53	−0.16 0.28	175.13	0.59
Affiliated	552	2.14				
Unaffiliated	123	2.08				

Career stage (excluding retired researchers)

Variable *Comparison group*	*n*	Group means	*t*-Statistic	Confidence interval	Degrees of freedom	*p*-Value
Comms			1.80	−0.01 0.34	344.17	0.07
Early	180	1.89				
Established	416	1.72				
External			1.95	0.00 0.39	395.05	0.05
Early	198	2.25				
Established	406	2.05				
Media			2.11	0.01 0.37	440.92	0.03
Early	220	3.14				
Established	436	2.95				
Consequences			7.02	0.47 0.83	411.73	<0.01*
Early	220	2.56				
Established	422	1.90				

Analysis of variance (ANOVA) tests

Career stage (including retired researchers)

Variable *Group*	*n*	Group means	Degrees of freedom	Sum of squares	Mean sq.	*F*-statistic	*p*-Value (means)	*p*-Value (post hoc *t*-test)		
								1–2	1–3	2–3
Comms			2	4.5	2.24	2.07	0.127	0.22	0.40	1.00
Residuals			627	680.2	1.08					
Early	180	1.89								
Established	416	1.73								
Retired	34	1.6								
Media			2	14.4	7.18	5.81	**<0.01***	0.10	**<0.01**	0.06
Residuals			689	852.1	1.23					
Early	220	3.15								
Established	436	2.95								
Retired	36	2.51								
External			2	5.0	2.49	1.80	0.16	0.17	1.00	1.00
Residuals			628	868.2	1.38					
Early	198	2.25								
Established	406	2.06								
Retired	27	2.15								
Consequences			2	66.5	33.2	28.15	**<0.01***	**<0.01**	**<0.01**	**<0.01**
Residuals			643	402.1	0.62					
Early	220	2.56								
Established	422	1.91								
Retired	33	1.75								

Province or Territory

Variable *Group*	*n*	Group means	Degrees of freedom	Sum of squares	Mean sq.	*F*-statistic	*p*-Value (means)
Comms			5	7.3	1.45	1.33	0.24
Ontario	215	1.77					
Prairies	118	1.74					
British Columbia	113	1.78					
Quebec	83	1.61					
Maritimes	88	1.98					
Territories	13	1.5					
Media			5	8.4	1.34	1.34	0.24
Ontario	232	2.94					
Prairies	130	3.06					
British Columbia	125	3.09					
Quebec	97	2.89					
Maritimes	94	3.06					
Territories	14	2.43					
Internal			5	5.8	1.16	1.77	0.11
Ontario	218	2.32					
Prairies	121	2.49					
British Columbia	117	2.36					
Quebec	89	2.26					
Maritimes	87	2.36					
Territories	14	1.94					
External			5	14.2	2.84	2.07	0.06
Ontario	213	2.12					
Prairies	119	2.32					
British Columbia	113	2.17					
Quebec	91	1.83					
Maritimes	81	2.16					
Territories	14	1.8					
Consequences			5	10.3	2.07	1.63	0.15
Ontario	225	2.12					
Prairies	127	2.33					
British Columbia	120	1.98					
Quebec	97	2.09					
Maritimes	91	2.05					
Territories	15	1.76					

Variable *Group*	*n*	Group means	Degrees of freedom	Sum of squares	Mean sq.	*F*-Statistic	*p*-Value (means)
Comms			6	4.2	0.70	0.64	0.69
Natural sciences	436	1.78					
Engineering	38	1.64					
Medicine	17	1.47					
Agriculture and veterinary sciences	17	2.06					
Social sciences	46	1.8					
Humanities and the arts	1	1					
Multidisciplinary	73	1.77					
Media			6	7.2	1.19	0.95	0.45
Natural sciences	478	3.02					
Engineering	43	3.1					
Medicine	19	2.7					
Agriculture and veterinary sciences	17	3.14					
Social sciences	53	2.73					
Humanities and the arts	2	3.5					
Multidisciplinary	77	2.96					
Internal			6	5.9	0.97	1.48	0.18
Natural Sciences	450	2.38					
Engineering	43	2.41					
Medicine	19	2.02					
Agriculture and veterinary sciences	14	2.38					
Social sciences	48	2.13					
Humanities and the arts	1	1.44					
Multidisciplinary	69	2.38					
External			6	5	0.82	0.59	0.73
Natural sciences	442	2.14					
Engineering	38	1.89					
Medicine	19	1.92					
Agriculture and veterinary sciences	16	2.27					
Social sciences	50	2.01					
Humanities and the arts	1	1.5					
Multidisciplinary	62	2.24					
Consequences			6	15.2	2.53	2.00	0.06
Natural sciences	469	2.14					
Engineering	43	2.16					
Medicine	20	1.57					
Agriculture and veterinary sciences	17	2.33					
Social sciences	49	1.8					
Humanities and the arts	1	1					
Multidisciplinary	74	2.28					

Qualitative codebook

Interference in Science Codebook

Q11. If yes, who asked you to make the modifications and for what reasons?

Context question: Have you ever experienced "undue modification" to your work by your organization, such as substantive changes to a text or story that downplay, mask, or include misleading information about environmental impacts? y/n/u

PARID

Respondent's PARID number.

Who requested the modifications? (Choose as many as applicable)

Code	Definition
Internal middle management	Managers, or supervisors, etc. who work at the same organization as the respondent
Internal senior management	Executives, Directors, Assistant Deputy Ministers, Board Members, etc. who work at the same organization as the respondent
Minister's office	The Minister, PMO, Minister's Office, etc.
External research partner (Industry)	Any party external to the respondent's organization who requested, funded, or are the subject of the research in question who are described as "industry", "industrial", or who are likely to be industry
External research partner (Government)	Any party external to the respondent's organization who requested, funded, or are the subject of the research in question who are described as "government" at the federal, provincial, or municipal level
External research partner (Other)	Any party external to the respondent's organization who requested, funded, or are the subject of the research in question who are not defined as industry or government
Workplace policy	Policy, regulations, or practices in place at the respondent's organization
Workplace culture/peer pressure	Coworkers, research team members, peers, or work culture or environment, internal to the respondent's organization
Self-censorship	Any time the respondent describes making undue modification to their work unprompted/without being asked or directed by any of the listed categories
Communications personnel	Any communications or media personnel/staff internal or external to the respondent's organization.
Other	Anything unlisted above. Use sparingly

For what reasons? (Choose as many as applicable)

Code	Definition
Risk to funding	Future funding for the researcher, research team, or respondent's organization is perceived as being at risk
Risk to halt development plans	Plans for infrastructure/resource development or land use could be halted, contended, or otherwise put at risk
Preserve partner/stakeholder relationships	Preservation of respondent's own, organization, or team relationship with research stakeholders, external partners, funders, governments at any level, etc.
Justify existing law or policy	Modified work in question could contradict existing laws or policy, OR work pursued should be exclusively in alignment with or in support of existing regulations, law, or policy
Sensitive information	Information is deemed sensitive/inappropriate for public knowledge to protect or preserve biodiversity/species/habitat, etc.
Avoid contention	Any contention avoidance unlisted or unexplained by other categories. Use sparingly
Protect org reputation	Protect the reputation of the respondent's (internal) organization OR a stakeholder (external) organization. Includes government, industry, NGOs, etc.
Downplay environmental risks or impacts	Downplay/water-down/gloss over/deemphasize research (findings) that describe environmental impacts or associated risks of any subject
Appease media	Modified comprehensive findings to appeal to or ease a certain audience (interests), for "click-bait", to fit a particular narrative ("good news story", exposé, etc.), or write for the laymen's understanding
Other	Anything not listed above. Use sparingly

Other response
If the response entirely fails to answer the question, copy it here without entering any responses to the above.

Q18. If yes, please briefly explain how your job satisfaction was affected.
Context Question: Has your job satisfaction been affected by restraints on public commentary on peer communication? y/n/u

PARID
Respondent's PARID number.

How has job satisfaction been impacted? (Choose as many as applicable)

Code	Definition
Work is redundant/pointless/invaluable	No point to conducting scientific research, OR work is not valuable/valued or is only valuable in serving political agendas, OR work is redundant
Poor internal working conditions	Work is stressful/frustrating, demoralizing/disheartening OR the work culture is negative or unpleasant, including lessened motivation or trust
Insufficient resourcing to conduct work	Ability to conduct scientific research compromised (interference, lack of funding, resources, capacity, etc.)
Muzzling	Ability to communicate scientific research compromised (censoring, constraints, restrictions, etc.)
Undue modifications	Work was altered as defined elsewhere
Career development opportunities lost	Any mention of opportunities missed to benefit career development (e.g., training, promotion/advancement, external partnerships)
Considered changing field/career/position	Any mention of consideration to quit a job in environmental studies or sciences, change careers, or enter a different field/department/sector, etc.
Unable to express authentic views	Any mention of an inability to express oneself honestly, in the form of personal values, opinions, thoughts, OR unable to "conduct the work we believe in" OR unable to act or inform based on possessed scientific expertise, OR moral objection to work
Working conditions are good or better	Working conditions at present are good, or better than they have been in the past
Other	Anything unlisted above. Use sparingly

Additional themes (Choose as applicable)

Code	Definition
Self-censorship	Any reference to having engaged in some form or self-censorship (as described elsewhere)
Reference to the Harper era	Any reference to Stephen Harper, years 2006–2015, "previous administration", "dark ages", "war on science", before Justin Trudeau, etc.
Funding	Any reference to being constrained by a federal funding agency OR having issues with achieving funding OR threat to future funding OR perception that federal funding agencies are a leading source or interference
Organization/industry/development over environment	Any mention of industry or an organization, OR support for government/existing law, policy, or regulations being prioritized over environmental protection or preservation

Other response

If the response entirely fails to answer the question, copy it here without entering any responses to the above.