Investigating interference in the environmental sciences and studies in Canada: Defining the phenomenon and measuring its prevalence and impacts

by

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For my mother, who has given me everything and who has learned everything the hard way, so I would never have to.

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ABSTRACT

When scientific researchers are sufficiently resourced to conduct research and communicate their findings, the knowledge produced can underpin technology and policy outcomes related to the environment and society. However, interference with the research process and sharing of results has been observed in several countries, particularly for environmental researchers. This study reviews the history of "interference in science" in Canada and offers a first definition of this term. To understand the prevalence and impacts of interference, researchers in the environmental studies and sciences in Canada were surveyed. The results indicate that these researchers, as of 2021, seem overall better able to conduct and communicate their work than in the past decade. However, ongoing interference in their scientific pursuits and communication remains cause for concern. After documenting consequences of interference in science communication, democratic governance, and the well-being of researchers' themselves, I recommend solutions to limit interference and improve knowledge mobilization.

LIST OF ABBREVIATIONS USED

ANOVA	Analysis of Variance statistical test
CDRC	Canadian Research and Development Classifications
DFO	Department of Fisheries and Oceans Canada
ISEDC	Innovation Science and Economic Development Canada
NGO	Non-governmental organization
NSERC	Natural Sciences and Engineering Research Council of Canada
PIPSC	Professional Institute of the Public Service of Canada
Q [#]	Survey Question Number
SSHRC	Social Sciences and Humanities Research Council of Canada

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POSITIONALITY STATEMENT

As a young, mixed-race woman early in her career as a researcher in the 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 and diversity has uniquely positioned me to take on this specific research project and contribute my expertise to the vital conversation on improving our methods for environmental protection and preservation. This research was carried out in alignment with values stated on the Westwood Lab website (www.westwoodlab.ca).

CHAPTER 1 INTRODUCTION

The role of scientific researchers is to produce knowledge and, in the case of applied research, to share that knowledge with decision-makers who can use it to inform their governance (Nguyen et al., 2017; Young et al., 2016). The process whereby knowledge is transferred from knowledge producers (researchers) to knowledge users (decision-makers) is known as "knowledge transfer", and it is an essential part of Western governments' ability to make reliable, democratic, and evidence-informed decisions. Researchers in the environmental studies and sciences are often in pursuit of knowledge relating to understanding and mitigating of the effects of anthropogenic harms to the environment, including climate change. Knowledge produced by environmental researchers may perform a vital role in informing law and policy that governs how we engage with the Anthropocene and the well-being of humans and the environment.

In recent years, however, it has been established that in Canada and elsewhere science is being unused or underused to inform policy and management processes (Cvitanovic & Hobday, 2018; Lubchenco, 1998; Marleau & Girling, 2017; Sutherland & Wordley, 2017; Westwood et al., 2019). Experts have pointed to the phenomenon of interference in science as a leading barrier to effective knowledge mobilization between scientists and policy makers (Anbleyth-Evans & Lacy, 2019; Driscoll et al., 2021; Turner, 2013; Westwood et al., 2017), although they have not used the specific term "interference in science". To provide an inclusive definition that allows the measurement of this phenomenon, I define "interference in science" as "deliberate actions that result in both the 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."

1.1. Statement of the problem

Canada has witnessed interference in science in the last two decades. This was particularly notable from 2012 to 2015 under the leadership of a majority Conservative government infamous for their attempts to control and limit communication by scientists in the public sector (Learn, 2017; Nelson, 2013; Sowunmi, 2015; Turner, 2013). The action taken by this government threatened scientific integrity for public sector scientists by failing to uphold its principles, including the ability to conduct scientific work free from political interference, and the ability to speak freely about their work (Presidential Actions, 2021; Science Integrity Project, 2015; Tides Canada et al., 2015). Concerns with scientific integrity in relation to research scientists in the public sector are ongoing in Canada and elsewhere, including the United States (Goldman et al., 2017; Sullivan, 2020; Woodward, 2020) and in Australia (Driscoll et al., 2021; Lewis, 2020b), where concerns are growing for researchers in academia, industry as well as the public sector, all working under the domains of environmental science and studies. Though the issue of scientific integrity in the public sector in Canada has received some attention (Legault, 2018), it is not known if, or how, under-resourcing or limits on communication impact environmental scientists in Canada in other sectors. Although gray literature reports on surveys conducted from 2013 (PIPSC, 2015) to 2017 (PIPSC, 2018) about interference in public sector science, to my knowledge, quantitative documentation and analysis of interference in science to academic standards (e.g., research design reviewed by an ethics board; academic peer-review of work) has not been undertaken in Canada. Given that interference in science can limit

knowledge mobilization practices that impact the environment, government policy, and people's livelihoods, it is vital to contribute a more robust understanding of this phenomenon.

1.2. Research objectives and thesis structure

The thesis is presented in six chapters. Chapter 2 is a literature review offering a detailed background on the history of interference in science in Canada, specifically, how interference has threatened scientific integrity and effective knowledge transfer during the "war on science" in the early 2010s. In Chapter 3, I outline the research design and methods for data collection used in my study. These first two chapters provide the context and methods to foreground the original research conducted in Chapters 4 and 5. A common method for sampling was used to collect data for Chapters 4 and 5, but each chapter has unique data analysis techniques to adhere to its respective research objectives and questions. In Chapter 4, I address my first research objective (to define appropriate terminology for the phenomenon) using evidence gathered from the literature review and primary data collected via survey. In Chapter 5, I focus on my second research objective (to document the prevalence of the phenomenon and describe its impacts). In Chapter 5 I answer: (1) Do Canadian environmental researchers experience interference with their ability to conduct and communicate their work, (2) from whom does this interference come, and (3) what are its impacts? I also report on (4) whether the experience of interference differs depending on research area, location, career stage, or affiliation with a scientific society, and (5) if perceptions of interference have changed since the federal government implemented scientific integrity policies across research led departments in 2019. Finally, Chapter 6 summarizes the key findings of the study and recommends solutions to limit

interference and improve knowledge mobilization. Overall, my thesis aims to emphasize the importance of contributing an academically-rigorous understanding of interference in science and the ongoing production of scientific knowledge.

1.3. Delimitations

In this thesis, I focus exclusively on the experiences of researchers under the umbrella of 'Western science', which I use as a term inclusive of academic disciplines that apply a scientific method, including those in the natural sciences and social sciences. Indigenous knowledge or Indigenous ways-of-knowing and their relationship to interference in science are not included in this work. In general, western science is conducted by academically-trained researchers whose intent is to contribute the best-available science to inform decision-making and law and policy writing for colonial government or other governing bodies.

One notable delimitation is the exclusion of Indigenous knowledge from my discourse. Although it is arguable that Indigenous knowledge — specifically of natural resources and the environment — is also typically unused or underused to inform policy and law writing and decision-making, it is not always in the interest of Indigenous knowledge holders to have their knowledge used to inform colonial governments or western scientific agendas (Martin, 2012; Westwood, et al., 2020). In the demographic survey questions, individuals had the option to identify as Indigenous and/or two-spirit. However, in my study, I have assumed that Indigenous and two-spirit survey participants answered the survey questions in reference to their work in fields of western science.

CHAPTER 2 LITERATURE REVIEW: A HISTORY OF INTERFERENCE IN SCIENCE IN CANADA

Note: an earlier version of this chapter is currently under review at the Dalhousie Interdisciplinary Journal of Management. Citation:

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2.1. Introduction

Research has shown that public policy is more effective when informed by a collaborative, democratic process that uses sufficient evidence, public opinion, critical thinking, and evaluation (Anbleyth-Evans & Lacy, 2019; Hahn, 2019; Heink et al., 2015; Kukkonen & Ylä-Anttila, 2020; Lester & Foxwell-Norton, 2020; Soomai, 2017; Westwood et al., 2019). In order to equip decision-makers with sufficient evidence to develop effective policy, knowledge transfer is required (Heink et al., 2015; Nguyen et al., 2017; Young et al., 2016). In addition, the integrity of the completed scientific work is vital to assure that the knowledge produced is the best-available information in its rigor, trustworthiness, and empirical basis (Douglas, 2012). According to the Liberal Canadian government elected in 2015, there are two key principles of scientific integrity for science conducted in the federal public sector. They are to: (1) maintain independence by protecting research from political interference and (2) communicate results transparently (Science Integrity Project, 2015; ISEDC, 2018). It is generally agreed that scientific evidence is valuable to decision-making and promotes a democratic approach to governance by raising awareness, issuing warnings, defining problems, assessing policy options before and/or after implementation, and monitoring implemented policies (Douglas, 2012; McNie, 2007; Westwood et al., 2019).

However, scientific integrity has not always been a priority for Canada's political leaders and governments.

Before the election of a majority Liberal government in 2015, Canada was governed by a Conservative majority led by Prime Minster Stephen Harper from 2011–2015. During that time, Canada witnessed what environmental scientists called "the death of evidence" and a "war on science" (Chung, 2014; Makuch, 2013). This "war on science" was characterized as an insufficiency of funds and opportunities for public sector scientists to research public health and the environment, and restrictions on public sector scientists' ability to freely communicate their research results internally to decision-makers or externally to the public without the burden of political or managerial interference (Learn, 2017; Turner, 2013; Wells, 2013; Westwood et al., 2019). This era had negative consequences for researchers, democratic processes, and the environment (Kheiriddin, 2012; Leblanc, 2012; May, 2012; Turner, 2013; Learn, 2017). In this chapter, I will provide a detailed history of interference in science in Canada, specifically by focusing on the "war on science" that took place between 2011 and 2015 to foreground the context of my research study.

2.2. The "death of evidence"

Prime Minister Stephen Harper held his seat in office from 2006 to 2015, but it was not until his third term beginning in 2011 that a majority Conservative government held power in the House of Commons and earned ultimate decision-making power over budget allocation (Learn, 2017; Leblanc, 2012). In 2012, the Conservative government began years of political interference with public sector research, particularly on issues such as climate change, oil and gas extraction, parks and protected areas, species at risk, and energy (Ghosh, 2012; Turner, 2013).

Under the majority Conservative government, research in these domains was defunded and prevented through burdensome restrictions on scientists' ability to conduct and communicate their research (Fitzpatrick, 2012; Gatehouse, 2013; Ghosh, 2012; Learn, 2017; Makuch, 2013; May, 2012; Turner, 2013; Wells, 2013). Political interference and control over messaging designed to fit the government's political and economic agenda weakened scientific integrity in Canada and led to negative impacts for the scientists who experienced overly controlled communications, reported in the public media as "muzzling" (Gatehouse, 2013; Ghosh, 2012; Makuch, 2013; Wattie, 2013).

2.2.1. Political interference

In 2012, the *Jobs, Growth and Long-term Prosperity Act* (S.C., 2012, c. 19) changed over 70 federal laws designed to protect and preserve the environment against further degradation due to climate change (Learn, 2017; May, 2012). The Act, popularly known as Bill C-38, repealed Canada's commitment to the Kyoto Protocol and replaced the Canadian Environmental Assessment Act (S.C., 1992, c. 37) and Canadian Environmental Protection Act (S.C., 1999, c. 33) with new versions (May, 2012). It also weakened agricultural protections, water programs, and other environmental regulations through amendments to the Navigable Waters Act (R.S.C., 1985, c. N-22), Fisheries Act (R.S.C., 1985, c. F-14), Parks Canada Agency Act (Parks Canada Agency Act, 1998), and more (May, 2012). The government made no announcements and issued no press releases around the passing of omnibus Bill C-38 that made major changes to many unrelated Acts at the same time, making it difficult to evaluate and debate in the House of Commons (May, 2012; Turner, 2013). Beginning with the 2012 budget, funding priorities were allocated away from scientific and environmental research, particularly those on the forefront of

monitoring anthropogenic climate change (Turner, 2013). When funding for the Polar Environment Atmospheric Research Laboratory was reallocated, researchers and the public began voicing serious concern (Turner, 2013; Learn, 2017). The eventual defunding of the Experimental Lakes Area facilities led to severe public backlash that prevented the shutdown of the facility entirely, however, its annual budget was still cut by two million dollars (Turner, 2013; Wells, 2013).

2.2.2. Controlling communications

According to an account published in Smithsonian Magazine (2017), Canadian scientists who were still sufficiently resourced and funded in order to be able to conduct research were operating under unbearably tight restrictions when it came to communicating their findings. It was well established that failure to adhere to the government's rules would cost them their jobs (Learn, 2017). Max Bothwell, from Environment Canada (now Environment and Climate Change Canada), explained that when a journalist reached out the following would take place; (1) scientists were expected to contact a media control center so that the center could ensure the messaging of the conversation was in alignment with the government's political agenda, (2) the media center contacts the journalist to request their questions, (3) the media center provides the scientists with the approved answers and sometimes omit parts of the answers [drafted by scientists] in their response to the journalist (Learn, 2017). In one instance, Bothwell recounted "110 pages of emails between 16 different government communications staffers" (Learn, 2017), and in others, recounted the media center simply stalling until the journalist's deadlines were passed (Learn, 2017). When the head of the Canadian Shark Research Laboratory, Steven Campana, responded to a media inquiry in 2014 without explicit permission from the media

center, he received a disciplinary letter and "threat of severe punishment upon a second infraction" (Learn, 2017).

Campana reported that his usual 30–40 interviews a year dropped to no more than three (Learn, 2017). In order to share a novel finding about ageing crustaceans, he was required to put in a request to share the story with the media, but permissions never came, so the research was not shared publicly until it was picked up by American news outlets two years later (Learn, 2017). Bothwell had a similar story about a CBC radio interview that was approved only as long as media staffers were able to be present and listening during the phone interview (Learn, 2017). Dr. Ian Stirling recounted being escorted around an Arctic conference in Montreal in 2012 by government chaperones who were responsible for "shield[ing] and filter[ing] possible media questions, listen[ing to] them speak to other scientists and track[ing] which research posters they read" (Learn, 2017). During Harper's majority term, no direct communication or un-authorized communication between public sector scientists and the public or news media was allowed.

2.3. The "war on science"

Beginning in 2012, scientists began to come forward with their concerns to the media and the public to expose how the Conservative government had restricted science and "muzzled" scientists (Fitzpatrick, 2012; Ghosh, 2012; Gatehouse, 2013; Makuch, 2013). Protests, marches, walks, and rallies were hosted across the country, but primarily in Ottawa, where in 2013 over 2000 scientists rallied on Parliament Hill to call attention to the "war on science" (Makuch, 2013). Science activists gained international media attention and the sympathy of a United States group based in Cambridge, Massachusetts, the Union of Concerned Scientists, who advocates for environmental science to support

sustainability (Chung, 2014). The group drafted an open letter, signed by more than 800 scientists in Canada and abroad calling on the Conservative government to remove "burdensome restrictions on scientific communication and collaboration faced by Canadian government scientists." (Chung, 2014).

In response to public outcry, several institutions began to investigate claims of muzzling (Kondro, 2013; PIPSC, 2015) and later confirmed intentional restriction of federal public sector scientists' communications by the sitting government (Legault, 2018). The Professional Institute of the Public Service of Canada (PIPSC) surveyed scientists employed by the federal government in 2013 and found that 90% of respondents felt that they could not speak publicly about their work. Another 71% of survey respondents reported political interference, and half reported being aware of cases where Canadians' health or safety and/or the environment was comprised because of political interference with their scientific work (PIPSC, 2015).

In Stephen Harper's final year as Prime Minister, despite public outrage and adamant opposition from researchers and scientists in Canada and abroad, the government closed seven out of eleven world-renowned Department of Fisheries and Oceans (DFO) marine libraries (Learn, 2017; Sowunmi, 2015; Wells, 2013, 2014). The libraries stored decades of scientific evidence and research related to the environment, aquatic ecosystems, water safety, marine species, and more (Learn, 2017; Sowunmi, 2015; Wells, 2014). The majority of archived materials were discarded and destroyed without being digitized (Sowunmi, 2015).

2.4. Impacts of the "war on science"

2.4.1. Impact on researchers

In 2013, PIPSC reported that 5,332 federally employed scientists had "already either been fired from their jobs of transferred to other duties" (Nelson, 2013). For those who were able to keep their jobs, the working conditions were demoralizing and frustrating since the scientists still employed could not effectively conduct their scientific research due to the restrictions and interference (Learn, 2017). Although the Harper government's "war on science" affected scientists in the medical and health sciences (Miller et al., 2017), the most severe consequences were experiences by scientists working in the environmental studies and sciences in the federal public sector.

2.4.2. Impact on the democracy and the environment

A protester from the "death of evidence" mock funeral on Parliament Hill closed their speech with the words "No science, no evidence, no truth, no democracy" (Fitzpatrick, 2012), arguing that the Prime Minister's choice to exclude sufficient relevant, credible, and legitimate evidence from the decision-making process was effectively propaganda (Fitzpatrick, 2012). There is consensus among political-science experts that in order for governments to engage in democratic decision-making processes that address the interests and priorities of tax-paying citizens who entrust government, sufficient evidence to weigh in that process and public engagement is crucial (Douglas, 2012; Hahn, 2019; Lester & Foxwell-Norton, 2020; McNie, 2007). When the Conservative government defunded, cut back, and in some cases destroyed evidence-producing agencies, labs, and libraries across Canada, it also lessened availability of the information required to inform the public.

Common consent not only internal to the government but externally among stakeholders and the public is crucial (Kerckhove et al., 2015), especially in evaluating which pieces of evidence are relevant, credible, legitimate, and the most useful to apply (Heink et al., 2015; McNie, 2007). Without the influence of public opinion, democratic decision-making on issues of policy is not possible (Douglas, 2012; Lester & Foxwell-Norton, 2020), but in order to equip the public with sufficient information to form an opinion, they must be allowed transparent access to the evidence that is communicated directly from scientists in layman's terms (Lester and Foxwell-Norton, 2020). During the "war on science," Canadians' opportunity to engage with the evidence, think critically about the information, and evaluate it in order to democratically form public opinion for the government to act on was sidelined, resulting in a significant decline in the public's trust of the federal government and its ability to uphold democratic processes (Beers, 2015; Kheiriddin, 2012; Turner, 2013).

The government's failure to implement adequate environmental protections through law and policy may have also led to further environmental degradation in the meantime (Anbleyth-Evans & Lacy, 2019; Sutherland et al., 2004; Wells, 2014). Scientists in Canada have claimed that under the Conservative government, the environment suffered the consequences of inadequacies in effective and protective research and evidence-informed policy (Fitzpatrick, 2012; Gatehouse, 2013; Learn, 2017).

2.5. Ending the "war on science"

As Canada approached the 2015 federal election, Prime Minister Stephen Harper had fallen so far out of favour with Canadians that some voters were agreeing to vote for parties whom they do not usually support, engage in vote swapping, and participate in public campaign

groups calling for votes for ‘Anyone but Harper’ and ‘Anything but Conservative’ (City News, 2015; Gordon, 2015). Over 50 candidates for Member of Parliament, including representatives from all major political parties, signed on to a 'science pledge' to, if elected, “restore funding to federal science-based initiatives and enshrine the right of public sector scientists to speak to the media” (Evidence for Democracy, 2015). In the colonial nation’s 154-year history, 2015 marked the first time that a federal electoral debate specifically about science was held (Gibbs & Westwood, 2015; Linnitt, 2015). The Liberal Party campaigned on a promise to “ensure that government science is fully available to the public, that scientists are able to speak freely about their work, and that scientific analyses are considered when the government makes decisions” (Liberal Party of Canada, 2019). Public sector scientists' ability to communicate was considered a key election issue (Halpern, 2015).

Upon successful election, Liberal party leader and Prime Minister, Justin Trudeau delivered immediately on some campaign promises related to scientific integrity. Trudeau swiftly freed scientists to communicate directly with the media and increased funding to federal science in Canada (May, 2016; Statistics Canada, 2017a, 2017b). Within the first few months of 42nd Parliament, Trudeau also created a new cabinet position for a Minister of Science, appointed a Chief Science Advisor, and renamed the Environment Minister's position to Minister of Environment and Climate Change (Jones, 2015). In 2017, PIPSC repeated their 2013 survey about the “muzzling” of federal scientists. They found that 50% of scientists surveyed still felt obstructed from communicating their work, in comparison to the 90% reported four years prior (PIPSC, 2018). The number of those who reported

they felt that political interference had compromised the use of scientific evidence in government decision-making dropped from 71% to 40% (PIPSC, 2018).

The second PIPSC survey demonstrated progress in terms of freedoms for public sector scientists, but the remaining percentage of respondents feeling obstructed from communicating and who felt that evidence was compromised by political interference remained cause for concern. In 2018, The Office of the Information Commissioner of Canada concluded a four-year review into federal scientists' ability to communicate (Legault, 2018). The study noted improvements since the Liberal government took power but found uneven policy application between departments and agencies and ongoing issues of independence of scientific offices (Legault, 2018).

A model for scientific integrity policies for federal science-based departments and agencies led by the Office of the Chief Science Advisor was developed in 2018 and implemented in 2019 (ISEDC, 2018, 2019) The policies were organized around two key principles of scientific integrity that (1) guarantee Canadian public sector scientists' right to communicate with the public about their areas of expertise, and (2) prevent political interference in the conduct or dissemination of research (ISEDC, 2018, 2019).

2.5.1. Addressing the consequences

In terms of consequences faced by environmental scientists, there is no easily accessible information to determine whether or not the Liberal government reinstated previous employment opportunities for environmental scientists and researchers in the public or private sector. Since the lifting of burdensome restrictions, evidenced by media reports (May, 2016), and implementation of policies to protect federal public scientists' freedoms

(ISEDC, 2018, 2019), it is reasonable to assume that they would not have ongoing reason to be frustrated or feel unproductive and demoralized at work. However, no known research has been conducted to support this assumption or understand how effective the Liberal government has been at addressing personal consequences to mental health and job satisfaction experienced by environmental scientists in the public sector or in any other sector or domain.

2.6. Conclusion

Years after the end of the "war on science" in Canada, it is apparent that attempts have been made to re-establish and protect scientific integrity. By immediately dedicating resources and personnel to address the status of scientific integrity in Canada (Jones, 2015; May, 2016) Prime Minister Justin Trudeau was able to keep his promises made in his first term election to lift the burdensome restrictions on science imposed by the previous government (Privy Council Office, 2019). The 2017 PIPSC report and study on communications by the Office of the Information Commissioner of Canada indicate a positive upward trend in improvements being made to the state of scientific integrity in the public sector (Legault, 2018; PIPSC, 2018) but no documentation on the perspective of environmental scientists and researchers in the public sector post-2017 is available. There is also no known evidence to suggest how the scientific-integrity policies have affected government-based researchers' ability to produce science free from political interference.

The media, gray literature, and peer-reviewed research published in Canada and elsewhere offers evidence of a history of interference in science, restrictions on researchers' ability to conduct and to communicate scientific work, and how interference impacts the ability of researchers to engage in effective knowledge exchange to inform the public and

decision-makers. It is clear that the consequences of interference in science can be severe for researchers, as well as democratic processes and the environment.

However, there are gaps in the literature that reveal a need for a rigorous assessment of the state of interference in science in Canada in the years following the most recent known study and the implementation of scientific integrity policies especially for environmental researchers in the public sector. Furthermore, there is no known research documenting the prevalence of interference in other sectors (e.g., academia, industry, provincial government, non-profits). It is additionally important to investigate if and how the broader research community experiences interference with their work. There are also no known studies of how researchers' personal identity demographics (e.g., marginalized identities such as visible minority, gender identity, sexual orientation, ability, etc.) may influence their experience of interference.

In order to continue to improve knowledge mobilization practices between research scientists, the public, and decision-makers, it is essential to first understand its barriers, including the phenomenon of interference in science. To protect against the risk of similar consequences experienced during Canada's "war on science" in past years, interference in science and its impacts should be investigated on a continuous basis, with special attention paid to the researchers affected.

CHAPTER 3 RESEARCH DESIGN AND METHODOLOGY

3.1. Introduction

To contribute to academic study of interference in science in Canada, I drew from methods employed by Driscoll et al. (2021) in the Australian context and PIPSC in the Canadian gray literature (PIPSC, 2015, 2018). With approval from the Dalhousie Research Ethics Board (REB#: 2021-5630, Appendix A), I used descriptive survey with closed (Likert scale, multiple choice, multiple checkboxes) and open-ended questions (text-fill). As there are no known studies of how Canadian researchers working in non-governmental sectors experience or perceive interference in science, the study population included any self-identifying researcher living in Canada and currently employed in the field of environmental studies or sciences. My survey offers a holistic picture of Canadian researchers from multiple sectors working in the environmental sciences as well as adjacent environmental studies that address social, political, and cultural relationships with the environment. Given that is has been four years since the last known study, this design addresses the need to update the recency of information, and the need for Canadian research that reports on the perceptions of public sector researchers and include those in other sectors such as academia, industry, and non-profits.

3.2. Survey design

The online survey was hosted on the Qualtrics platform (Qualtrics, 2021). I asked participants about their scientific and workplace demographics including research area and career stage; their perceived freedom to communicate their scientific works; whether they feel adequately resourced to meet their scientific objectives; their perceptions of

managerial or political interference in their scientific work and its consequences to the public and/or environment; and, whether their perceptions of these outcomes have changed since the announcement of federal scientific integrity policies in Canada in 2019 (Appendix B). I also asked participants about their personal demographics (gender identity, sexual orientation, visible minority status, wearing of religious signifiers, and others). Personal demographic variables and whether any researcher's identity impacted their experiences of interference was analyzed separately from my work and is reported by Chu, 2022.

The survey used 31 questions including three screening questions that determined participant eligibility. Eligible participants were required to self-identify as a researcher currently working in the environmental studies or sciences and the Canadian province or territory of residence from where they predominantly conduct work. The expected time required to complete the survey was 25 to 30 minutes depending on the time used to complete open-text responses.

3.3. Data collection

The survey was available in English from August 3 to August 22, 2021. In order to reach the largest possible sample of the study population, including researchers outside of the public sector, responses were collected through a two-phased approach using purposive sampling to specifically target the population of interest. First, I identified Canadian scientific societies in disciplines of environmental studies and sciences established for at least five years (Appendix C). I contacted the societies via their designated contact by email and asked them to distribute the survey to their membership by email or via their official newsletter. Of the 29 societies contacted, 15 agreed to participate. I asked them to provide me with the number of individuals who received the invitation, but as these numbers were

unknown for many societies, I was unable to provide response rate estimates from this distribution phase.

In the second phase, I 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. I identified relevant journals by research areas covered by 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). I only included journals classified in a SSHRC category which mentioned the environment or one of the relevant NSERC categories in their titles to ensure their relevance to environment studies. Non-English and explicitly non-Canadian focused journals were excluded along with any cross-listed or duplicate journals. I identified 3,719 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, an SQL query (select distinct email from reprint_author where right (email,3) = '.ca')) was written to retrieve the journal and the name and email address of the corresponding author for all publications indexed in the Web of Science published on or after 2008. The results were exported in a tab-delimited text format. Results were then loaded the file in Excel and the results were filtered to include only the journals that fit my criteria from which 43,969 email addresses belonging to a corresponding author with a ".ca" suffix were identified. Qualtrics was used to distribute the survey invitation (Appendix C), and the transmission was successful to 37,494 email addresses.

As an incentive, participants were given the option to voluntarily enter into a draw to win one of three $50 gift cards to an online store of their choice, or a donation of $50 to the

organization or charity of their choosing. The option to participate in the draw was only available to participants who submitted a completed survey. The final page of the research survey invited participants to exit and provided them a link to a separate survey where they were able to enter the draw by providing their email (Appendix B). The respondent's survey responses were kept anonymous since they were entirely separate from the draw entry where they confidentially provided an email. The three draw winners were contacted and awarded their gift cards or donation to a fund in December 2021.

3.3. Data Analysis

In this section, I report methodology for cleaning of the overall dataset, measures, and a description of the participants. Specific data analysis techniques, including quantitative statistical testing and qualitative text analysis, are described in Chapters 4 and 5 as the methods applied were linked directly to specific research questions. Data analysis methods for relevant variables is described in detail in section 4.2. of Chapter 4 and in section 5.2. of Chapter 5.

3.3.1. Data cleaning

After distribution via 15 scientific societies and directly to 43,969 email addresses, 1,291 responses were collected. I manually cleaned the data by removing record of respondents who did not consent to the survey (83), who did not pass the screening questions (288) or who failed to complete the entire survey (179) and removing any repeat IP addresses (0). After data cleaning, a total of 741 responses were deemed usable for data analysis.

3.3.2. Measures

Work demographics were each measured using one categorical variable. Respondents identified their province or territory, which I later grouped into regions. Career stage was identified by selecting one of three options; early-career (first employed as a researcher, inclusive of post-docs, after 2015), established (first employed as a researcher before 2015), and retired. Participants were asked to indicate what association or society they hold membership to in an open-text field. The responses were converted to a dichotomous variable ("Affiliated" or "Unaffiliated") indicating whether a participant was a member of any association. All research areas identified by participants in the open-text responses (*n* = 277) and in the options provided were classified into one of the six broad disciplines of the Canadian Research and Development Classification (CRDC) (Statistics Canada, 2020). Participants that mentioned multiple research areas that fell under different CRDC disciplines were categorized as "Multidisciplinary" category.

3.3.3. Participants

The survey garnered response from researchers in every one of Canada's thirteen provinces and territories: 33% in Ontario, 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). Most respondents (63%) identified as established career researchers, who have been employed in the field since before 2015. Another 32% identified as early career researchers who began working in the field after 2015 (inclusive of post docs). Five percent are retired. The majority are

also (82%) affiliated with one or more scientific society, and 18% identified as unaffiliated. Respondents work predominantly in the Natural Sciences (68%), and Multidisciplinary researchers account for 12%. The remaining work in Social Sciences (7%), Engineering (7%), Medicine (3%), Agriculture and vet sciences (3%), or the Humanities and the Arts (<1%). A demographic summary of participants' personal identities is not relevant to this thesis, but is reported in Chu (2022), who analysed the impacts of researchers' identity factors on their experiences of interference in science.

3.4. Limitations

The survey was not made available in French or any other language, which may have limited participation from non-English reading/speaking researchers. Consequently, some scientific societies also declined to participate in its dissemination as it did not meet their standards for bilingual communications.

The dissemination methods used targeted researchers who lead the publication of their work in academic journals. Depending on their role, researchers in non-academic sectors may have limited opportunity to lead academic publications in a first-author capacity. Although no quantitative data was collected to identify respondent's sector, many respondents self-identified or indicated their sector in open-text response, and researchers from academia, government, industry, and NGOs were identifiable in the data set.

In the case of my research, it is possible that the results may be biased towards individuals who have experienced disproportionately negative experiences with interference. Eight percent of respondents reported never having experienced any type of interference with their work. One of the challenges of anonymous online survey means I was disallowed

from clarifying any confusing responses or being able to identify whether any reported experience of interference truly exemplified an instance of interference in science as defined in my research. In the results, I assume all experiences shared are indeed factual and qualifying to be considered incidents of interference.

Unless specifically stated by the respondent, I was also unable to assume the timeline of any reported occurrence since most of the survey questions borrowed from PIPSC (2015 & 2018), and Driscoll et al. (2021) do not define temporal landmarks for researchers' experience. Therefore, the respondents' answers regarding their experience with interference could be based on experiences before the 2015 Canadian federal election where a Liberal government replaced the previous Conservative leadership. Responses may also refer to a time before the implementation of the scientific integrity policies asked about in a later part of the survey (Q20 & Q21).

While PIPSC surveyed only public-sector employees, and Driscoll et al. (2020) surveyed ecologists identified based on membership in a scientific society focused on the environmental sciences only, my population of study differs to include researchers working in adjacent environmental studies fields and researchers from academia and industry. Difference in the study populations makes it impossible to directly compare my findings to the findings of previous studies that inspired this work.

3.3. Conclusion

My research design is intended to fill the gaps identified in the literature review by gathering data directly from the environmental researchers who experience and are most familiar with interference in science in Canada, and its prevalence and impacts post-2017

and the implementation of scientific integrity policies across Canadian federal government departments. Each of the following chapters responds to one of my research objectives, and answers separate research questions using unique methods for data analysis on data collected by different sections of the online survey. To analyze the data collected, both qualitative and quantitative methods of data analysis were employed to best understand the researchers' perception of interference in science in Canada. The following chapters both rely on rigorous methods of data collection and analysis to contribute new knowledge and inform recommendations for eliminating interference in science.

CHAPTER 4 INTERFERENCE IN SCIENCE: DEFINING THE PHENOMENON

4.1. Introduction

Recent Canadian history exemplifies two key ways in which the work of government researchers in the environmental studies or sciences was affected by political interference. First, researchers' capacity to conduct scientific research was threatened by highly selective funding, or funding cuts that lead to insufficient resourcing for equipment, technology, staff, travel, and other essential costs (Turner, 2013; Wells, 2014). The second way researchers were affected was in their diminished ability to communicate research results and findings that have been restricted or constrained. Government researchers across Canada claimed their employers prevented them from presenting at conferences or engaging directly with the media or with the public via interview and social media (Turner, 2013; Learn, 2017). Before disseminating their results, researchers were expected to earn several stages of internal approvals which did not always come before a conference, media, or publisher's deadline for work submissions (Learn, 2017). Scientific research communication was also limited between knowledge-producing researchers and knowledge-using groups, including decision-makers who require the best-available science to inform research and evidence-based decisions on law and policy (Kerckhove et al., 2015; McNie, 2007; Turner, 2013; Westwood et al., 2017).

Canada is not the only country where the ability of public sector scientists to communicate both internally and externally, as well as to be sufficiently resourced to meet their research objectives, has been called into question. Reports have emerged from both the United States and in Australia of communication restriction and reduced capacity or funding

constraints impacting environmental scientists in the public sector, academia, and industry (Driscoll et al., 2021; Jones, 2021; Lewis, 2020b; Lin, 2018; Mannix, 2022). Although little evidence of interference of this type in countries beyond Canada, the United States, and Australia was discovered in my literature review (conducted in English), it is possible that that environmental researchers in many other countries worldwide have experienced interference with their ability to conduct and to communicate research.

4.2. Methods and data analysis

The primary literature review was conducted using Boolean logic and operators to search for relevant media, gray literature and peer-reviewed publications in several databases and online libraries. In the fall 2020 I queried Scopus using various search strings. I manually evaluated the returned results for their relevance to the topic and noted the terms that were used by these results. I also searched secondary data sources (the literature, reports, and media articles referenced within the returned results, which were predominantly peer-reviewed articles) and performed subsequent searches every four months from November 2020 until August 2022.

In addition to a literature search, I collected primary data using the survey. Respondents were asked to provide a definition of the "interference in science" in their own words (Appendix B). I coded their responses using a deductive approach (Kleinheksel et al., 2020) and conceptual content analysis (School of Public Health, 2019) to observe frequency of use of key terms. Informed by relevant media, gray literature, and peer-reviewed research identified during my literature search, I identified *a priori* 12 terms used most frequently and synonymously to describe actions that perpetuate interference in science (alter, block, censor, constrain, control, limit, modify, muzzle, pressure, prevent, restrict, and suppress).

Using the text-search query in NVivo version 12.7.0. (NVivo, 2019), I was able to search for each of the terms identified in the deductive codebook (Appendix D) for their frequency of reference (every time they were used by a respondent in their open-text response). Text-search included stemmed-words (e.g., limits/limited/limiting, etc.) throughout responses to survey Q19 "How would you define interference in science?" (n = 741).

4.3. Results

4.3.1 Existing terminology related to interference in science

Several terms have been used in the media, gray literature, and peer-reviewed research that refer to elements of interference in science. For example, in 2012 and 2013, the term "muzzling" was popularized in the Canadian media to refer to the excessive restrictions placed upon researchers in the public sector that prevented them from communicating their findings (Gatehouse, 2013; Ghosh, 2012; Makuch, 2013). More recently in Australia "science suppression" has been used to refer to the political interference that constrains the ability of researchers in multiple sectors to engage in public commentary or publicly share their research results (Driscoll et al., 2021; Lewis, 2020b). In both the United States and Australia, the term "censorship" is also commonly used in reports in the media and peer-reviewed publications that document recent alterations or undue modifications made to researchers' work that lead to the spread of misinformation to the public (Carter, 2019; Lewis, 2020b; Waters, 2018).

Table 1. Terminology used in publications most relevant to the interference in science phenomenon.

Term	Publication type	Author
"Muzzling"	Media	Ghosh, 2012; Makuch, 2013; May, 2016; Sullivan, 2020; Turner, 2013; Woodward, 2020
"Science suppression"	Peer-reviewed journal article	Driscoll et al., 2021; Lewis, 2020b
"Censorship"	Peer-reviewed journal article; Media	Carter, 2020; Driscoll et al., 2021; Kerckhove et al., 2015; Lewis, 2020a, 2020b; Waters, 2018
"Scientific-integrity"	Peer-reviewed journal article; Media	Carrol et al., 2017; Malakoff, 2021; Presidential Actions, 2021
"Knowledge-exchange"	Peer-reviewed journal article	Nguyen et al., 2017; Peters et al., 2018
"Science-policy interface"	Peer-reviewed journal article	Engels, 2005; Heink et al., 2015; Kukkonen & Ylä-Anttila, 2020; Soomai, 2017; Young et al., 2016

Other publications on the subject of knowledge exchange, scientific integrity, and the science-policy interface sometimes discuss shared thematic elements of interference in science and its impacts, particularly for science communication, but do not specifically name or report on the phenomenon. In addition to terminology that could be used in a search to uncover literature with thematically related studies, terms such as constrain, restrict, or limit, were also found to be useful in conducting a search for relevant literature. However, these words are only relevant in context, so they are more challenging to use when searching for specific results. The first few attempts made to conduct a comprehensive review of the literature proved challenging because of few relevant publications and the inconsistent and competing nature of key terms.

4.3.2. Canadian researchers' definitions of interference in science

Of the 741 total survey respondents, 695 provided a definition of "interference in science." Out of those 695 definitions of "interference in science," 291 unique responses contained any one of the 12 search terms applied. Each of these responses were analyzed using selective coding methods that allowed me to identify which of the 12 terms was used in the response and its context. Table 2 demonstrates the frequency for each term's use in the context of describing researchers' ability to conduct work, or researchers' ability to communicate work.

Table 2. Frequency of reference for each term in the deductive codebook as applied to definitions for "interference in science" from survey respondents (n = 695).

Term	Frequency of reference	Number of unique responses	In reference to conducting research	In reference to communicating research
Prevent	105	93	30	78
Pressure	58	55	26	38
Suppress	46	44	6	42
Limit	41	33	16	26
Alter	39	38	13	34
Restrict	31	29	15	16
Modify	27	26	5	23
Block	16	15	7	11
Control	14	14	9	7
Constrain	13	12	8	7
Censor	10	9	0	8
Muzzle	5	5	0	5

I additionally investigated the frequency of use for "communicate" (or a stemmed variation, e.g., communicates/communicating/communicated) and for "conduct" (or a stemmed variation, e.g., conducts/conducting/conducted). Across the 695 responses that provided a definition, "communicate" was used 134 times in 120 unique responses (Figure 1), and "conduct" was used 43 times in 39 unique responses (Figure 2). Thirteen respondents (2%) used both "conduct" and "communicate" (or stemmed variations) in their definition and 121 respondents (17%) implied both the ability of researchers to conduct and communicate research in their definition of interference in science using other terminology.

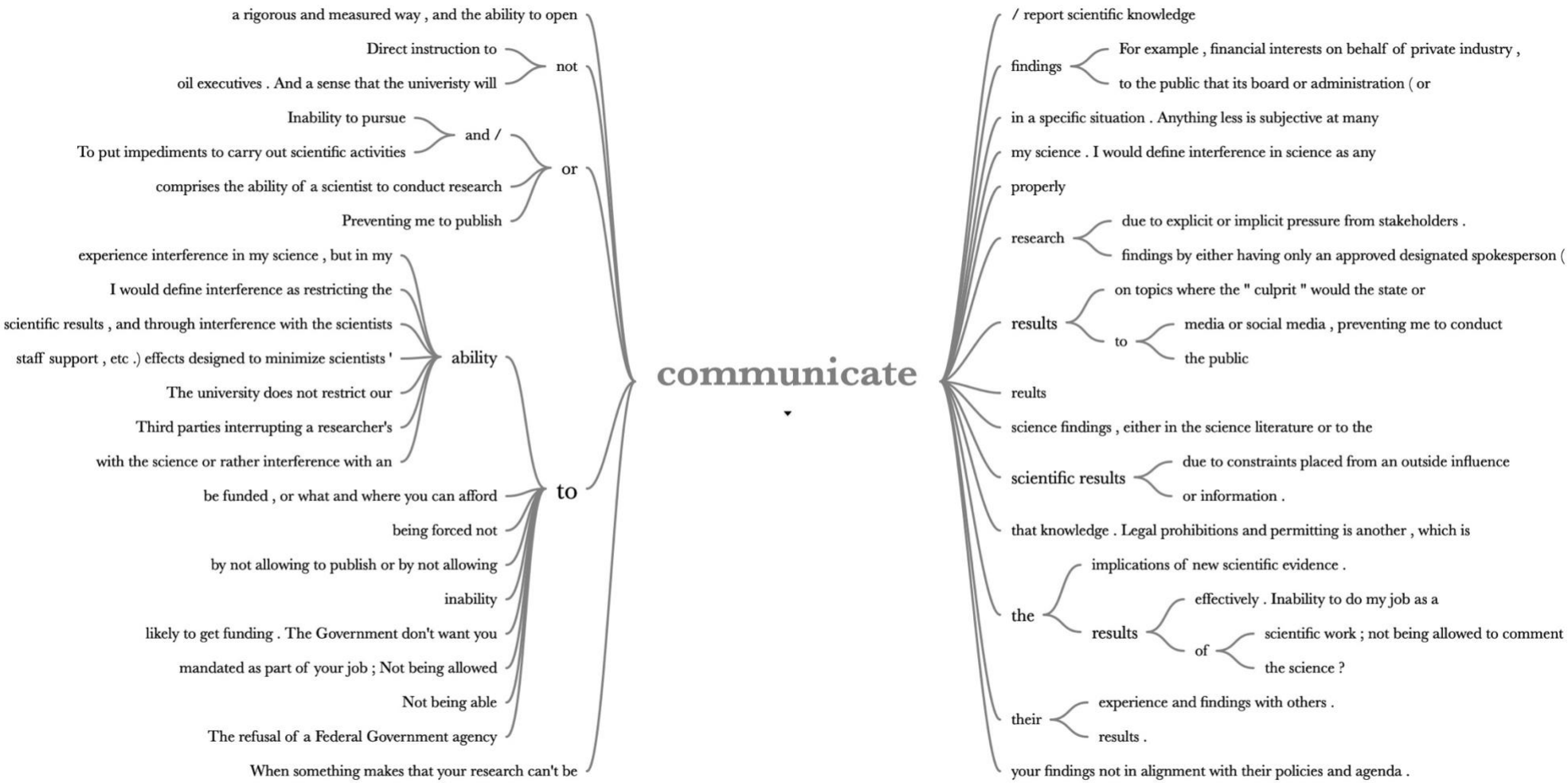

Figure 1. Results for NVivo text-search query for "communicate" with up to ten surrounding context words (n = 695).

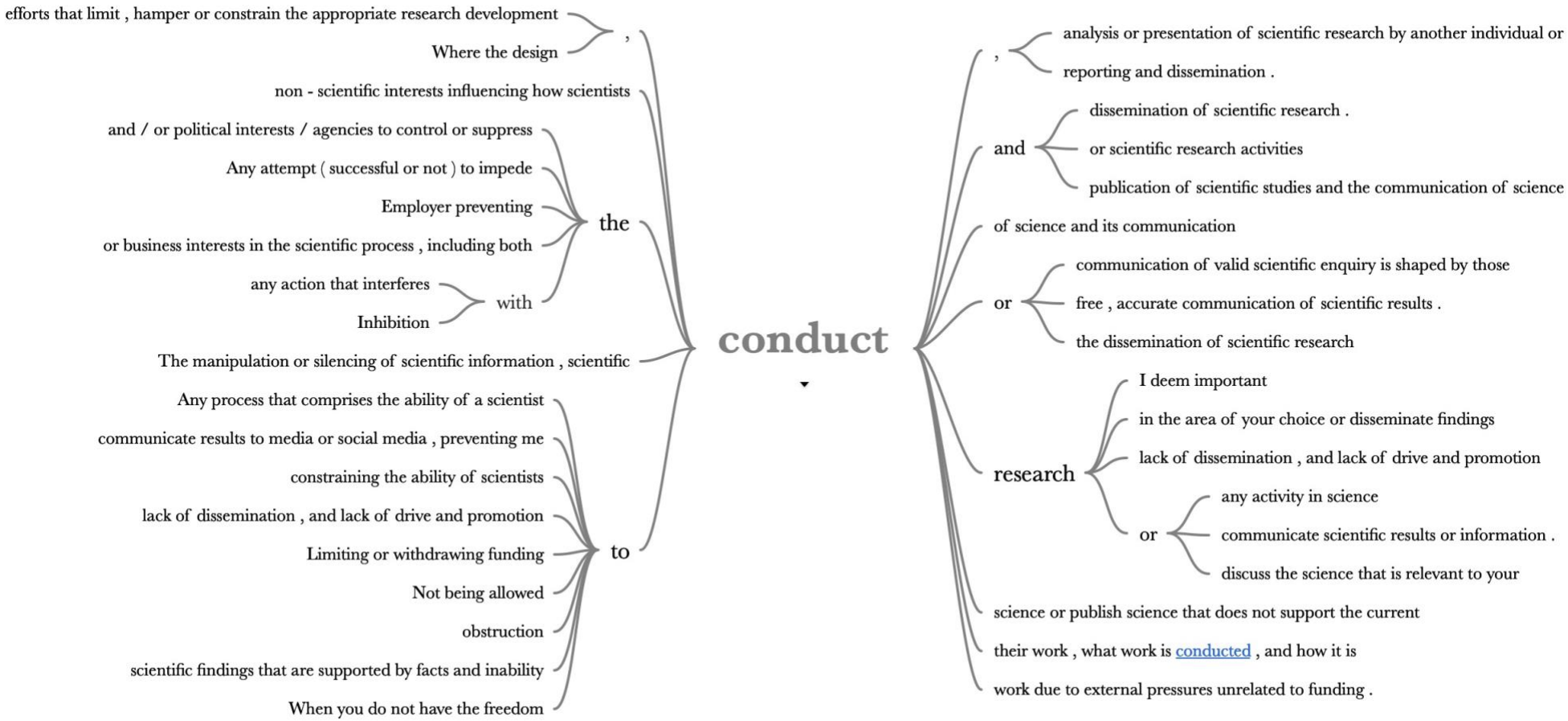

Figure 2. Results for NVivo text-search query for "conduct" with up to ten surrounding context words (n = 695).

4.3.3. Discussion

The results of the conceptual content analysis demonstrate how the terminology most frequently used in the literature is used, or not used, by researchers themselves. In their definitions, most respondents emphasized interference in science as an issue affecting their ability to communicate scientific research. The definitions laid out by researchers who used the term "conduct" in their research sometimes also used "communicate." In total, 134 respondents described interference as a phenomenon that affects both researchers' ability to conduct and communicate research, representing 19% of the respondents who answered the question. This supports additional survey findings that reveal that interference impacts both researchers' ability to conduct scientific work as well as communicate it.

None of the terms previously used (muzzling, censorship, science suppression) fully encompass both limits on communication *and* conduct of research. In order to pursue study of interference in science with a robust understanding of exactly what is being investigated and reported, a definition of the terminology is required. Furthermore, new reports of funding cuts and capacity constraints in Australia (Mannix, 2022) also signal the likelihood that this phenomenon is not exclusive to Canada and may be worth formal investigation to assess the prevalence of interference in science more globally. Using a single term to universally refer to and encompasses the full scope of the phenomenon would be useful because it could act as a consistent point of reference allowing future researchers to easily find related studies.

4.4. Proposing a new definition for interference in science

The terms "interference," "interference with science," or "political interference" have been used in the literature and are emerging in recent media reports (Carroll et al., 2017; Lewis, 2020a; Lubchenco, 1998; Miller et al., 2017; Szeto, 2022; Young et al., 2016). However, no consistent or clear definition accompanies the use of the terms to describe exactly what those examples of interference entail. Based on both my review of the literature and the definitions posed by the survey respondents, I propose a definition for interference in science as "deliberate actions that result in both the 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."

4.5. Conclusion

Popular terminology such a muzzling, science suppression, and censorship is recognizable and legitimate in its use to describe deliberate managerial or political actions that can impact researchers' work. While "muzzling" is arguably most recognizable by the North American public due to its frequency of use in media reporting across Canada in the early 2010s and emergence in United States media reports in 2020 (Gatehouse, 2013; Ghosh, 2012; Makuch, 2013; Sullivan, 2020; Wattie, 2013; Woodward, 2020), it refers only to limits placed upon communication. Canadian history however, and the results of the survey, show that interference in science affects both researchers' ability to communicate and ability to conduct work. Introducing a new term could be perceived as adding to the complexity of already competing terminology present in the literature. However, pre-

existing terms do not encompass the phenomenon in a way that is comprehensive enough to refer to the full extent of its causes and impacts, especially since the terms in circulation are not specifically defined in the contexts where they are used. To proceed with my research, it is useful to contribute a definition for the terminology that I employ which appropriately encompasses the full scope of the phenomenon of study. The definition for interference in science I have proposed may not necessarily be the most appropriate terminology for other research contexts, but it may act as a useful starting point for future researchers who are interested in investigating the same phenomenon in another time, location, or domain.

CHAPTER 5 INTERFERENCE IN SCIENCE: DOCUMENTING SCIENTISTS' PERSPECTIVES ON THEIR ABILITY TO COMMUNICATE AND CONDUCT ENVIRONMENTAL RESEARCH IN CANADA

5.1. Introduction

Scientific evidence produced by researchers in the public sector, academia, and industry can be linked to policy and management outcomes by raising awareness, issuing warnings, defining problems, assessing policy options before and/or after implementation, and monitoring implemented policies (Douglas, 2012; Engels, 2005; McNie, 2007). However, best-available scientific research and evidence are often unused or underused in informing law and policy (Cvitanovic & Hobday, 2018; Lubchenco, 1998; Sutherland & Wordley, 2017).

There have been reports of interference with research in the disciplines of environmental studies and sciences from several countries. Recent evidence from Australia suggests researchers working in the environmental studies and sciences, along with medicine and health science researchers, are facing severe science suppression (Driscoll et al., 2021), censorship (Lewis, 2020b), and interference (Mannix, 2022). After similar reports in the United States (Carter, 2019; Lin, 2018; Waters, 2018), the American federal government implemented new scientific integrity policies and launched a 120-day review to document instances of improper political interference (Malakoff, 2021). In Canada, interference of federal environmental researchers began drawing public attention with accounts of "muzzling" in 2012 and 2013 (Gatehouse, 2013; Ghosh, 2012; Turner, 2013). Specifically, there were concerns about scientific integrity in the domain of environmental impact assessment for both public sector science and industry-led science (Haddock, 2018; Jacob

et al., 2018; Office of the Ombudsperson of British Columbia, 2014; Smith et al., 2017; Westwood et al., 2019).

Following the 2015 federal election in Canada, the newly-elected Liberal government introduced a model policy on scientific integrity designed to facilitate federal government researchers' ability to conduct and communicate work free of political interference in over 20 departments and agencies (Treasury Board of Canada Secretariat, 2018). The model policy was adopted across the federal public service; however, there are inconsistencies reported between unique department and agency applications (Legault, 2018). These policies only directly apply to public sector scientists at the federal level; however, it is possible that symbolic leadership by the 2015 (and 2019) elected federal governments who implemented them (Kelly, 2019) may have influenced researchers' ability 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 across Canada.

Beyond negative consequences for the environment, interference in science can affect environmental researchers themselves through mental health impacts of anxiety, grief, or hopelessness (Gilford et al., 2019). When compounded with conflict in the workplace due to increased public contention and politicization of work, negative mental health consequences can worsen and impact job security, motivation, and sense of trust (Driscoll et al., 2021; Gilford et al., 2019).

Informed by the history of interference in science in Canada, this chapter offers an investigation of (1) the prevalence of interference in science for researchers in the

environmental studies and sciences in Canada; (2) the sources of interference in science, and (3) its impacts. The study also describes (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 federal Scientific Integrity Policies has impacted researchers' perceptions of interference.

5.2. Methods

An online survey was used to collect data from self-identified researchers currently living in Canada and working in the environmental studies and sciences. Survey design, data collection, data cleaning, and a summary of participants were described in detail in Chapter 3. For data analysis, I used a mixed methods approach to study both the quantitative and qualitative data collected via the survey responses to four work demographic questions and 13 experience questions.

5.2.1. Quantitative analysis

I used parametric statistical testing to examine whether perceptions of interference differed across province/territory, career stage, research area, and affiliation with any scientific society. For questions recorded as binomial variables (yes = 1 no = 0), including *experience of undue modification to work* (Q10) and *impacts on job satisfaction* (Q17) I used independent chi-square tests. For continuous variables (measured on the 5-point Likert scale), such as freedom to communicate research results (Q12 and Q13) I used one-way ANOVAs to test for omnibus group differences. Cronbach's Alpha test of reliability was also employed in the analysis of Q16 (*perceptions of externally-imposed and internalized sources of interference*) to test reliability of subscales to measure factors that constrain

public commentary. All statistical analyses were completed in R version 1.4.1717 (RStudio, 2021) and the significance threshold was set at $\alpha = 0.05$. When I observed significant differences in ANOVA tests, I probed between group differences further using pre-planned contrasts, and where contrasts were tested post hoc, I corrected for family-wise error by dividing the significance value ($p = <0.05$) by the number of tests performed (Bonferroni correction). All results for statistical tests are available in Appendix E.

5.2.2. Qualitative analysis

Open-text responses were manually coded for themes by two human coders. Each coder was trained on the codebook (Appendix D) and conducted independent coding on 100% of the responses for inter-coder reliability assessment. The process for theme and codebook development allowed for ongoing consensus building between the two manual coders on how to best represent the response themes (O'Connor & Joffe, 2020; Roberts et al., 2019). Following independent coding, a sufficient ~75% reliability threshold was established between the coders (Frey, 2018). Where there was disagreement about how any response should be coded, the coders were given the opportunity to reflect upon and discuss their evaluation, and either keep or change their initial assessment (to address an error or misinterpretation). If the two coders could not come to an agreement, a third member of the data analysis team was asked to break the tie. This approach was used to separate the "noise" of coder disagreement due to mistakes from the "signal" of disagreement, which reflects different and considered judgment of people with different experiences and perspectives (Zade et al., 2018). Codes presented in the paper reflect 100% consensus for highest possible trustworthiness in reporting (Frey, 2018; Nowell et al., 2017; Roberts et al., 2019).

5.3. Results

A total of 741 survey responses are included in the descriptive statistics and statistical analysis reported (Appendix F). Respondents from across Canada are represented in the sample. The largest representation by Province or Territory was from the 33% 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) (Figure 3).

Established career researchers, who have been employed in the field since before 2015 made up the majority of respondents (63%) while only 32% identified as early career researchers who began working in the field after 2015 (inclusive of post docs). The remaining 5% who identified as Retired were screened into the study because they also identified themselves as individuals "currently working in the field of environmental studies or sciences." Most retired individuals identified as professors emeritus or consultants on ongoing research studies and are therefore, included in results for the entire study population. Most (82%) indicated affiliation with one or more scientific society, and 18% were identified as unaffiliated. Multidisciplinary researchers made up 12% of respondents. The remaining were defined according to CDRC classifications, including the Natural Sciences (68%), Social Sciences (7%), Engineering (7%), Medicine (3%), Agriculture and vet sciences (3%), and the Humanities and the Arts (<1%) (Figure 4).

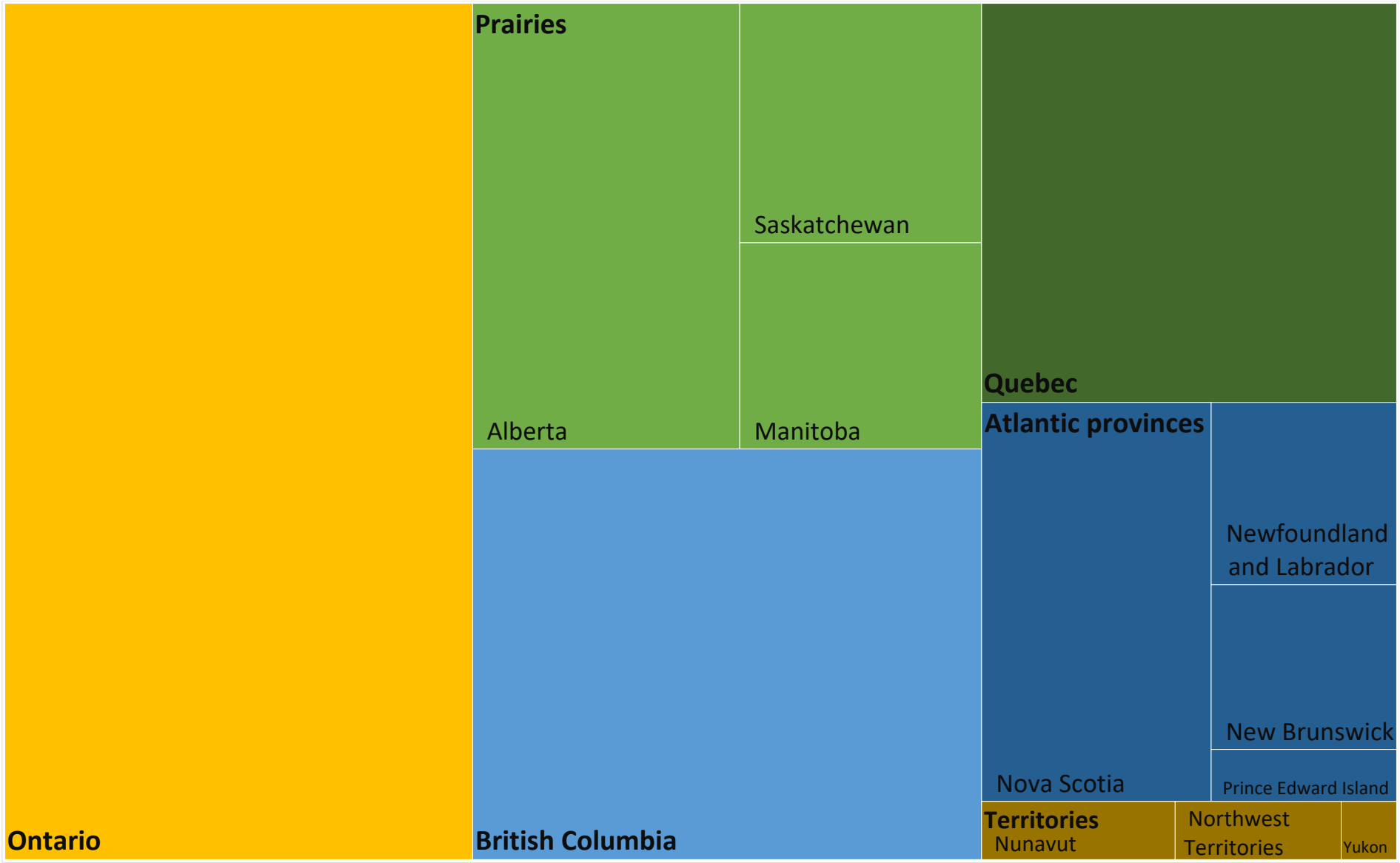

Figure 3. Responses for Q3: Province or Territory. Responses reported in figure (n = 741).

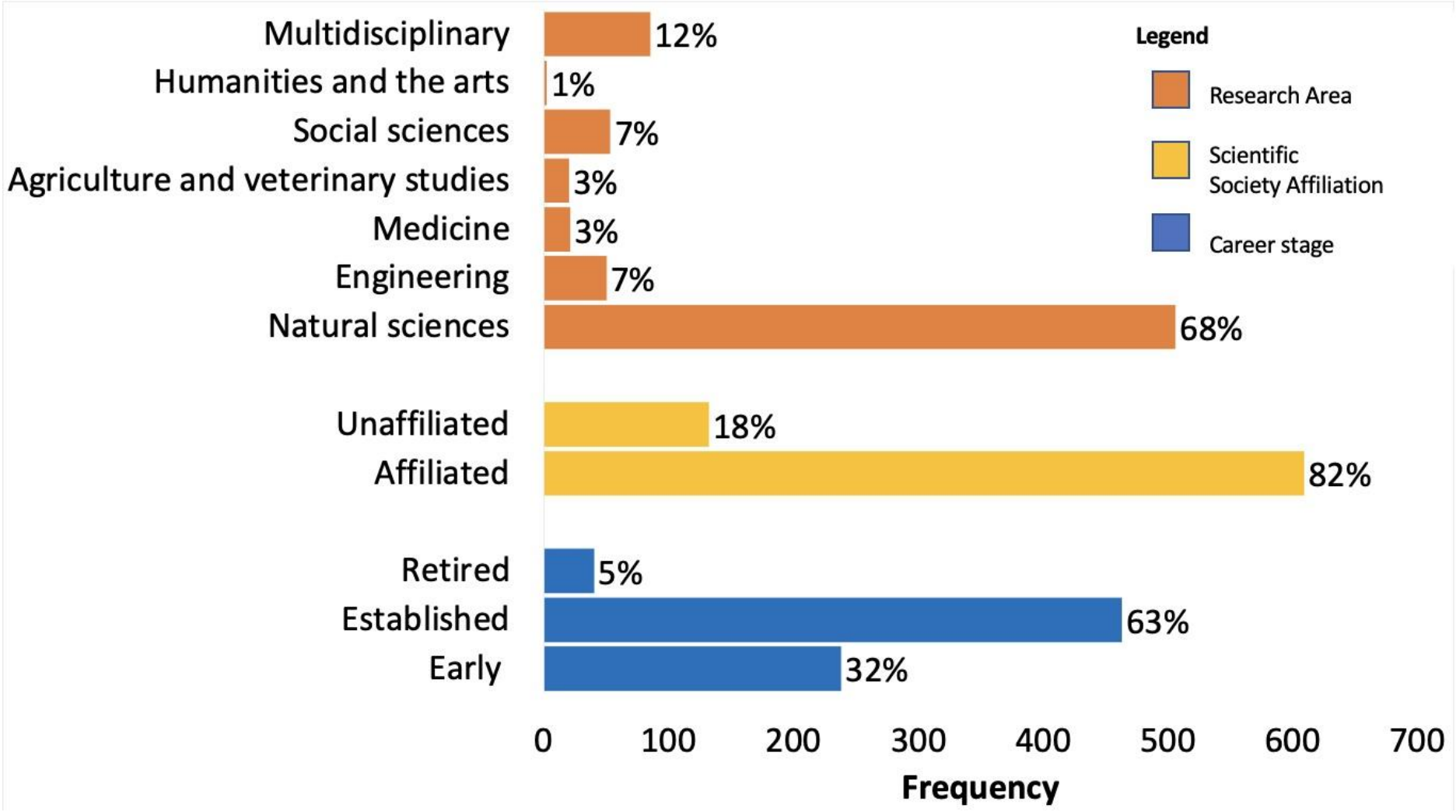

Figure 4. Responses for Q4: Research Area, Q5: Society Affiliation, and Q6: Career Stage. Responses reported in figure (n = 741).

5.3.1. Prevalence of interference in science

To assess prevalence, I first considered the full study sample's experience with interference. Most (84%) respondents said they had never been asked to make "undue modification" (defined as substantive changes to a text or story that downplays, masks, or includes misleading information about environmental impacts) to their work. Nine percent of respondents said they had, and 5% were unsure if they had ever experienced "undue modification" (Q10).

When asked about their ability to communicate work, 54% strongly disagreed with the statement that they are not allowed by their organization to speak freely and without constraints to the media about their research in the environmental studies or sciences (21% somewhat disagreed, 8% somewhat agreed, 7% strongly agreed, and 5% neither agreed nor disagreed) (Q12). Fifty-nine percent strongly disagreed when asked if they have ever received a question from the public or media that they have the expertise to answer but were prevented by doing so by their organization (strongly agree, somewhat agree, somewhat disagree, and neither agree nor disagree all <10%) (Q13) (Figure 5).

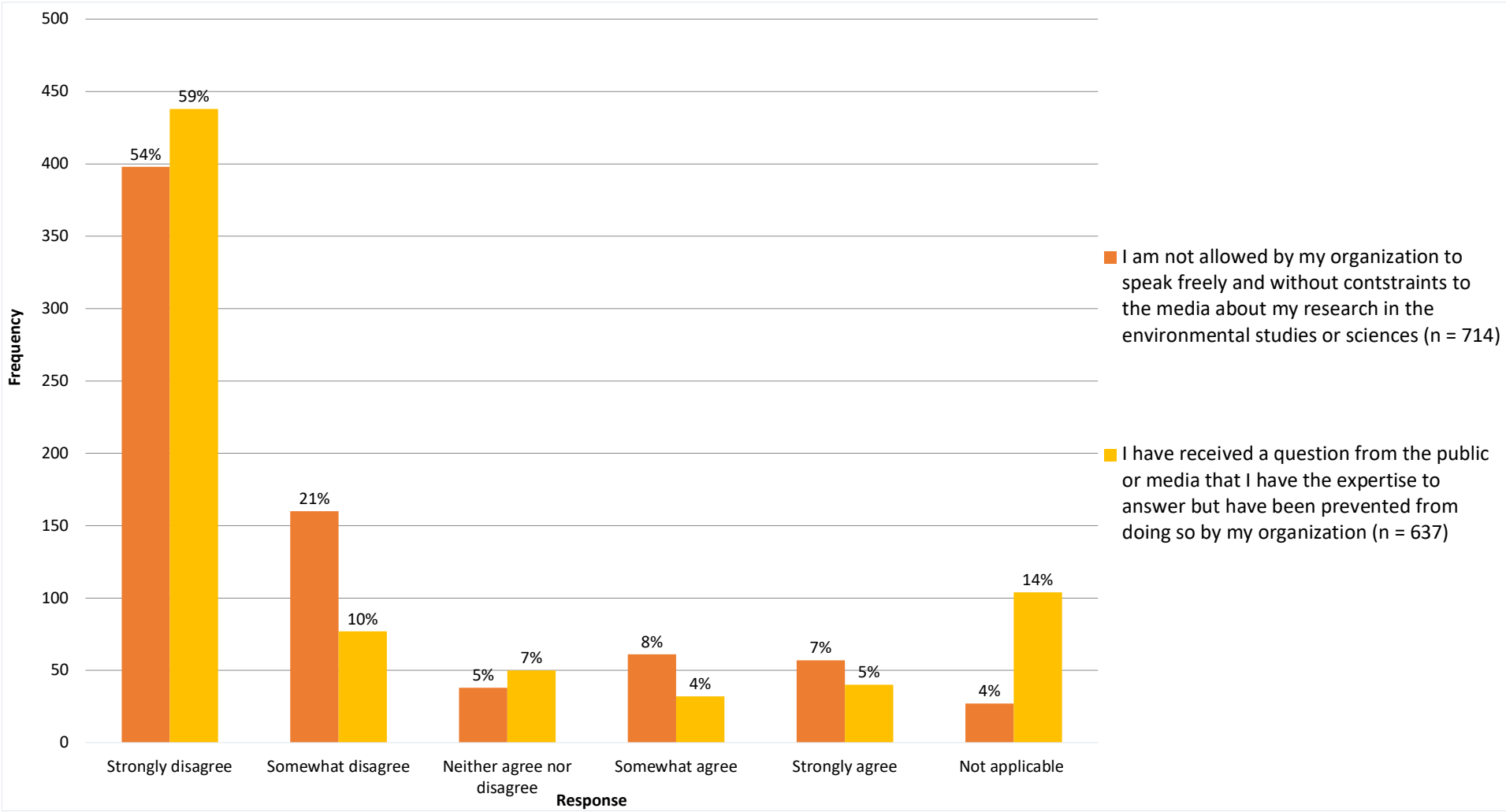

Figure 5. Responses for Q12 (n = 714) and Q13 (n = 637): Ability to communicate research. Responses reported in the figure.

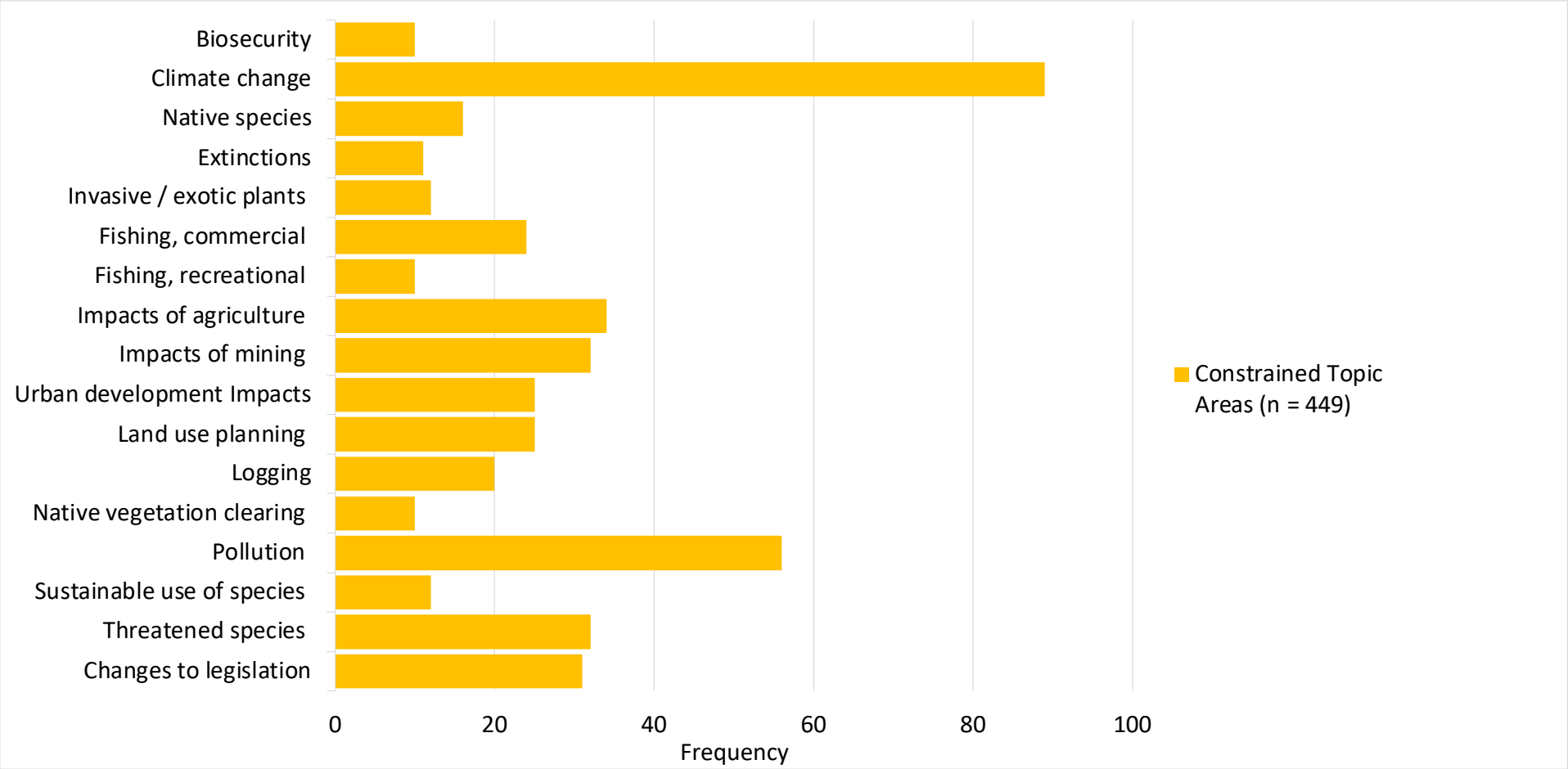

Figure 6. Responses for Q14; Constrained Topic Areas. Responses reported in figure (n = 449).

5.3.2. Sources of interference in science

According to the researchers who reported experiencing undue modification, these modifications were most commonly requested by internal senior management (29%) and 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 that undue modifications be made to scientific work was to downplay environmental risks (26%). Other reasons included to justify an existing law, policy, or Ministerial position (18%), to preserve stakeholder or research partner relationships (11%), avoid internal or public contention (13%), avoid putting any development plans at risk (7%), and to protect an organization's (internal or external) reputation (4%). Appeasing bodies of media or communications staff was reported by 9% of respondents and 7% mentioned risk to current or future funding opportunities for publishing authentic research results (Table 3).

Table 3. Coded responses for Q11: Undue Modification. Why were you asked to make modifications to your work? (n = 67)

Reasoning for modifications requested	Example open-text response excerpt	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 & coworkers 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**

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 percent 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 (39% 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) (Figure 7).

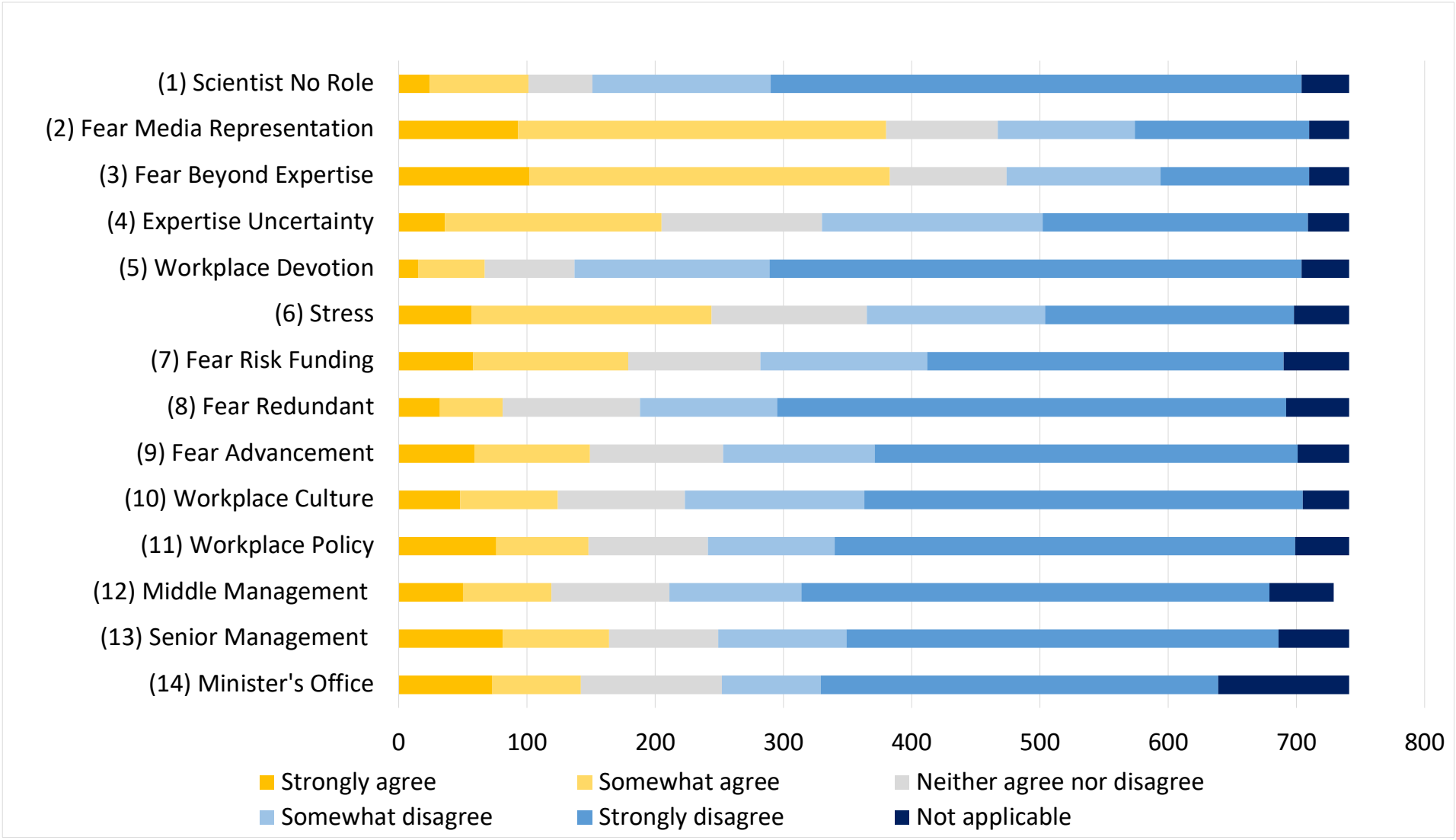

Figure 7. Responses to Q16: Public Commentary. Factors affecting researchers' ability to conduct and communicate research as rated by researchers. Responses reported in figure (n =741).

5.3.3. Impacts of interference in science

5.3.3.1. Environmental impacts

Fourteen percent strongly agreed they were aware of cases where the health and safety of Canadians (or environmental sustainability) has been compromised because of political interference with scientific work at their organization (18% somewhat agree, 20% neither agree nor disagree 12% somewhat disagree, 35% strongly disagree) (Q7) (Figure 8).

5.3.3.2. Science communication

Eleven percent strongly agreed that they were aware of cases where their organization 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 agree, 14% neither agreed nor disagree, 15% somewhat disagree and 40% strongly disagree) (Q8) (Figure 8).

Thirteen percent strongly agreed they were aware of cases where the exchange or transfer or 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 agree, 13% neither agree nor disagree, 13% somewhat disagree, 36% strongly disagree) (Q9) (Figure 8).

5.3.3.3. Researcher's job satisfaction

Nineteen percent of respondents said that their job satisfaction has been affected by restraints on public commentary and peer communication (Q17).

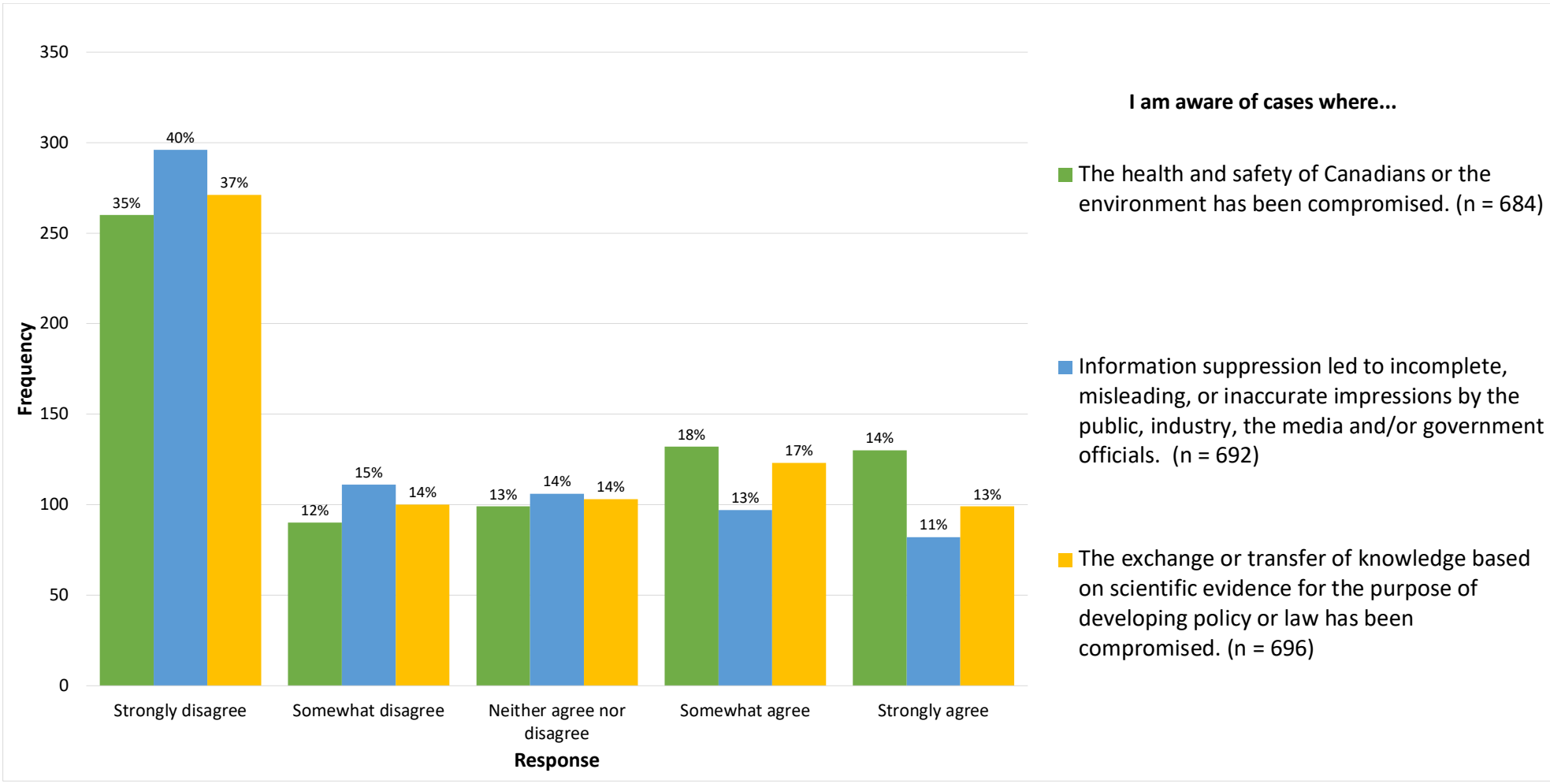

Figure 8. Responses to Q7 (n = 684), Q8 (n = 692), and Q9 n = 696): Awareness of impacts of interference on the environment and science communication. Responses reported in figure.

Table 4. 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 open-text response excerpt	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 my 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 my middle management support/ignored by senior management."*	56	26
Unable to express authentic views	*"The fear of how my peers would judge me has limited my potential to speak about issues that I believe (and know) to be important to ecological processes"*	22	10
Work is redundant, pointless, or invaluable	*"Why am I here if no one cares enough to listen to my evidence, despite 10-25 years of research."*	18	8
Career development opportunities lost	*"Career advancement as a scientist within my organization requires that I participate in media interviews and act as a provincial spokesperson on issues, both of which I am 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

Factors affecting researcher job satisfaction	Example open-text response excerpt	N	Percent (%)
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 my 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**

Of the 129 whose job satisfaction was affected, 30% percent cited muzzling, constraints, and restrictions in communicating scientific work and 5% said insufficient resourcing to conduct work contributed to an impact on their job satisfaction. Others described poor internal working conditions (26%), inability to express authentic views (10%), or feeling that their work was pointless, redundant, or not valuable (8%). A few indicated that they had considered changing fields (4%) or felt that they had lost out on opportunities for professional development due to interference (7%) (Table 4).

Almost half of the respondents (48%) to Q18 (Briefly explain how your job satisfaction was affected), mentioned the 2006–2015 Conservative Party Leader and Prime Minister Stephen Harper or 'the previous administration' in their response (n = 24). Another 28%

referred to instances where an organization or industry development plan had been priorized over environmental protection. Funding as a source of constraint was an issue identified by 12%, and another 12% mentioned having engaged in some form of self-censorship.

5.3.3. Difference of experience of interference in science

To assess the impact of all factors that constrain researchers' public commentary (Figure 7), I used Cronbach Alpha's test of reliability to assess how each of the fourteen factors identified might fit together as subscales. The internalized factors subscale consisted of factors 1–9 ($a = 0.82$). The externally-imposed factors subscale encompassed factors 10–14 ($a = 0.91$). Fear of the media subscale used factors 2, 3, 6 ($a = 0.78$), and fear of negative consequences for engaging in public commentary used factors 7, 8, 9 ($a = 0.83$). Each of these subscales was used to test difference of experience of interference in science in each demographic group. ANOVAs and t-tests found that career stage was the only group with a significant ($p \leq 0.05$) between group difference in their experience of factors constraining their public commentary in areas where they are knowledgeable (Q16).

In comparison to established ($M = 2.95$) and retired researchers ($M = 2.51$), early career researchers ($M = 3.15$) showed significantly higher fear of the media ($F_{(2,689)} = 5.81$, $p < 0.01$). Early-career researchers ($M = 2.56$) also showed significantly higher fear of negative consequences for engaging in public commentary ($F_{(2,643)} = 28.15$, $p < 0.01$) than established ($M = 1.91$) or retired ($M = 1.75$) researchers. Significantly more experience with internalized factors of constrain on public commentary ($F_{(2,643)} = 20.08$, $p<0.01$) was also observed for early career researchers ($M = 2.61$) in comparison to

established (M = 2.25) or retired (M = 1.89) researchers. No significant differences in experiences of interference were observed as a result of province/territory, research area, or affiliation with a scientific society (Appendix E).

5.3.4. Impacts of scientific integrity policies on interference in science

The majority (69%) of respondents were not aware of Canada's most recently introduced Scientific Integrity Policies (ISEDC, 2018) (Q20). Of the 31% who said they were aware of the policies, 41% said that the policies have improved researchers' ability to conduct and communicate scientific research but 12% identified ongoing political interference (Table 5).

Table 5. 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 open-text response excerpt	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. I have personally seen no change."*	28	13
Unsure / I don't know / Not that I am aware of	*"I am not sure - I have not seen any data to support this one way or the other."*	27	13

Impact of the implementation of the scientific-integrity policies	Example open-text response excerpt	N	Percent (%)
Political interference is ongoing	*"No substantial effect at present. This was mainly a response to abuses that occurred during the Harper administration….* *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."*	26	12
Too soon to say	*"I think it's still a bit early to determine the wider consequences of the policies, but I 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**

Open-text responses (Q21) indicate that perceptions of interference have changed since the change of federal governance in 2015 (from Conservative to Liberal leadership), but that the scientific integrity policy model introduced in 2018 is limited in its impact. Thirteen percent belive the policies had no impact, or are unsure, while another 5% believe it is too soon to say.

5.4. Discussion

My research documents the perceptions of environmental researchers living in Canada and working in the environmental studies and sciences several years after the end of the alleged "war of science." The results indicate that although it is not the experience of most researchers, political interference with researcher's ability to conduct and communicate their work is ongoing for many. Internal managerial bodies, and external research partners are the primary perpetrators of interference in research focus and results dissemination. Interference in science has negative consequences for the environment, and for science communication that could otherwise imply effective knowledge transfer between knowledge producers and users including decision-makers and the public.

However, the consequences of interference are primarily affecting researchers' themselves. In particular, early career researchers demonstrate a stronger fear of the media and of negative consequences for engaging in public commentary, which may lead to self-censoring behaviours and widen the science-policy gap in Canada. In open-text responses, a number of individuals did indicate that since the election of a Liberal government in 2015, conditions for researchers seem to have improved in comparison to the prevalence

of interference between 2011 and 2014. However, the new scientific integrity policy model is not frequently credited by survey respondents as the source of those improvements.

5.4.1. Drivers of interference in science

Constraints on communication were defined in Q14 as any pressure applied to deter public or political engagement, or provision of information or commentary in areas that a researcher is scientifically knowledgeable. Respondents indicated that they experienced this type of constraint on communication on the topic of climate change, pollution, and the impacts of a broad range of industries (Figure 6). 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 (Haddock, 2018; Jacob et al., 2018; Maclean et al., 2015; Office of the Ombudsperson of British Columbia, 2014; Paskett et al., 2011; T. Smith et al., 2017; 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 (Figure 6) are also congruent with media reports in Canada from 2012–2013 (Ghosh, 2012; E. May, 2012; Turner, 2013).

Surveyed researchers who have experienced undue modification to their work indicated that modifications had been requested because of political motivations. For example, to justify existing laws, policies, and regulations that allow resource development to continue despite the negative consequences for the environment (Table 3). Concerns are ongoing, as accusations have recently been reported in the media against senior management at the Department of Fisheries and Ocean Canada (DFO) for undue modification, whereby a science advisory report was substantively altered without the knowledge of the scientific

researchers who produced the report (Szeto, 2022). The researchers interviewed believe that DFO is attempting to "cover up" research that could identify current commercial fishery regulations as a culprit leading towards the extinction of local fish species (BCWF, 2022; Szeto, 2022).

Though it may only seem relevant to government researchers, political motivations can impact all sectors. Laboratories and academic institutions across the country rely substantially on federal funding agencies who are perceived as having interests implicitly aligned with the federal government and in alignment with industry and financial motivations (e.g., response to Q18 (Table 4): *"Public opinion or ideas other than scientific facts are taken/used by politicians, then became a policy or funding theme constrains which would affect my research advancement to be forced steering towards these ideas"*). Some of the survey respondents believe that research proposals have been rejected by federal funding agencies on the basis that it may uncover evidence to contradict the industry preferred findings on environmental impacts (e.g., response to Q11 (Table 3): *"My Department Chair, because the findings were deemed too unflattering for the provincial government, which provides funding for my institution. This happened numerous times. My Dean of Science, because the findings were contrary to the claims made by the provincial government"*). Though federal scientific integrity policies have been put in place to "free" federal researchers, some respondents indicated that they believe the focus and types of research proposed are still politically motivated. Similar reports are emerging in Australia that indicate funding agencies may be exhibiting detrimental biases against researchers, particularly those working in "fundamental research areas" (Mannix, 2022).

5.4.2. Navigating interference in science communication

Effective science communication results in an informed public, and informed decision-makers (McNie, 2007). Decision-makers are the people who draft, negotiate, and enact laws and policies, ideally, informed by the best-available research and evidence. An informed public is in turn, also equipped with the information required to form opinions about what laws, policies, and political actions they support, and which ones they disagree with. As a result, they are able to act on those opinions when it comes to their democratic vote (Driscoll et al., 2021; Lester & Foxwell-Norton, 2020; Qaiser et al., 2022). When the public is misinformed by misleading, partial, or false information there is no way to ensure democratic processes based on informed public opinion can take place (Douglas, 2012; Hahn, 2019; Lester & Foxwell-Norton, 2020; McNie, 2007). It is therefore cause for concern that 24% of the total researchers surveyed (178 individuals) agreed that they are 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 (Q8).

Constraints and undue modification to scientific research and evidence result in an ill-informed public and ill-informed decision-makers who are responsible for weighing all available evidence (Douglas, 2012; Hahn, 2019; Heer et al., 2021; McNie, 2007). When the public is ill-informed, they are unable to partake in the democratic decision-making process that relies on transparent access to all the information available (Lester & Foxwell-Norton, 2020; Qaiser et al., 2022). In addition, fake news can fill the voids where appropriate evidence is lacking, which can advance the erosion of democratic processes (Driscoll et al., 2021).

Issues with public sector researchers' ability to communicate scientific work that is accurate and timely was frequently anecdotally reported in Canadian media between 2012–2014 (Learn, 2017; Turner, 2013), but appears to be an ongoing issue for some of the surveyed researchers (63) who described experiences with muzzling, restrictions on communication and constraining factors that affect job satisfaction. 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). Although most respondents did not mention a contentious relationship with communications staff, several describe frustration with having to work with personnel who do not share their expertise which can results in miscommunication of evidence to the public or to decision-makers who act upon it (e.g., response to Q11: *"Public relations. Reason is hard to tell. Probably because they lack experience in the area.", "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 of myself (and my colleagues) do (and of course what our research actually means)"*). It is worth noting that communications personnel themselves are likely not deliberately misrepresenting the research they report. It is much more likely they simply do not share the expertise of researchers. Similarly, researchers do not always have an expertise in communication and information dissemination. Issues arise when findings are altered or when key information is removed that leads to misrepresentation or to the dissemination of misinformation.

5.4.3. Fear and self-censorship in environmental research

Incidents of self-censorship have been reported in the United States (Carter, 2019) and by Driscoll et al. (2021) who found evidence of self-censorship as a primary factor

constraining scientists from providing public commentary. Consistent with findings from Carter (2019) and Driscoll et al. (2020), some of my survey respondents shared a fear of the media and of negative consequences that lead to self-censoring of public commentary (e.g., response to Q18 (Table 4): *"I have been publicly attacked because if (sic) my research and media experiences. My student had to deactivate her Twitter account because of harassment."*) More than one third of the sample strongly agreed that fear of how they may be represented by the media was a factor constraining their public commentary (Q16). Fear of being drawn to comment beyond the boundaries of their expertise (54%), and stress around discussing contentious issues (33%) was also relatively high both in my survey, and according to Australian respondents surveyed by Driscoll et al. (2021).

New results in my research study additionally reveal that early career researchers in Canada experience the highest rates of fear and self-censoring behaviours in comparison to established researchers. This was contrary to my expectation that higher rates of fear would be among researchers who had been working in the field prior to 2015, under a Conservative government infamous for inciting the "war on science" in Canada (Ghosh, 2012; Turner, 2013). One potential cause of fear and self-censorship experienced by early career researchers is the compounding effects of the negative psychological impacts sometimes associated with working in the field of environmental sciences and studies (Gilford et al., 2019).

Environmental and climate research is perceived both by respondents from my survey and by environmental professionals represented in Guilford et al. (2019) as sometimes redundant or hopeless (8%), in part because of governments' ineffectiveness at implementing adequate environmental protections through law, policy, and regulations for

industry (Table 4). Evidence suggests that the combined challenges of needing to engage in self-advocacy in addition to conducting scientific work and holding the responsibility for communicating the findings effectively, is causing undue emotional strain for researchers (Gilford et al., 2019). In many cases, this strain can lead to anxiety, self-doubt, and negatively charged emotions (Gilford et al., 2019) potentially contributing to the sense of fear and uncertainty in engaging with public commentary (Q16).

A proportion (9%) of the researchers surveyed also expressed issues with job satisfaction due to restraints (Q17). Respondents cited moral disagreement with what they were being asked to do, feeling demoralized or frustrated, having low trust and motivation, and some mentioned an inability to express authentic views or carry out work that they believe in (Table 4). Some of the affected group also reported feeling that their work was redundant, pointless, or not valuable (8%) due to corrupt research motivations or corruption of research at the dissemination and action phase. The total number of researchers in my study sample who identified as experiencing these conditions on an ongoing basis is relatively small (<10%), however, any amount of severe dissatisfaction with their work, particularly due to political interference, worthy of attention.

5.4.4. Effectiveness of solutions studied

Forty-one percent of the survey respondents that were aware of the scientific integrity policies (86 individuals) believe that the policies' implementation has improved researchers' ability to conduct and communicate scientific research (Table 5), specifically, 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 are able to

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 that the scientific integrity policies themselves did not have the most impact (e.g., response to Q21 (Table 5): *"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"*). Each federal department required to implement scientific integrity policies was responsible for developing policies that were based on the model policies, but unique to the department, so their application between departments and enforcement is sometimes uneven and is not always enforced (Table 5).

5.6. The way forward

Eliminating interference in science would better ensure that environmental researchers have the resources and support necessary to conduct their work and communicate their findings to knowledge users who can then consider the best-available information in their decision-making processes. Protecting scientific integrity and the 'freedom' of environmental researchers to conduct scientific work and communicate results does not imply that knowledge mobilization will be effective, nor does it guarantee evidence-informed environmental decision-making in the future. What it can achieve, however, is support for democratic processes by enabling the public to form research-based opinions and influence government action.

Moving forward, early career researchers in the environmental studies and sciences in particular must be supported to mitigate the environmental grief, anxiety, and hopelessness associated with their work in order to preserve their motivation and engagement, which is vital to the continued production of knowledge (Gilford et al., 2019). Science communication itself must also be improved to combat the void filled by fake news or misinformation that impact democratic decision-making process (Driscoll et al., 2021; Heer et al., 2021). This could be achieved by offering science communication and media training for interested researchers to alleviate their fear of the media and increase their opportunity to engage in public commentary. Hiring specialized personnel trained in science communication to facilitate knowledge transfer between researchers and communications staff, or training both existing researchers and communications personnel on how to communicate scientific evidence in laymen's terms (Lester & Foxwell-Norton, 2020) could reduce some of the contention with communications personnel reported by the researchers surveyed.

As recommended in previous research (Driscoll et al., 2021; Jacob et al., 2018; Westwood et al., 2019), authorities independent of government and industry could also be mandated with preventing interference in science and fostering 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 support trust of science and science communication.

5.6.1. Future research

In other parts of the world, extreme cases of interference are being experienced. 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, have also increased in the United States in the past five years (Carter, 2019; Goldman et al., 2017; Lin, 2018; Sullivan, 2020; Waters, 2018) before investigations into political interference in science were initiated in 2021 (Malakoff, 2021). In Australia researchers have witnessed increased funding for engineering and technology, and experimental development research but the proportion of funding allocated to fundamental research and natural sciences has declined in comparison to twenty years ago (Mannix, 2022). Still, little is known about what other forms and prevalence science interference has in other parts of the world.

In Canada, extreme and life-threatening consequences are not an imminent risk, and researchers surveyed (75%) agree they are able to freely communicate their work. However, the fact that 92% of researchers surveyed have experienced at least one facet of interference in science is an important and concerning finding. It is also evident that there are degrees of politically-driven interference that are ongoing that cannot be ignored. I propose future research be conducted into accusations of political bias in federal funding agencies, and that interference in science more generally be regularly studied in Canada to contribute up-to-date knowledge about the prevalence of the phenomenon on an ongoing basis. If future researchers continue to create an awareness for the issues and consequences associated with interference, attention for the issue can increase, and hopefully, lead to improvements.

5.7. Conclusion

My research study reveals that interference in science is an ongoing phenomenon in Canada and the experience can be more severe for early career researchers in comparison to established researchers. Although some improvements have been made in the last decade to strengthen scientific integrity and free environmental researchers to communicate their results, my data reveals that many researchers perceive ongoing interference and corresponding impacts to their careers. Environmental researchers contribute valuable information that can support decision-making on the part of the public and of the elected officials who are responsible for representing them and their interests. However, it is still the case that this research is not always prioritized, viewed in full, or in some cases, allowed to be pursued. Although each individual facet of interference is not experienced by the majority of researchers, ongoing constraints leading to the erosion of democratic processes, environmental consequences, and negative impacts on researchers' mental health and job satisfaction remain cause for concern. Future and regular research into the prevalence of interference is vital to bring awareness to challenges being faced by researchers and develop an understanding of potential solutions to reduce interference and avoid its consequences.

CHAPTER 6 CONCLUSION

Recent history suggests that the ability of environmental researchers in the public sector to conduct and communicate work in Canada has been threatened by politically-motivated interference in science (PIPSC, 2015, 2018; Turner, 2013; Szeto, 2022). In my research study, I focused on two overarching objectives. First, to define appropriate terminology for the phenomenon and second, to document the prevalence of interference in science post the last known study in 2017, and since the implementation of scientific integrity policies in federal government departments to describe its impacts.

In my thesis, I used science to refer to academic disciplines that apply a scientific method, including those in the natural sciences and social sciences. Interference in science, when deliberate and intended to compromise scientific research or science communication is posited as a problem in the context of my research because it threatens democratic decision-making processes, effective knowledge mobilization, and information evaluation that could lead to better environmental management and outcomes, and the improved mental health and job satisfaction of researchers. What constitutes interference however, and how to differentiate between constraints on researchers and other consequences of interference as a result of intentional and deliberate action or unintentional action can be subjective.

Informed by my research I was able to develop a definition of interference that appropriately encompasses the full scope of the phenomenon prevalent in Canada and possibly elsewhere in countries like the United States and Australia. The most important consideration when developing my definition was that both researchers' ability to conduct scientific work, and their ability to communicate the results of their work was accounted

for because of the impacts interference in science has on both of those parts of the researcher's role. The value of the term's definition is specific to my research and may not necessarily prove useful in other research contexts, but it is an important starting point to encourage future research on this topic.

Actions that constrain researchers like budget cuts, or unpublished research is quantifiable, but the motivations driving those actions are speculative. In this thesis, I accept respondents' accounts of their experiences of interference and its impacts as true, but there is no way for me to know whether those experiences were a result of deliberate political interference on the part of those accused.

Overall, my work contributed a definition for interference in science, and new primary data on the perceptions of environmental researchers and their experiences with interference in Canada. Given the potentially severe negative impacts of interference in science on researchers, democratic decision-making processes, and environmental management, the merits of its definition and the measures used to quantify the phenomenon are worthy of further discussion and debate in future research pursuits.

In particular, I found that early-career researchers in Canada have been disproportionately affected by interference as compared to their peers, predominantly because of their fears related to engaging with the media and negative consequences for engaging in public commentary. The resulting self-censoring behaviours may, over time, perpetuate the science-policy gap. A third of environmental researchers surveyed were aware of cases where the health and safety of Canadians (or environmental sustainability) has been compromised because of political interference, and there is evidence of ongoing

interference in the public sector despite steps taken by the federal government to protect scientific integrity. Despite the improvements made in the past decade, any amount of ongoing political interference in science that compromise researcher's ability to conduct and/or communicate scientific work is cause for concern.

This research study was limited in its scope to measure interference only in Canada, and only for researchers working in the environmental studies or sciences, but as the awareness and reporting of interference in science grows in Australia (Driscoll et al., 2021; Lewis, 2020a, 2020b; Mannix, 2022), the United States (Lin, 2018; Sullivan, 2020; Woodward, 2020) and elsewhere, so does the necessity for solutions. In extreme cases, ecological researchers in Brazil have experienced life-threatening forms of interference such as death threats, break-ins, and attempted kidnappings for research in agrochemicals and deforestation (Torres, 2021). Public calls for support have been issued for a case in Iran (Nature, 2022) where environmental researchers studying endangered species have been imprisoned (Catanzaro, 2019; Nature, 2022). Still additional research is required in locations outside of Canada to understand what forms interference in science can take and how they can impact science communication, policy and governance, and the researchers involved.

In Canada, regular follow-up survey of researchers could provide an understanding of the changing prevalence of interference in science over time. Extending the methods beyond surveys to qualitative interviews could allow for insight into approaches to prevent or mitigate interference. In other domains, like medicine and public health, the COVID-19 pandemic has shed light on the politicization of research in medicine, which would be

worthy of attention as public health science and communication are being interfered with as well, leading to issues in public opinion informed by misinformation (Heer et al., 2021).

It is generally agreed upon in academic communities that in order to make important decisions, we must be equipped with the best-available science to debate upon and inform the most appropriate way forward (Gibbs & Westwood, 2015). However, in recent years the rising debate has been on science itself and the validity of scientific investigation as a means of determining fact. This politically and financially motivated debate, perpetuated in particular by social media, has led to an increase in mis or disinformation that is inherently not factual or based in scientific fact and the widening of a dangerous political divide (Heer et al., 2021). In some cases, misinformation has been created to fill an evidence gap where scientific research and evidence are lacking in the public sphere (Driscoll et al., 2021).

Without sufficient scientific evidence to inform public opinion, the public is less able to evaluate information and make determinations about what they believe is the best way forward (Douglas, 2012; McNie, 2007). If this knowledge gap is going to be filled with reliable, empirical evidence, researchers must be sufficiently resourced to achieve their objectives and produce research and evidence that the public and decision-makers can access and understand. To equip knowledge users with the information they require to weigh and make determinations about the information, we must support knowledge producers to develop and share that information through knowledge mobilization. Interference in science poses a barrier to knowledge mobilization, and by studying this phenomenon, it can be brought to the attention of those who are in a position to act to ensure the protection of scientific integrity and research in their institutions.

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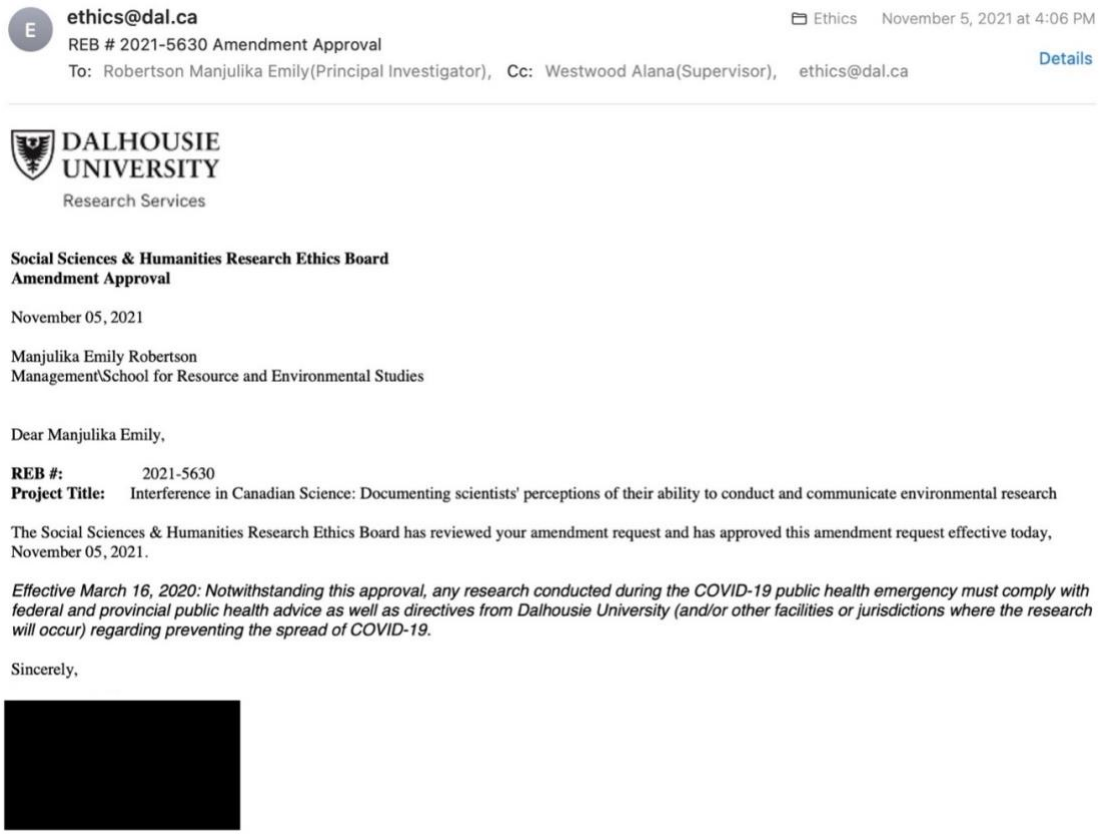
APPENDIX A ETHICS CERTIFICATE

Ethics approval



ethics@dal.ca
REB # 2021-5630 Amendment Approval
To: Robertson Manjulika Emily(Principal Investigator), Cc: Westwood Alana(Supervisor), ethics@dal.ca

Ethics November 5, 2021 at 4:06 PM
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]

Confidentiality agreement

Confidentiality Agreement

This agreement is between:

Dr. Alana Westwood & Manjulika E. Robertson,
School for Resource and Environment Studies, Dalhousie University
and
Samantha Chu, Dalhousie University
for
Interference in Canadian Science: Documenting scientists' perceptions of their ability to conduct and communicate environmental research [REB file #2021-5630]

Summary of job description/service provision:

Lead the data analysis for Research Question 3, participate in the drafting of public-facing communication materials, and co-lead the second publication.

I agree to:

1. keep all the research information shared with me confidential. I will not discuss or share the research information with anyone other than with the *Researcher(s)* or others identified by the *Researcher(s)*.

2. keep all research information secure while it is in my possession.

3. return all research information to the *Researcher(s)* when I have completed the research tasks or upon request, whichever is earlier.

4. destroy all research information regarding this research project that is not returnable to the *Researcher(s)* after consulting with the *Researcher(s)*.

5. comply with the instructions of the *Researcher(s)* about requirements to physically and/or electronically secure records (including password protection, file/folder encryption, and/or use of secure electronic transfer of records through file sharing, use of virtual private networks, etc.).

6. not allow any personally identifiable information to which I have access to be accessible from outside Canada (unless specifically instructed otherwise in writing by the *Researcher(s)*).

7. other (specify):

Transcriptionist/Research staff:

Samantha Chu	[redacted]	07/05/2021
(Print Name)	(Signature)	(Date)

I agree to:

1. Provide detailed direction and instruction on my expectations for maintaining the confidentiality of research information so that *Samantha Chu* can comply with the above terms.

2. Provide oversight and support to *Samantha Chu* in ensuring confidentiality is maintained in accordance with the Tri Council Policy Statement *Ethical Conduct for Research Involving Humans* and consistent with the Dalhousie University Policy on the *Ethical Conduct of Research Involving Humans*.

Researcher(s)

Alana Westwood		07/05/2021
(Print Name)	(Signature)	(Date)
Manjulika E. Robertson	[redacted]	07/05/2021
(Print Name)	(Signature)	(Date)

Permission to replicate survey questions

From: Don Driscoll d.driscoll@deakin.edu.au
Subject: RE: Permission to replicate your study
Date: June 3, 2021 at 5:49 PM
To: MJ Robertson manjulika.robertson@dal.ca
Cc: Alana Westwood a.westwood@Dal.Ca

DD

CAUTION: The Sender of this email is not from within Dalhousie.

Hi MJ, I give you permission to use the same questions that were included in my survey and published in my conservation letters paper of 2020: Driscoll, D. A., Garrard, G. E., Kusmanoff, A. M., Dovers, S., Maron, M., Preece, N., Pressey, R. L. & Ritchie, E. G. (2020). Consequences of information suppression in ecological and conservation sciences. *Conservation Letters* **14**, e12757. https://conbio.onlinelibrary.wiley.com/doi/full/10.1111/conl.12757.

Don

From: MJ Robertson <manjulika.robertson@dal.ca>
Sent: Friday, 4 June 2021 6:18 AM
To: Don Driscoll <d.driscoll@deakin.edu.au>
Cc: Alana Westwood <a.westwood@Dal.Ca>
Subject: Permission to replicate your study

Hello Dr. Driscoll,

I hope you are well!

I'm reaching out to seek written confirmation from you that I have your permission to use the questions used in your survey studying science suppression in Australia in the survey I that I am replicating in likeness to distribute to researchers in Canada for my thesis. We have discussed the use of the questions previously, I know, but I am looking for your explicit permission so that I can demonstrate it to Dalhousie's Research Ethics Board who are currently reviewing my application and research proposal.

Thank you in advance for your support!

Best,
MJ

Manjulika E. Robertson (she/her)
MES Candidate, School for Resource and Environment Studies
Dalhousie University, Halifax (K'jipuktuk), Nova Scotia

APPENDIX B RESEARCH INSTRUMENTS

Research study survey

Survey screening questions

Page 2: Screening Questions

1. Do you identify as a researcher in the 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
    - Northwest Territories
    - Nunavut
    - Yukon

Survey questions

Page 3: Scientific / Work Demographics

1. 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

2. 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

3. 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).

4. 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 my organization.

5. I am aware of cases where my 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.

6. 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 my organization has been compromised by political interference.

7. Have you ever experienced 'undue modification' to your work by your organization, such as substantive changes to a text or story that downplays, masks, or includes misleading information about environmental impacts?
    - Yes
    - No
    - Unsure

8. 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).

9. I am allowed by my organization to speak freely and without constraints to the media about my research in the environmental studies or sciences.

10. 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.

11. 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 = I have not experienced any constraints

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

13. 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).

My 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 = My belief that scientists have no role in making public commentary beyond information provision

2 = My concern about how I may be represented by the media

3 = My fear of being drawn to comment beyond the boundaries of my expertise

4 = My uncertainty about the boundaries of my expertise

5 = My belief that my primary obligation is to my organization, rather than to the public

6 = My stress around discussing contentious issues

7 = My fear of risking funding opportunities

8 = My fear of being made redundant

9 = My fear of reducing opportunities for advancement

10 = My workplace colleagues / peer pressure / work culture

11 = My workplace policy

12 = My middle management

13 = My senior management

14 = The Minister's office

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

15. 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

16. How would you define the term 'interference in science'?
    Open Text Response

17. Are you aware of the Scientific Integrity Policies implemented in Canadian federal government departments by in 2019?
    - Yes
    - No

18. 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

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

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

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

22. 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

23. 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

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

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

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

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

28. 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

Follow-up survey

Page 1: Follow-up Options

Thank you for participating in our survey on interference in the environmental sciences in Canada.

We have a few additional questions for you and a chance to win one of three gift cards. Your answers to these questions are not linked to your responses on the previous survey in any way.

1. Would you like to be informed of the results of this research?

   Upon completion of the data analysis, the research team will compile an overview of the results and send out information on where the results can be found to participants who indicate 'Yes' below and provide their email address.

   - Yes
   - No

2. Would you like to be contacted to participate in future research opportunities related to this issue?

   - Yes
   - No

3. Would you like to be entered for the chance to win a $50 gift card or a donation of $50 to the organization of your choice?

   Of the survey participants who indicate 'yes', three individuals will be randomly selected and contacted via email to claim their $50 prize of a gift card or donation. These communications will be kept confidential and brief and take place after the data collection period is complete.

   - Yes
   - No

4. If you answered yes to any of the above, please enter your email address so that we may contact you.

   Your email address will be kept confidential and used only for the purpose of communicating with you about your interests as indicated above.

   Email: *Open Text Response*

   Submit

Page 2: Debrief

Thank you for completing the follow-up survey.

If you indicated interest in being informed of the research results, you will be contacted once via email before the end of 2021 to receive information on the findings of the study.

If you are one of the three winners of the draw, you will be contacted individually after the data collection period is complete (estimated to be [DATE TBD]). Unsuccessful participants will not be contacted.

Thank you for submitting your responses to the survey on interference in environmental sciences in Canada.

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 | woodlab@dal.ca

Email to winners of the draw

FROM: woodlab@dal.ca

Hello,

Congratulations! You have won one of three prizes of a $50 gift card to an online store of your choice or sum to be donated on your behalf to the organization/charity of your choice.

Please reply to this email before [DATE TBD] to indicate your choice of gift card or donation and the name of the store or organization/charity of your choosing.

Thank you again for your participation in the research study on interference in the environmental sciences in Canada.

If you have any further questions, you may contact us 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 | woodlab@dal.ca

APPENDIX C RECRUITMENT MATERIALS

List of scientific societies

Society name	Participation status	Dissemination method	Reach (if known)
Canadian Society for Ecological Economics	Yes		
Canadian Institute of Forestry	Yes	Newsletter; social media	
Atlantic Canada Coastal and Estuarine Science Society	Yes	Email to membership	
Canadian Meteorological and Oceanographic Society	Yes	Email to membership	
Atlantic Society of Fish and Wildlife Biologists	Yes	Email to membership; social media	
The Canadian Network for Environmental Education and Communication (EECOM)	No		
Alberta Mycological Society	No		
Canadian Society for Hydrological Sciences	No		
The Canadian Section of The Wildlife Society	No		
Society of Canadian Ornithologists	No		
Entomological Society of Manitoba	Yes	Email to membership	
Environmental Studies Association of Canada	Yes	Listserv; Newsletter	

Society name	Participation status	Dissemination method	Reach (if known)
Canadian Entomological Society	Yes	Website; social media	
Canadian Society of Zoologists	Yes	Email to membership; website	
Birds Canada	No		
Alberta Native Plant Council	No		
Canadian Association of Geographers	Yes	Listserv	
Canadian Herpetological Society	Yes	Email to membership	345
IALE - North America	No		
MEOPAR	Yes	Internal email	125
Society for Ecological Restoration	No		
Canadian Society for Ecology and Evolution	No		
Canadian Society of Soil Science	Yes	Email to membership	
Royal Canadian Geographical Society	No		

Communications instruments

Email request for scientific societies to disseminate survey

FROM: woodlab@dal.ca

Hello [INSERT NAME OF CONTACT OR SOCIETY],

I am a Master's student at Dalhousie University at the School for Resource and Environment Studies under the supervision of Dr. Alana Westwood. We are conducting a survey-based study characterizing the perceptions of Canadian researchers in the environmental studies and sciences with regard to interference in their work.

Your society has a broad membership and a strong reputation for representing the interests of researchers in the [DISCIPLINE WITHIN THE ENVIRONMENTAL SCIENCES AND/OR STUDIES]. I would like to ask if your society would disseminate our survey link directly to your members.

We believe that the results of our survey will be of interest to your membership. Participants may request to be advised of study results as well as to be entered in a draw for one of three $50 gift cards. In addition, I can offer your society summarized demographic data related to your membership. These data will assist in providing an increased awareness of who your membership is most representative of and which demographics you are reaching, which will be particularly useful if your society has inclusion and diversity targets.

For more information on the survey and its objectives, I have pasted a template email for your reference and potential use in disseminating the survey below my signature.

Our survey is currently undergoing the ethical review by the Dalhousie Research Ethics Board.

Once the project is approved, I will confirm the dates for the data collection period wherein you may disseminate the survey link.

If this is request is feasible and of interest, please respond as soon as possible so that we may confirm your agreement and sort out the details.

Thank you in advance for your consideration and I hope to hear from you soon.

Sincerely,

Manjulika E. Robertson (she/her)
MES Candidate, School for Resource and Environment Studies
Dalhousie University, Halifax (K'jipuktuk), Nova Scotia
www.westwoodlab.ca | woodlab@dal.ca

[INSERT TEXT FROM 2.3.1, 2.3.2, and 2.4.1 HERE]

Reminder / check in with scientific societies

FROM: woodlab@dal.ca

Hello [INSERT NAME OF CONTACT OR SOCIETY],

You recently received an email from this address asking for your collaboration on a study and for you to disseminate a survey to support research on interference in the environmental sciences in Canada. The text from the original email detailing the request is below:

~
I am a Master's student at Dalhousie University at the School for Resource and Environment Studies under the supervision of Dr. Alana Westwood. We are conducting a survey-based study characterizing the perceptions of Canadian researchers in the environmental studies and sciences with regard to interference in their work.

Your society has a broad membership and a strong reputation for representing the interests of researchers in the [DISCIPLINE WITHIN THE ENVIRONMENTAL SCIENCES AND/OR STUDIES]. I would like to ask if your society would disseminate our survey link directly to your members.

We believe that the results of our survey will be of interest to your membership. Participants may request to be advised of study results as well as to be entered in a draw for one of three $50 gift cards. In addition, I can offer your society summarized demographic data related to your membership. These data will assist in providing an increased awareness of who your membership is most representative of and which demographics you are reaching, which will be particularly useful if your society has inclusion and diversity targets.

For more information on the survey and its objectives, I have pasted a template email for your reference and potential use in disseminating the survey below my signature.

Our survey is currently undergoing the ethical review by the Dalhousie Research Ethics Board.

Once the project is approved, I will confirm the dates for the data collection period wherein you may disseminate the survey link.
~

We are looking for you to confirm if this is feasible and of interest. Please respond as soon as possible so that we may confirm your agreement and sort out the details.

Thank you in advance for your consideration.

Sincerely,

Manjulika E. Robertson
MES Candidate, School for Resource and Environment Studies
Dalhousie University, Halifax (K'jipuktuk), Nova Scotia
www.westwoodlab.ca | woodlab@dal.ca

[INSERT TEXT FROM 2.3.1, 2.3.2, and 2.4.1 HERE]

Invitation to participate in the survey

FROM: [Scientific Society Address] OR woodlab@dal.ca

Hello,

You are invited to a participate in a research study on interference with environmental research in Canada conducted by a Master's Thesis student from the School of Resource and Environment Studies, at Dalhousie University.

Purpose: To document scientists' perceptions of their ability to conduct and communicate environmental research in Canada.

Eligibility: If you are currently working in Canada in the field of environmental studies or sciences, you will be asked to answer questions about your work, personal demographics (e.g., career stage, gender, etc.) and to recount any experiences with interference in your ability to conduct or communicate your work.
This survey is anonymous. It should take you 20 - 30 minutes to complete.

Impact: Results from this academic research will be presented at national fora on science policy and decision-making and could have policy implications that will directly affect your future work.

Incentive: Participants who complete the survey will have the option to provide their email address to enter a draw and win one of three $50 gift cards or donations to the organization of their choice. Email addresses will be collected separately from the survey to maintain anonymity in responses and will be kept confidential.

The deadline to complete the survey is on or before [INSERT DATE].

Follow this link to the Survey:

[INSERT LINK]

Or copy and paste the URL below into your internet browser:

[INSERT LINK]

If you have questions or concerns, please contact the research team at woodlab@dal.ca.

Thank you very much. Your participation is important to us.

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 | woodlab@dal.ca

Reminder of invitation to participate in the survey

FROM: [Scientific Society Address] OR woodlab@dal.ca

Hello,

please ignore this message if you have already taken the survey, apologies for cross-posting

You recently received an email asking for your participation in a survey about interference in environmental research in Canada. If you have not already completed the survey, please consider this a gentle reminder to do so on or before the deadline of [INSERT DATE].

[We are contacting you to participate in this survey because you have previously published work related to the environmental studies and sciences. Your input is very important to us.]

The text from the original email detailing the request is below:

~
You are invited to a participate in a research study on interference in with environmental research in Canada conducted by a Master's Thesis student from the School of Resource and Environment Studies, at Dalhousie University.

Purpose: To document scientists' perceptions of their ability to conduct and communicate environmental research in Canada.

Eligibility: If you are currently working in Canada in the field of environmental studies or sciences, you will be asked to answer questions about your work, personal demographics (e.g., career stage, gender, etc.) and to recount any experiences with interference in your ability to conduct or communicate your work.
This survey is anonymous. It should take you 20 - 30 minutes to complete.

Impact: Results from this academic research will be presented at national fora on science policy and decision-making and could have policy implications that will directly affect your future work.

Incentive: Participants who complete the survey will have the option to provide their email address to enter a draw and win one of three $50 gift cards or donations to the organization of their choice. Email addresses will be collected separately from the survey to maintain anonymity in responses and will be kept confidential.

Follow this link to the Survey:

[INSERT LINK]

Or copy and paste the URL below into your internet browser:

[INSERT LINK]

If you have questions or concerns, please contact the research team at woodlab@dal.ca.

Thank you.

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 | woodlab@dal.ca

Template text for society newsletter

Have you ever experienced interference with your work in the environmental studies or sciences?

We are conducting a survey gathering of scientists' perspectives to understand interference in science in Canada. Fill out the anonymous survey from Dalhousie University. [INSERT LINK]

Survey 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 I 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 on environmental sciences or studies. We will also ask for your demographic information.
All responses are anonymous.

Is my 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, 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 minutes to complete.

What will happen to my 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 to, 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 be re-analyzed in 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 for 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 interested in receiving direct communication about the results of the research or be 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 I direct my 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)

APPENDIX D 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 downplays, masks, or includes 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 for 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 the environmental studies or sciences, change careers, or into a different field/department/sector, etc.
Unable to express authentic views	Any mention of inability to express oneself honestly, in the form of personal values, opinions, thoughts, OR unable to "conduct the work I 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 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 issue 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 for the above.

Q19. How would you define the term 'interference in science'?

Text Search Query Terms:

Alter; block; censor; constrain; control; limit; modify; muzzle; pressure; prevent; restrict; suppress
*Include stemmed words

Use assessment

CODE	**DEFINITION**
Conduct	Every time a term is used synonymously with interference to describe interference with researchers' ability to conduct scientific research.
Communicate	Every time a term is used synonymously with interference to describe interference with researchers' ability to communicate scientific research to the public or decision-makers.
Both	Any response that describes interference in both conducting and communicating research.
Non-descript	Any time the term is being used in a way that is not descriptive enough to code.
Other Use	Any time the term is not being used to describe interference.

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?

Context Question: Are you aware of the Scientific Integrity Policies implemented in Canadian federal government departments in 2019? y/n

PARID

Respondent's PARID number.

Has there been an impact, what kind? (Choose as applicable)

CODE	**DEFINITION**
Yes, science communication improved	Respondent answers "yes", OR specifically describes improvements to researchers' ability to conduct and/or communicate research.
No, no impact	Respondent believes the policies have had no impact.
Unsure / I don't know / Not that I am aware of	Respondent is unsure of the impact or does not know or say they are not aware of any impact.
Too soon to say	Respondent believes it is too soon to say whether the policies have had any impact.
Political interference is ongoing	Respondent describes ongoing political interference from the federal government specifically OR internal to their organization (perpetuated by externally imposed or internalized factors listed elsewhere).
Uneven impact or application	Description of uneven applications of the policies across departments, levels of governance (federal, provincial, municipal), workplaces/sectors, fields, etc.
Funding as a source of constraint	Federal funding agencies are described as a leading factor of interference (impact ability to conduct research).
Other / NA	Anything unlisted above OR "NA" responses. Use sparingly.

APPENDIX E 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			

Variable ***Group Comparison***	**n**	**X-squares**	**Degrees of freedom**	**p-value**
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			

Variable ***Group Comparison***	**n**	**X-squares**	**Degrees of freedom**	**p-value**
Quebec	95			
Atlantic provinces	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			

Variable ***Group Comparison***	**n**	**X-squares**	**Degrees of freedom**	**p-value**
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			

Variable ***Group Comparison***	**n**	**X-squares**	**Degrees of freedom**	**p-value**
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			

Variable ***Group Comparison***	**n**	**X-squares**	**Degrees of freedom**	**p-value**
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			
Atlantic provinces	100			
Territories	13			

Variable ***Group Comparison***	**n**	**X-squares**	**Degrees of freedom**	**p-value**
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

Variable ***Group Comparison***	**n**	**X-squares**	**Degrees of freedom**	**p-value**
Natural Sciences	552			
Engineering	56			
Medicine	36			
Agriculture and veterinary sciences	26			
Social sciences	73			
Humanities and the arts	3			

Cronbach's alpha reliability tests

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

Variable ***Comparison Group***	**n**	**Group Means**	**T-statistic**	**Confidence Interval**	**Degrees of freedom**	**p-value**
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				
Internal			5.22	0.22 0.49	396.02	<0.01*
Early	211	2.60				
Established	404	2.24				
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								
Internal			2	25.1	12.55	20.08	<0.01*	<0.01	<0.01	0.04

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**
Residuals			643	402.1	0.62					
Early	211	2.61								
Established	404	2.25								
Retired	31	1.89								
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					
Atlantic provinces	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					
Atlantic provinces	94	3.06					

Variable ***Group***	**n**	**Group Means**	**Degrees of freedom**	**Sum of squares**	**Mean sq**	**F- statistic**	**p-value (means)**
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					
Atlantic provinces	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					
Atlantic provinces	81	2.16					

Variable ***Group***	**n**	**Group Means**	**Degrees of freedom**	**Sum of squares**	**Mean sq**	**F- statistic**	**p-value (means)**
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					
Atlantic provinces	91	2.05					
Territories	15	1.76					

RESEARCH AREA

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					

Variable ***Group***	**n**	**Group Means**	**Degrees of freedom**	**Sum of squares**	**Mean sq**	**F- statistic**	**p-value (means)**
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					

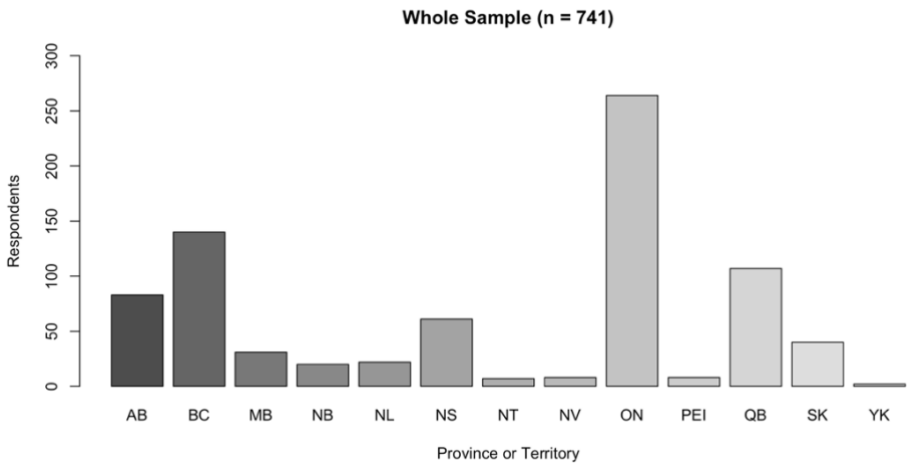
Variable ***Group***	**n**	**Group Means**	**Degrees of freedom**	**Sum of squares**	**Mean sq**	**F- statistic**	**p-value (means)**
Humanities and the arts	2	3.5					
Multidisciplinary	77	2.96					
Internal			6	5.9	0.97	1.48	0.18
Natural Sciences	450	2.38					
Engineering	43	2.41					
Medicine	19	2.02					
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					

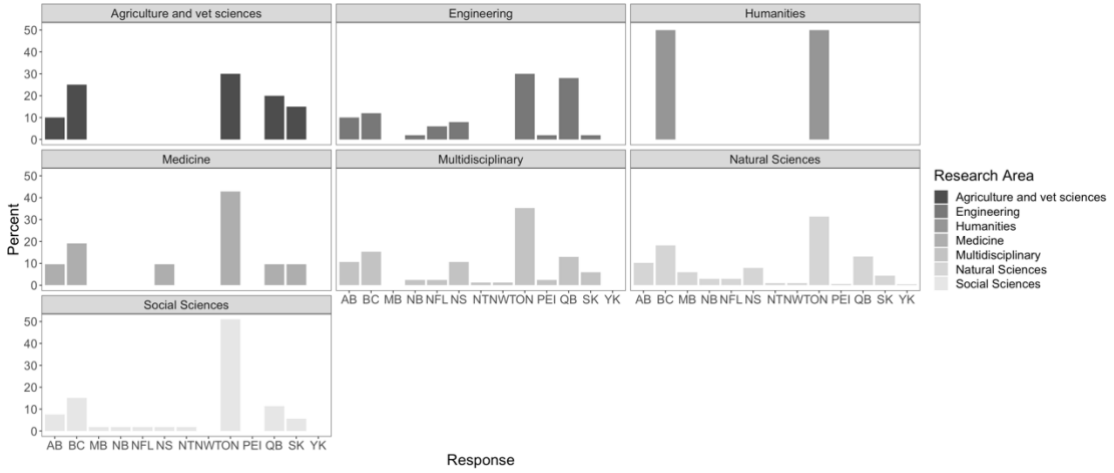
Variable ***Group***	**n**	**Group Means**	**Degrees of freedom**	**Sum of squares**	**Mean sq**	**F- statistic**	**p-value (means)**
Engineering	38	1.89					
Medicine	19	1.92					
Agriculture and veterinary sciences	16	2.27					
Social sciences	50	2.01					
Humanities and the arts	1	1.5					
Multidisciplinary	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					

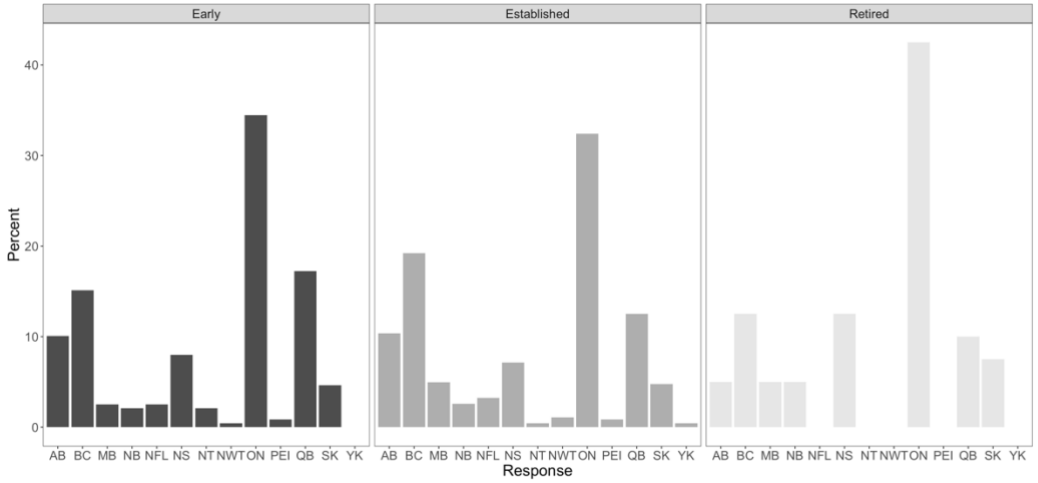
Variable ***Group***	**n**	**Group Means**	**Degrees of freedom**	**Sum of squares**	**Mean sq**	**F- statistic**	**p-value (means)**
Humanities and the arts	1	1					
Multidisciplinary	74	2.28					

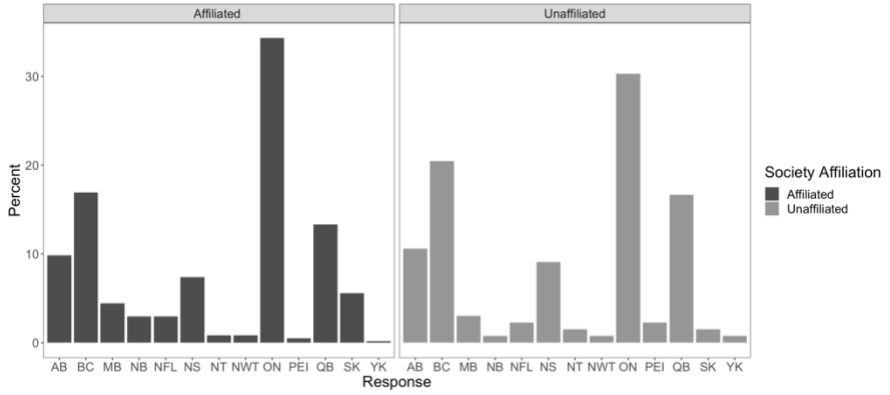
APPENDIX F DESCRIPTIVE SURVEY RESPONSE STATISTICS

Q3. In what Canadian Province or Territory do you predominantly conduct work?

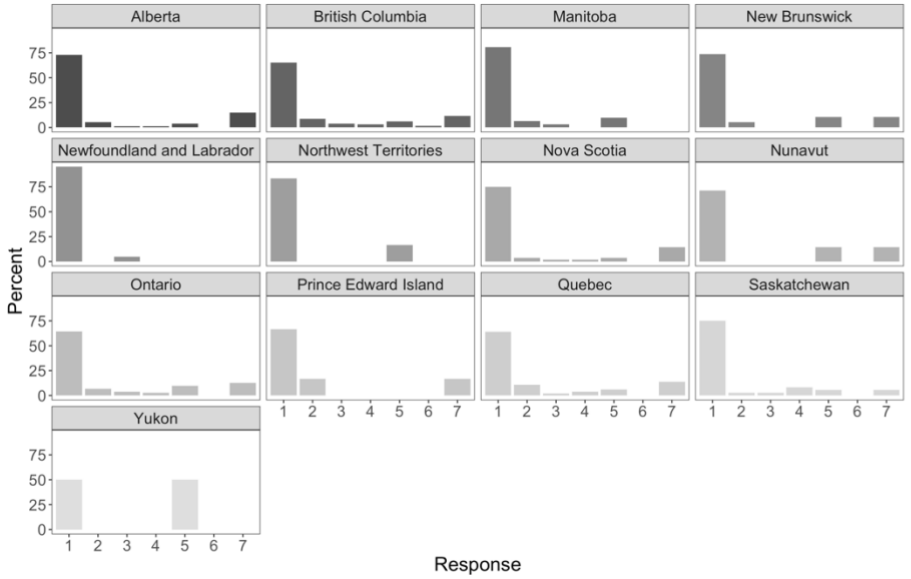


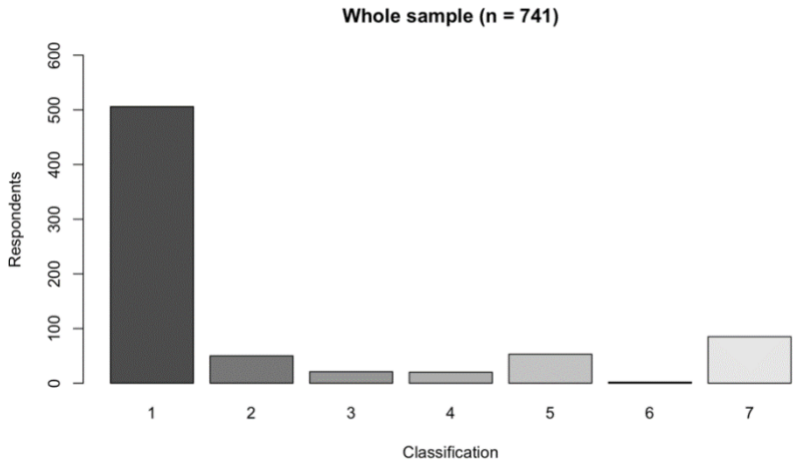


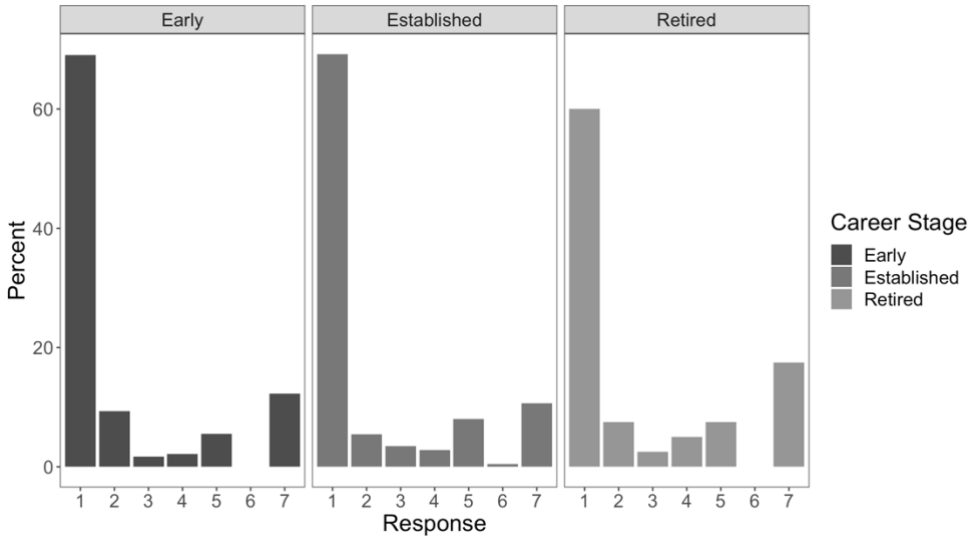


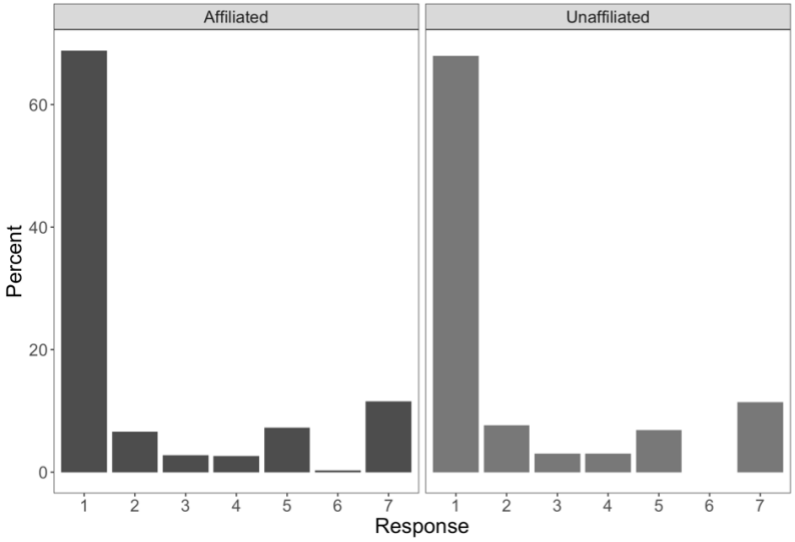


Q4. Please indicate your primary areas of research or your discipline. (1 = Natural Sciences, 2 = Engineering, 3 = Medicine, 4 = Agriculture and vet sciences, 5 = Social Sciences, and 6 =Humanities and the arts, 7 = Multidisciplinary)

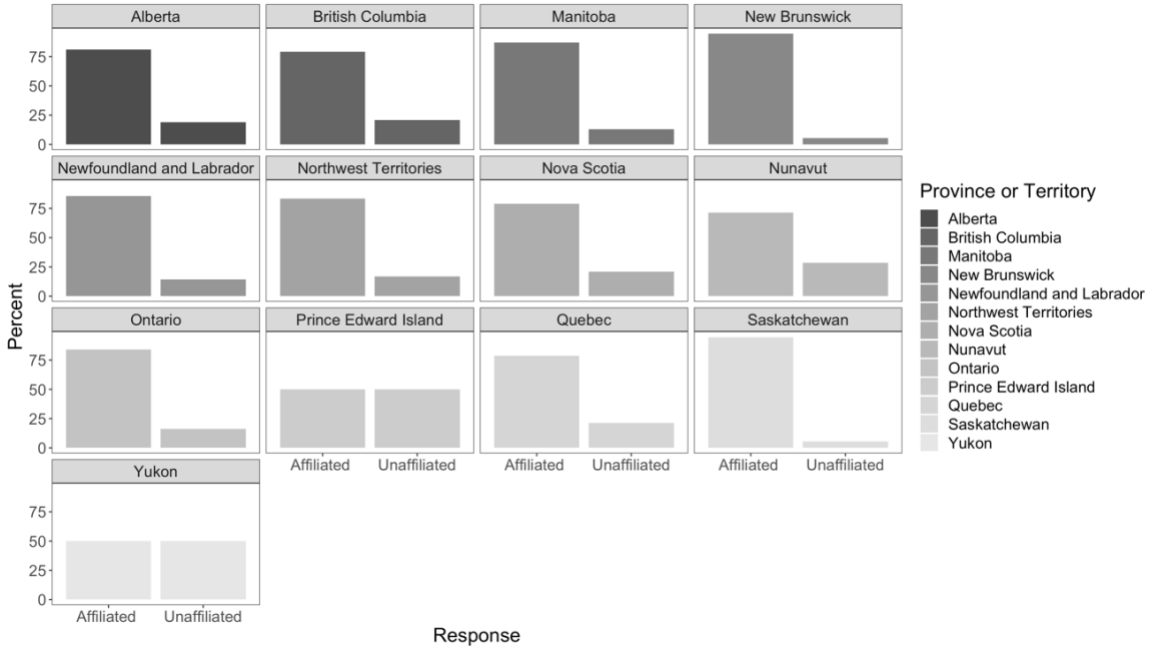


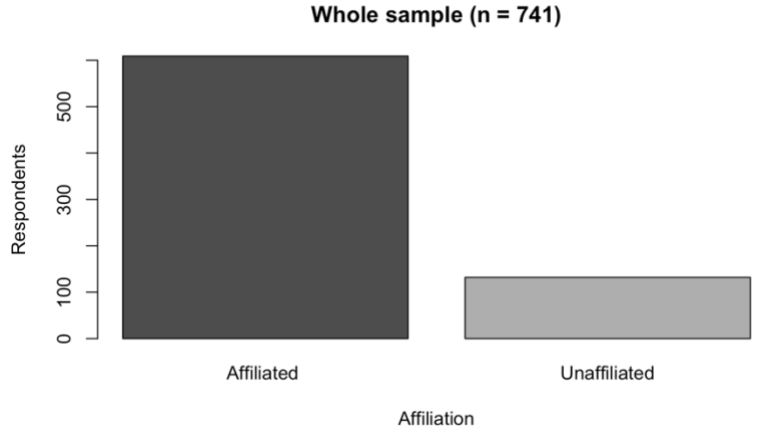


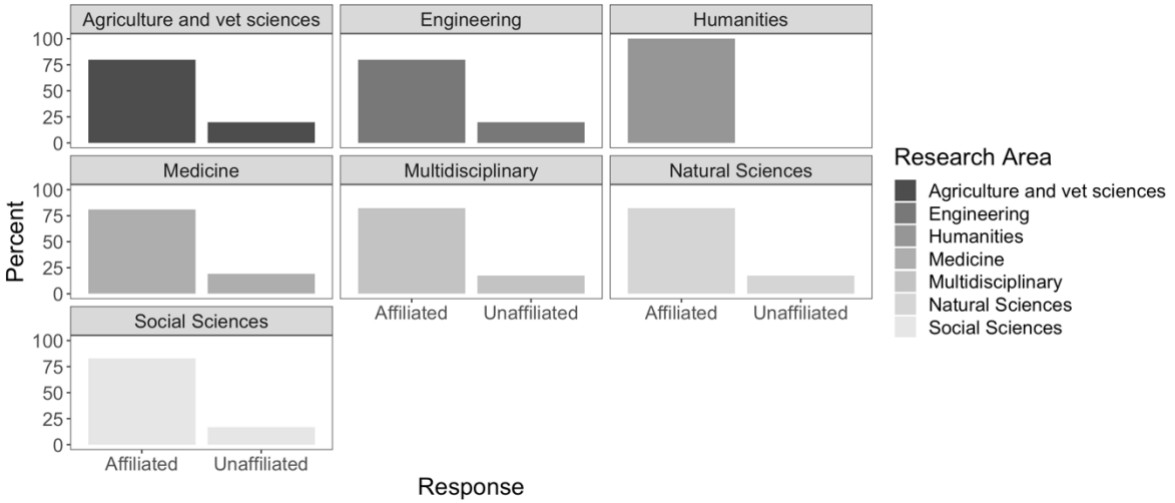


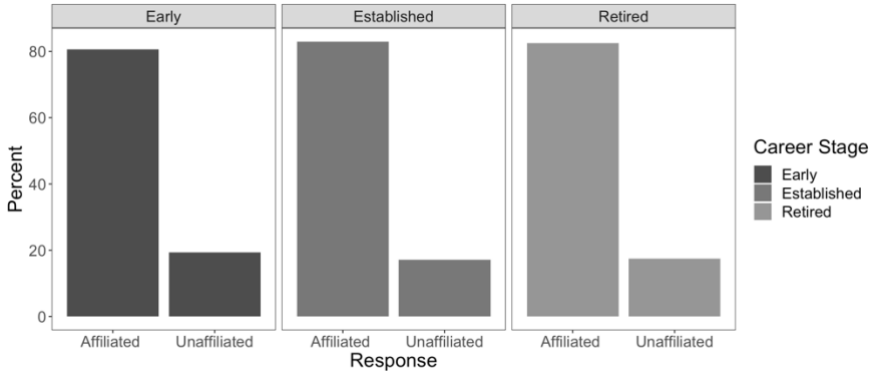


Q5. Please indicate whether or not you are affiliated with any scientific society.

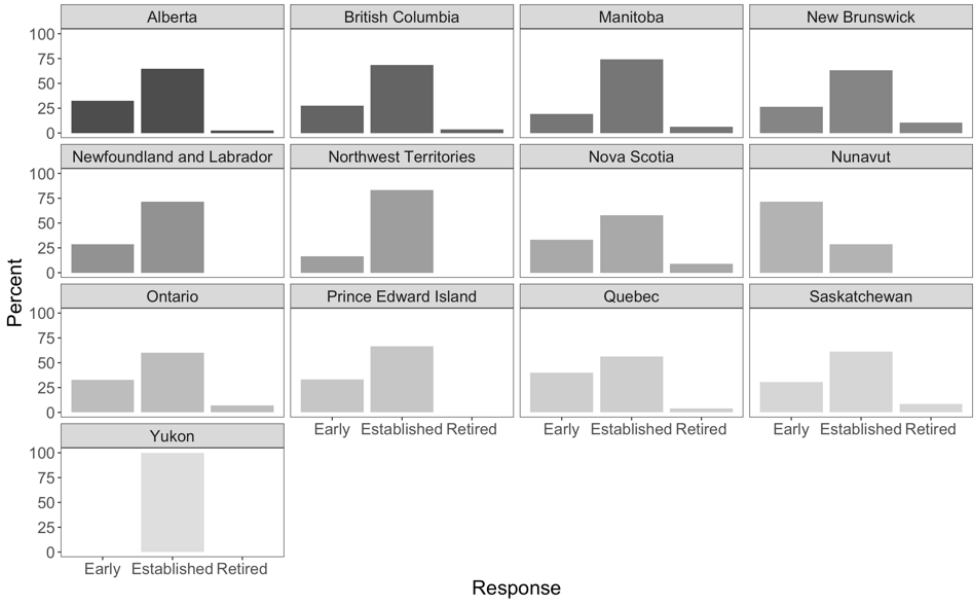


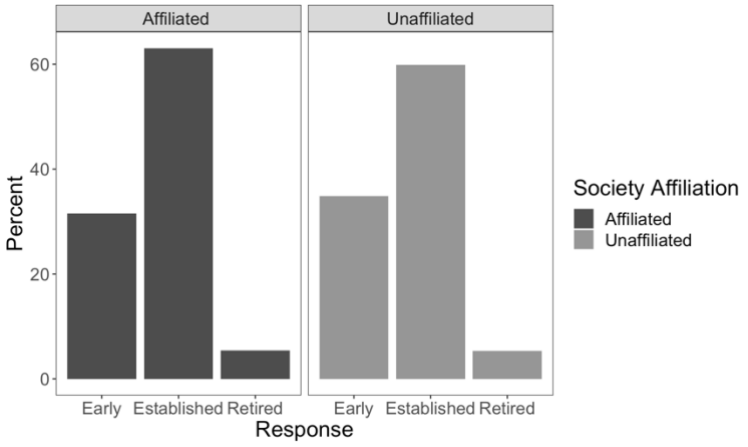


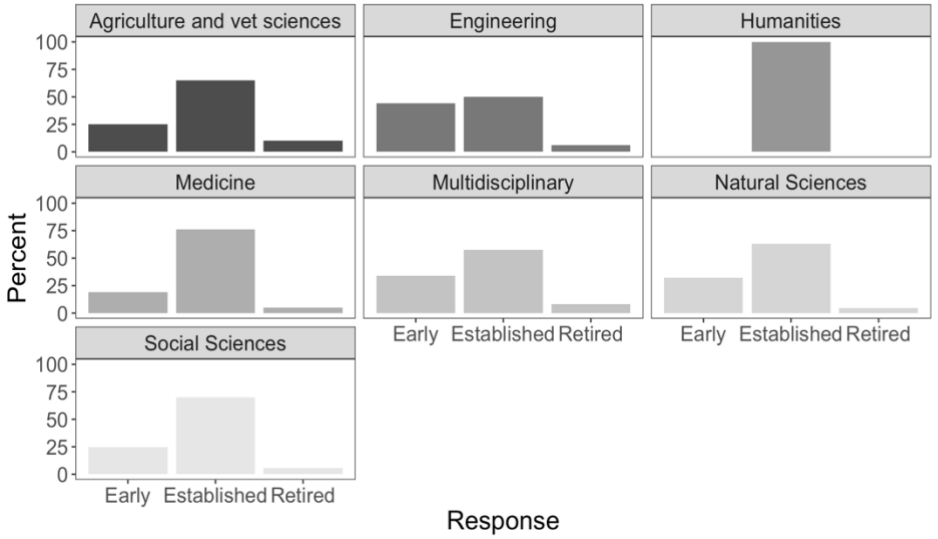


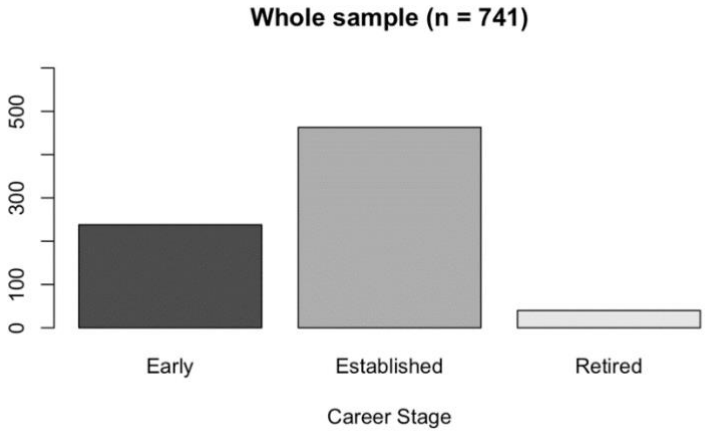


Q6. What career stage are you in?

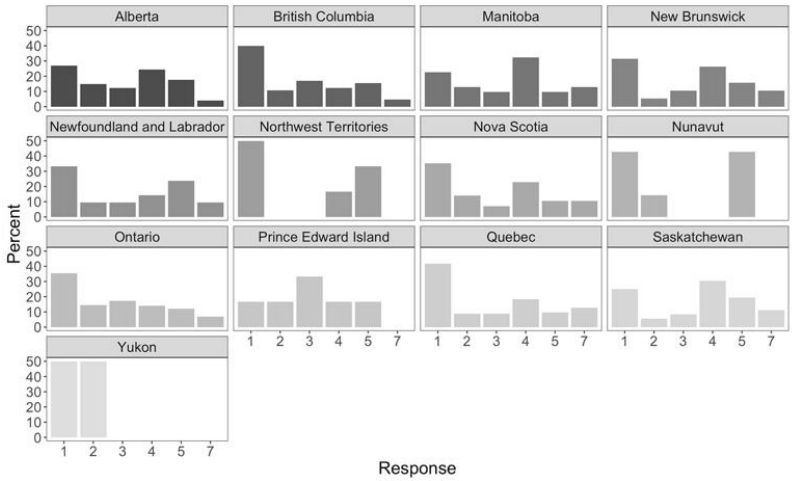


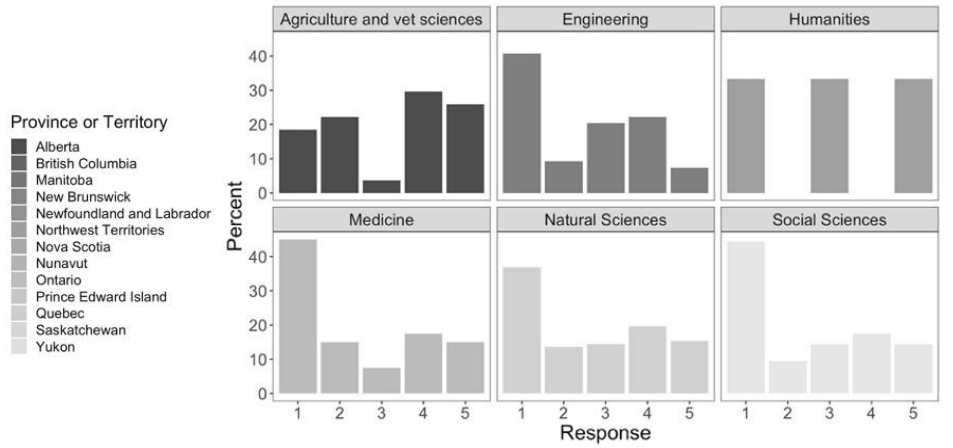


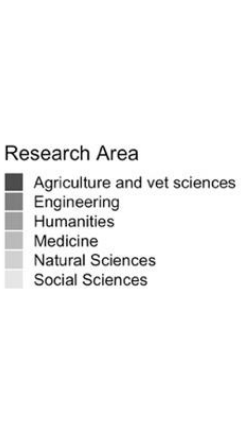


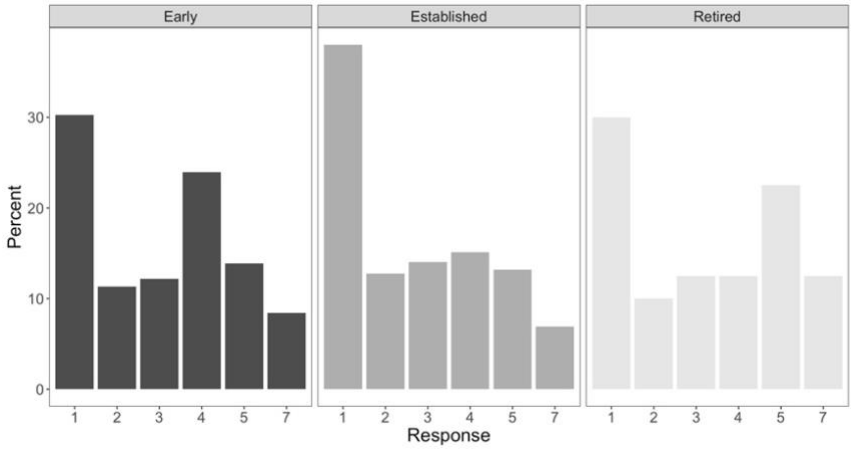


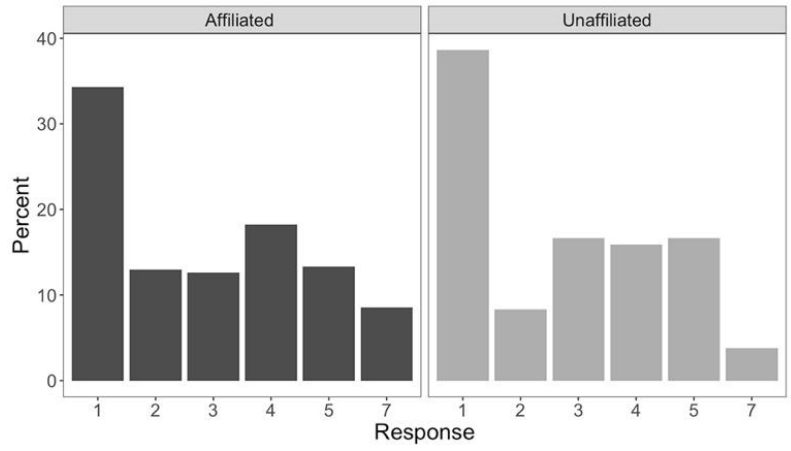
Q7. I am aware of cases where the health and safety of Canadians (or environmental sustainability) has been compromised because of political interference with scientific work at my organization. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)



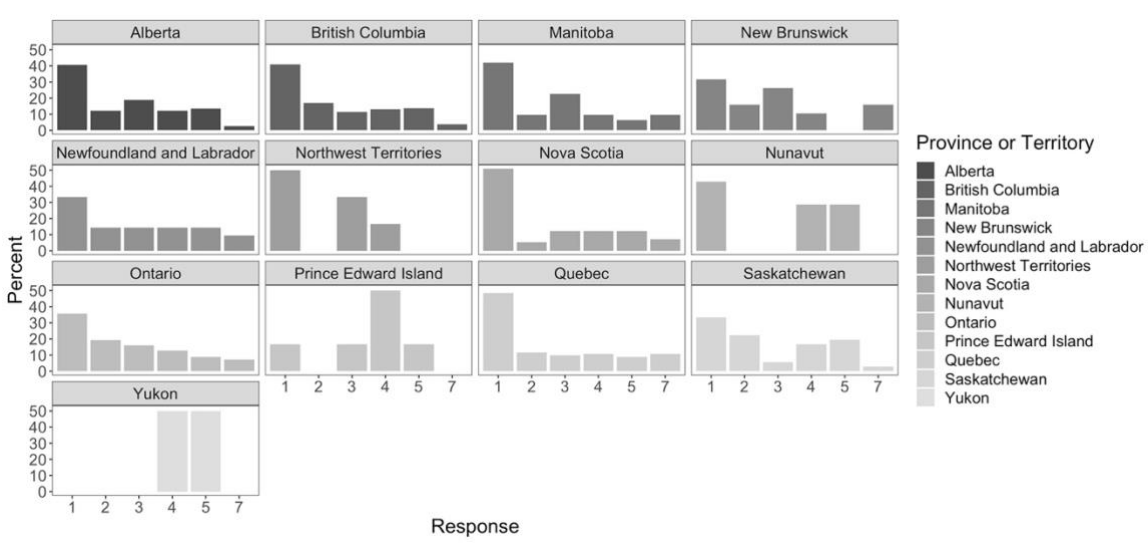


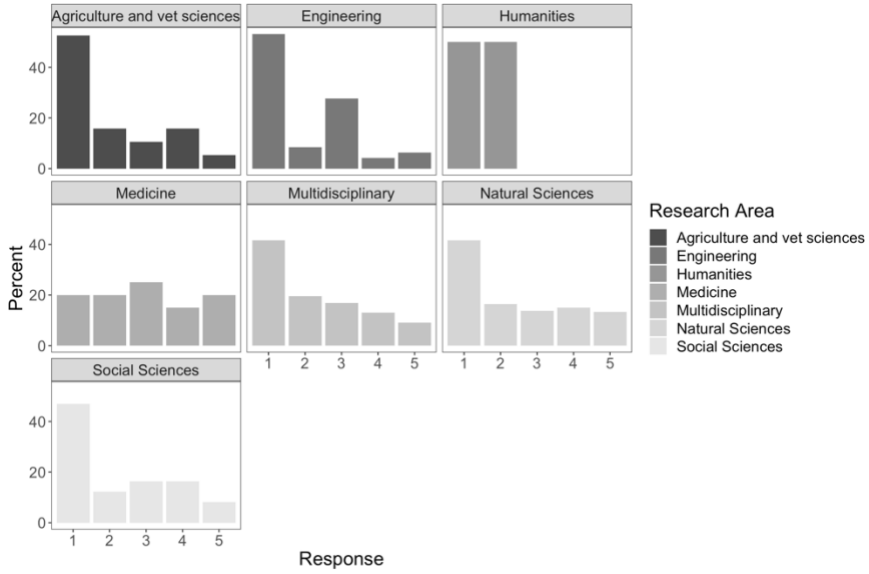


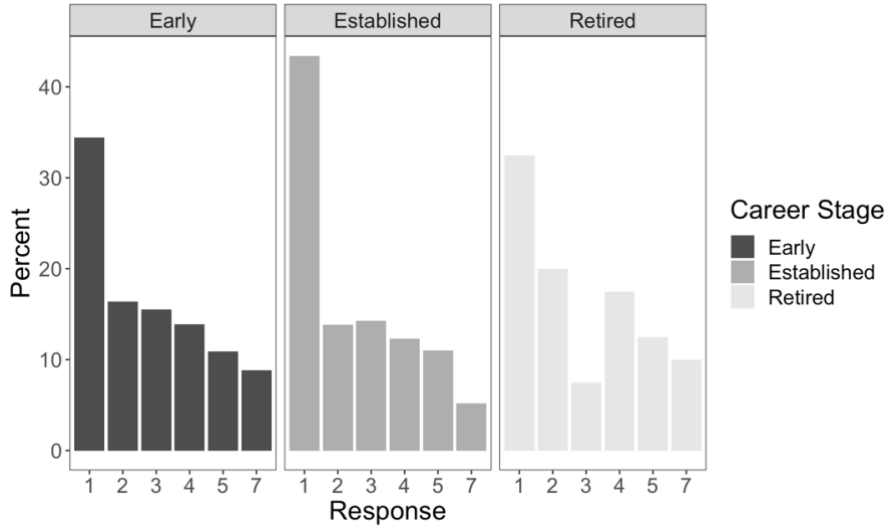


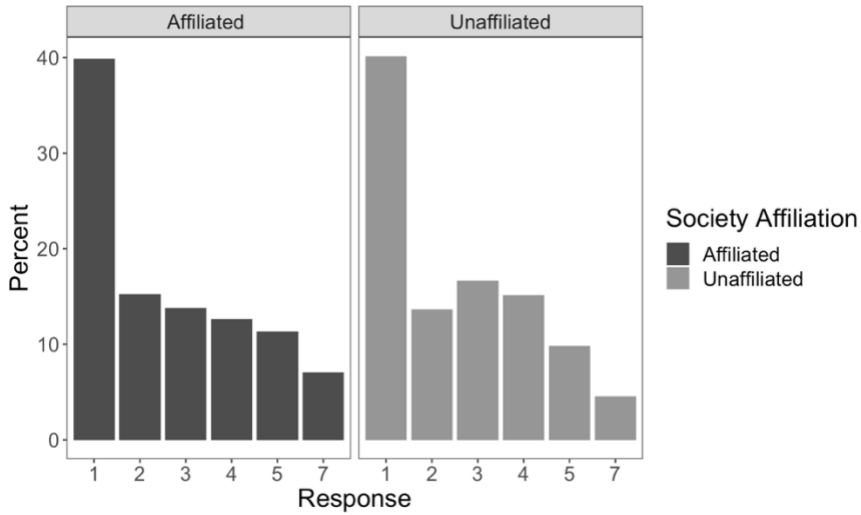


Q8. I am aware of cases where my organization has suppressed or declined to release information, leading to incomplete, inaccurate, or misleading impressions. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)

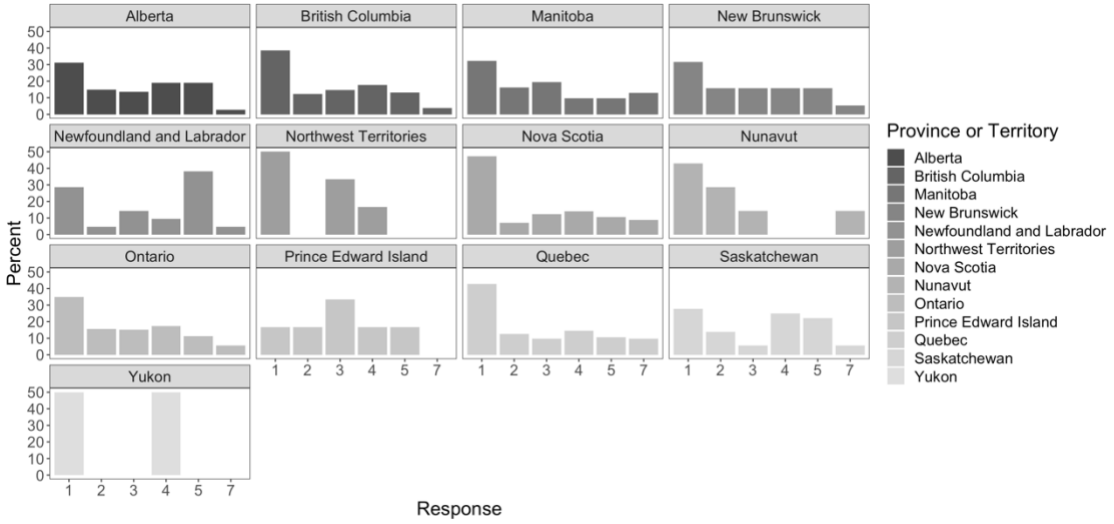


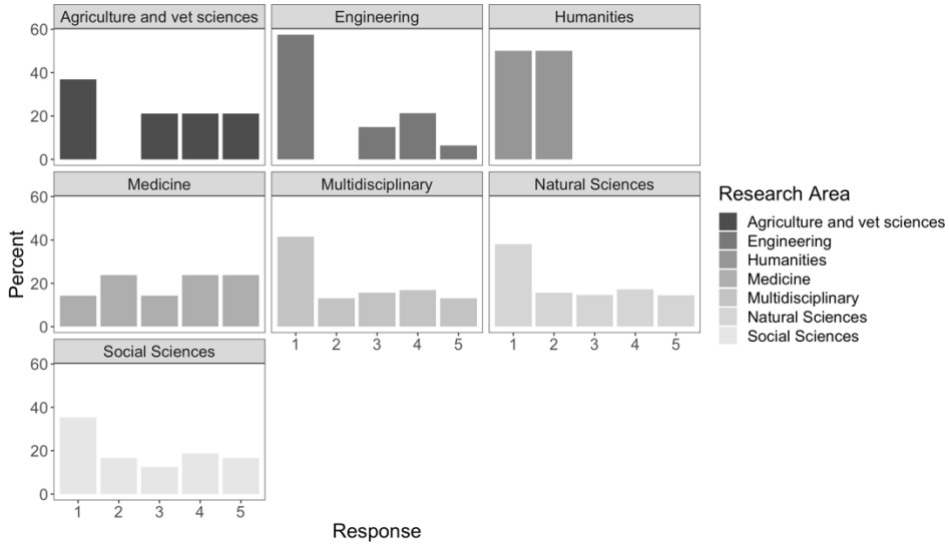


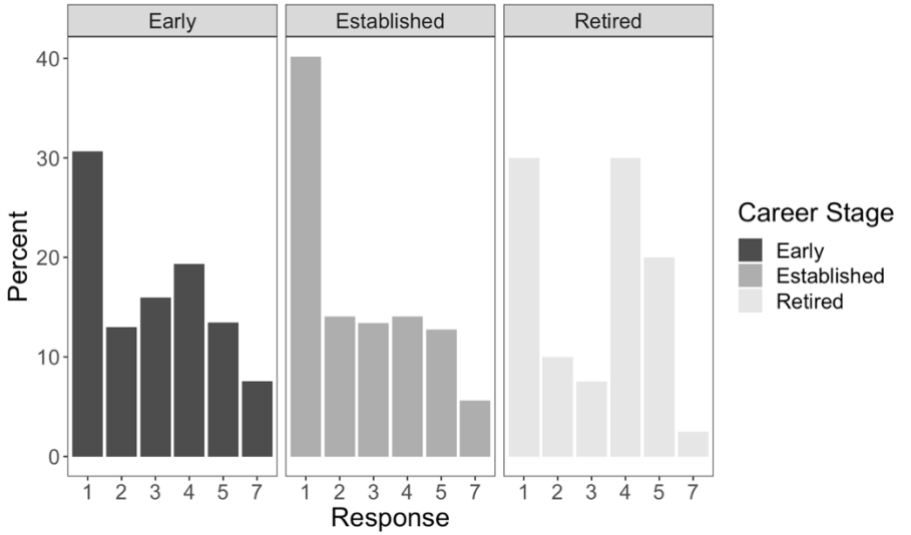


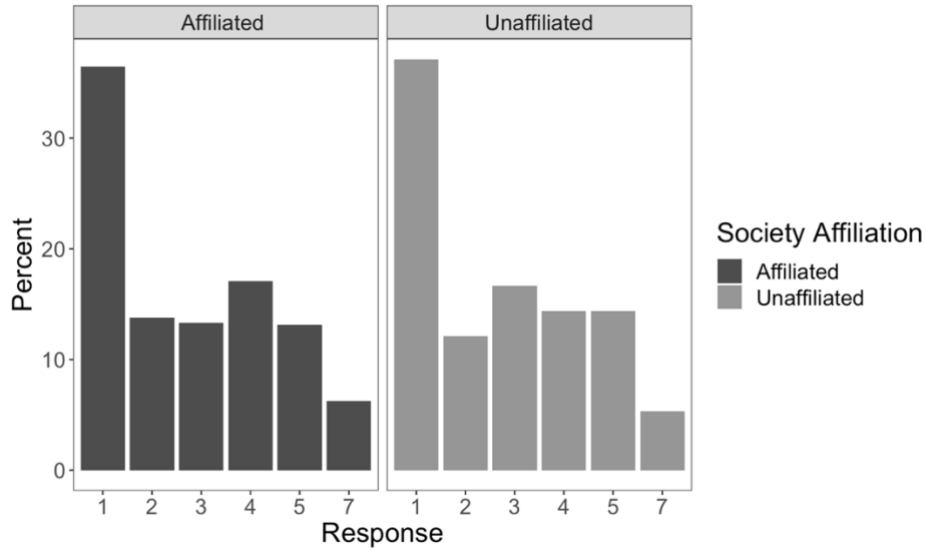


Q9. I am aware of cases where the exchange of scientific evidence for the purpose of developing law or policy has been compromised by political interference. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)

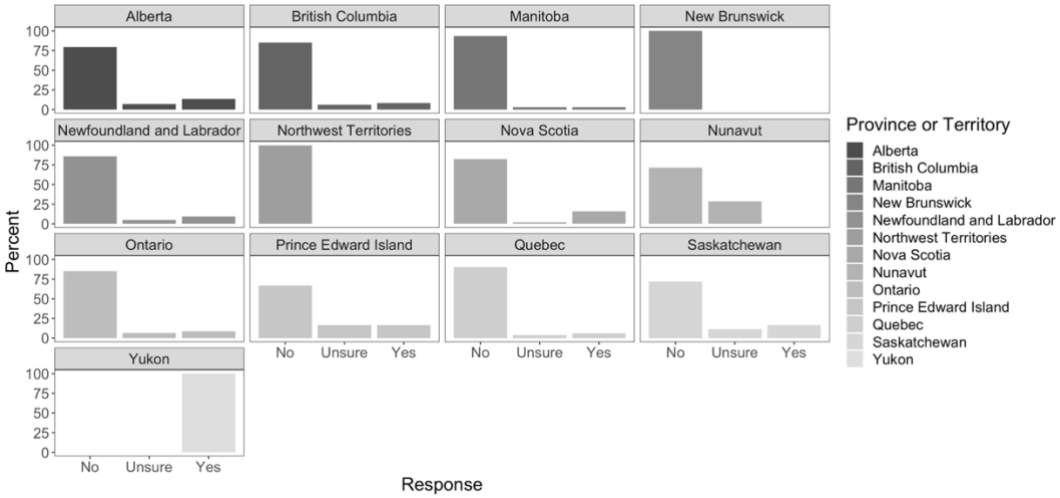


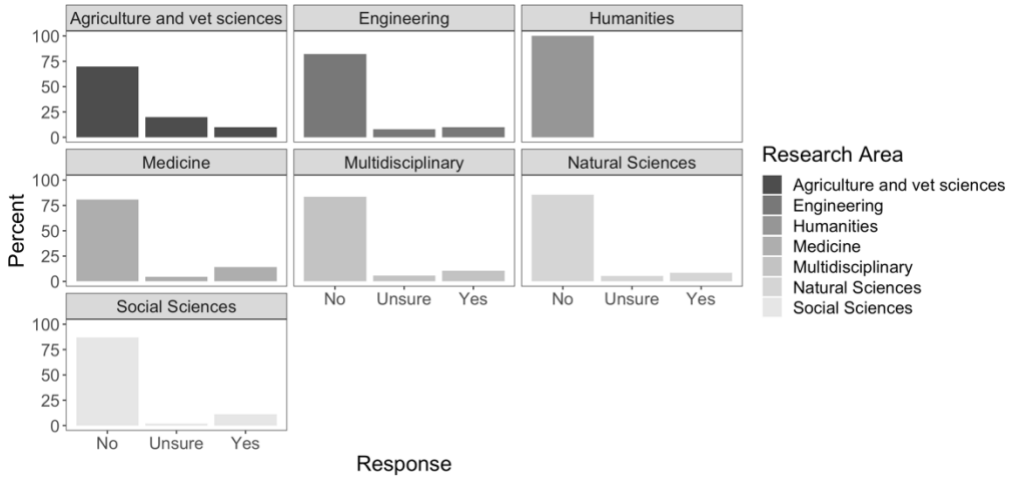


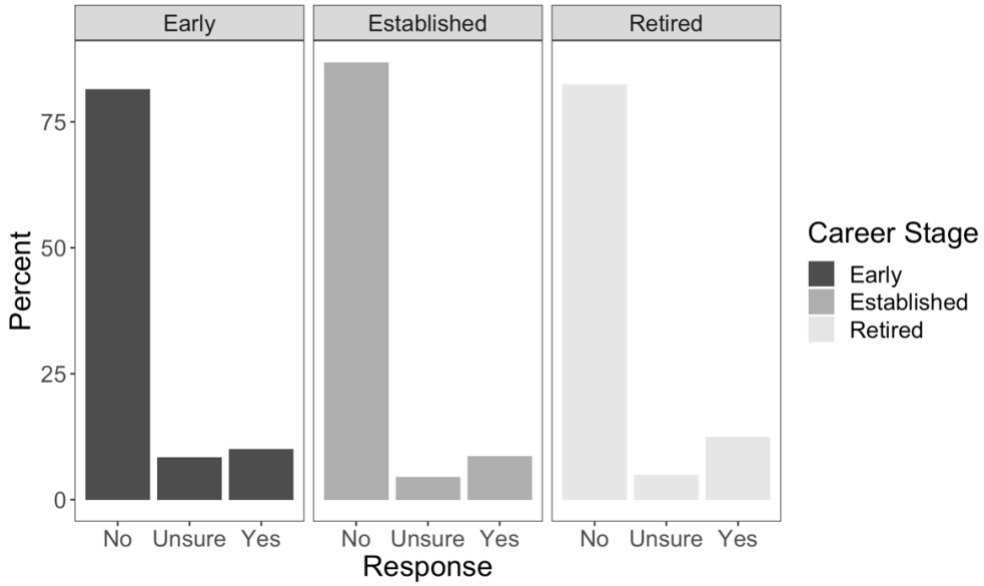


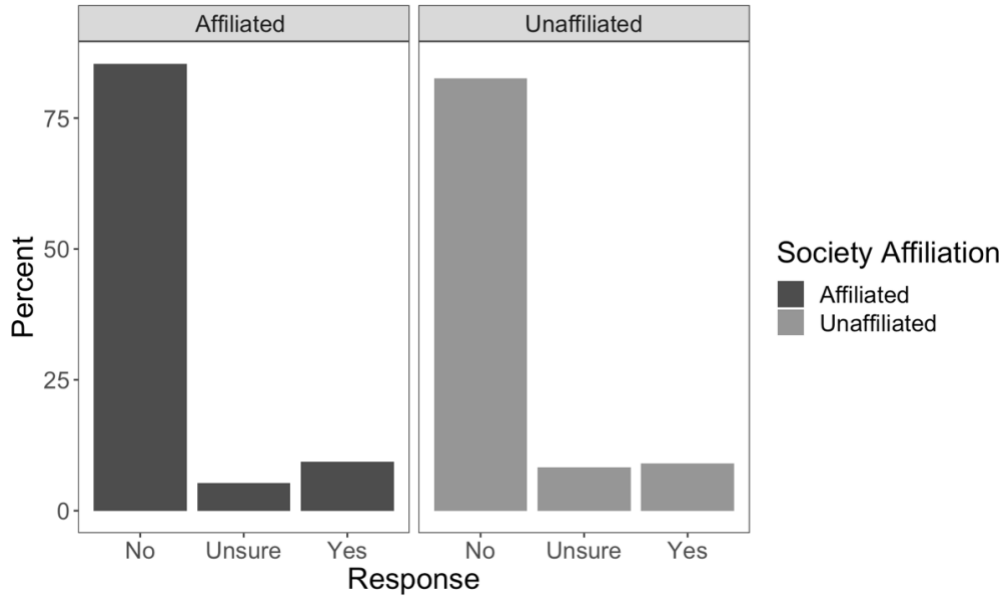


Q10. Have you ever experienced 'undue modification' to your work that alters the information about environmental impacts?

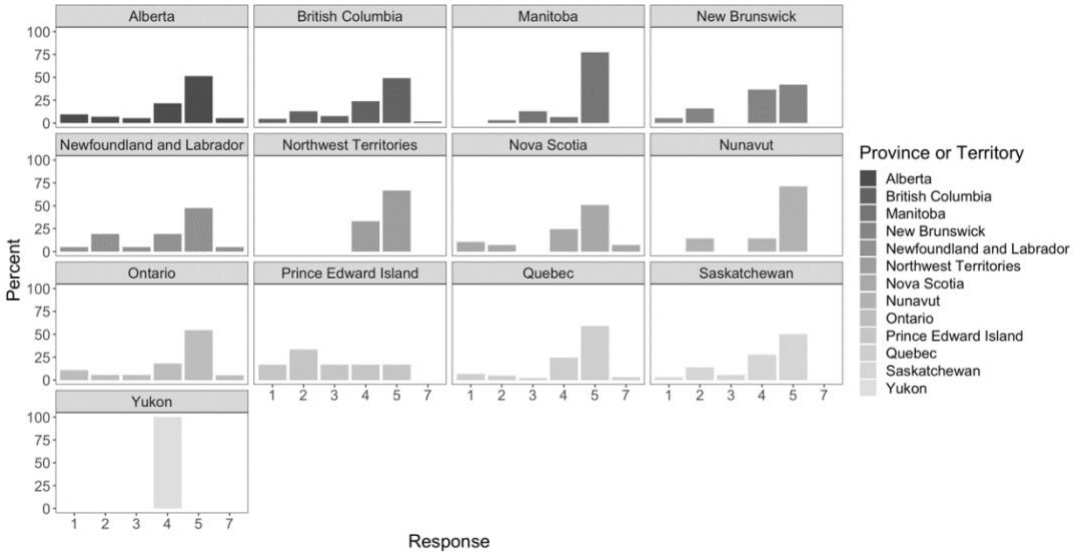


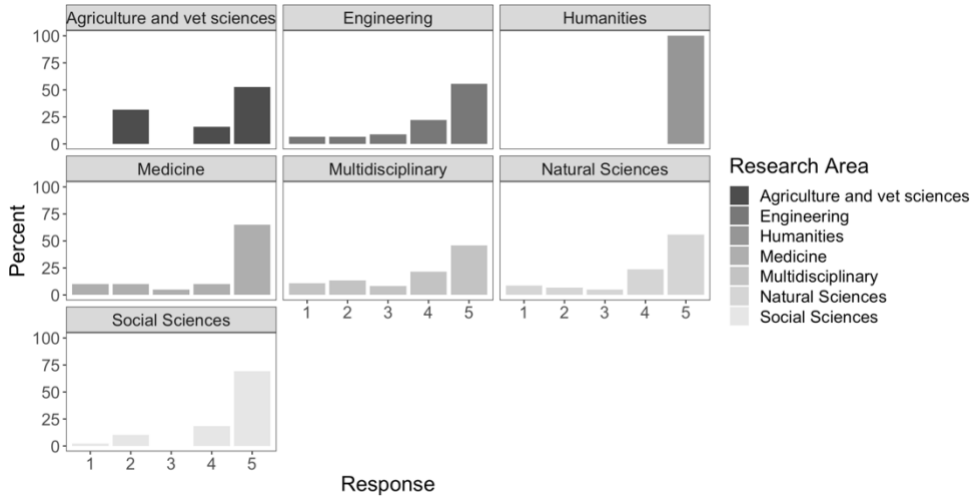


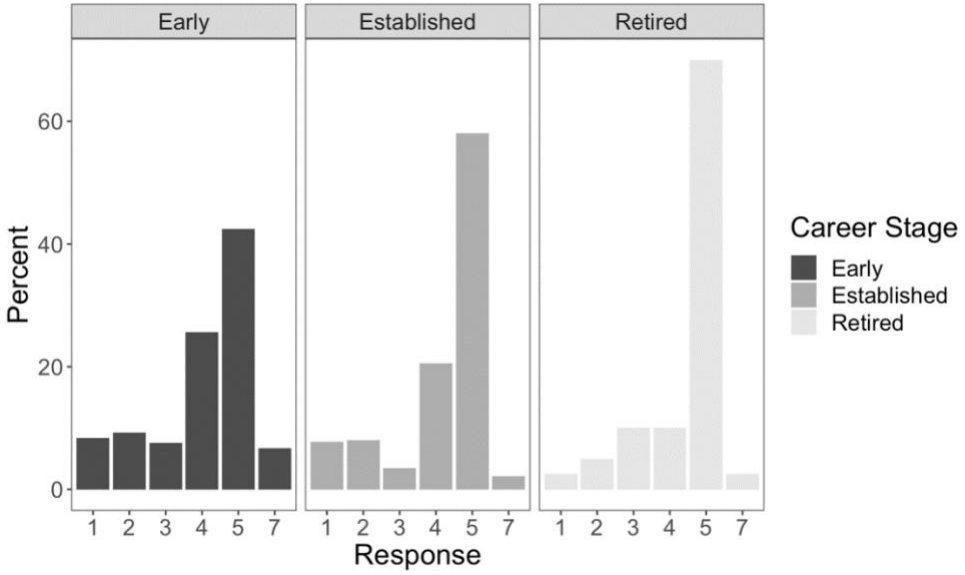


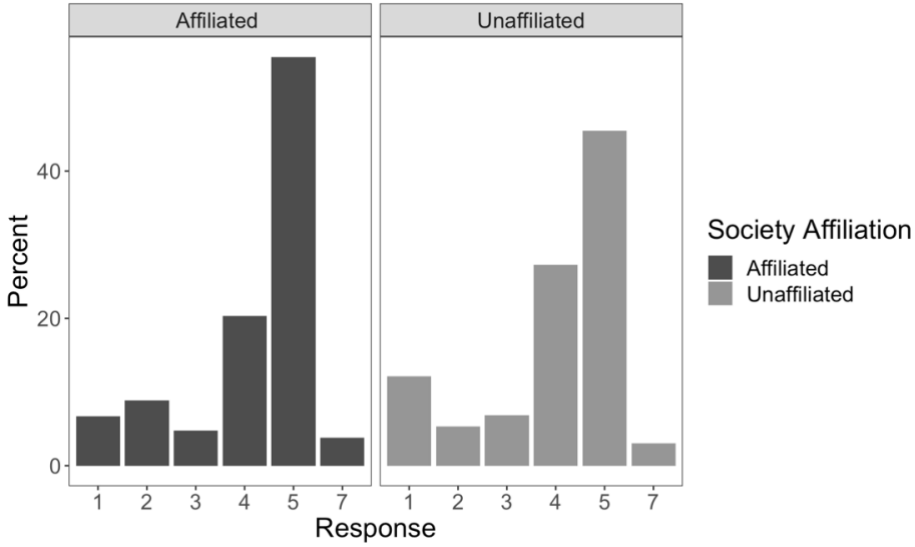


Q12. I am allowed by my organization to speak freely and without constraints to the media about my research in the environmental studies or sciences. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)

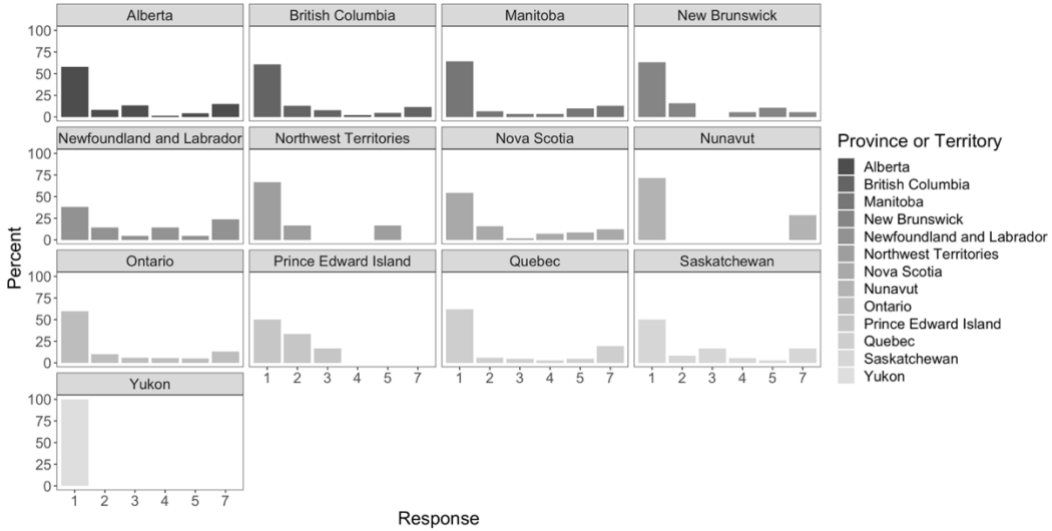


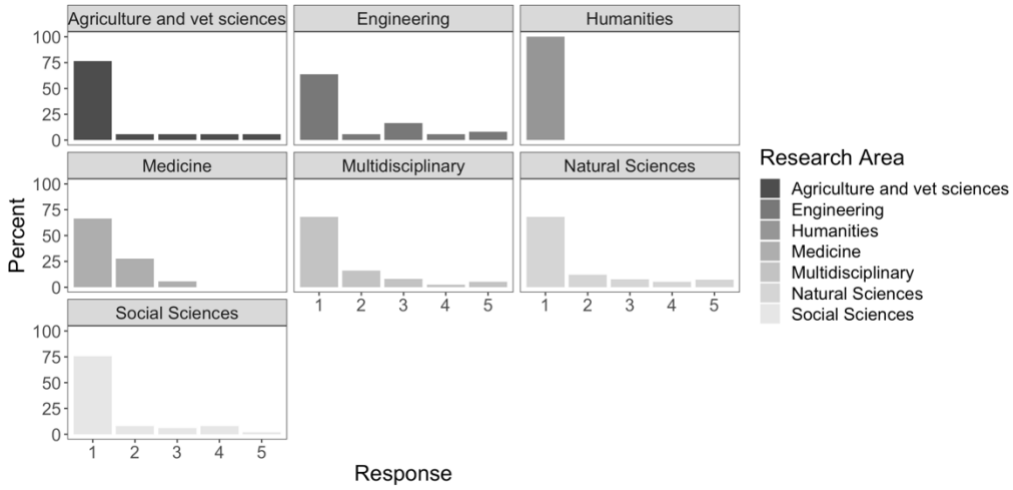


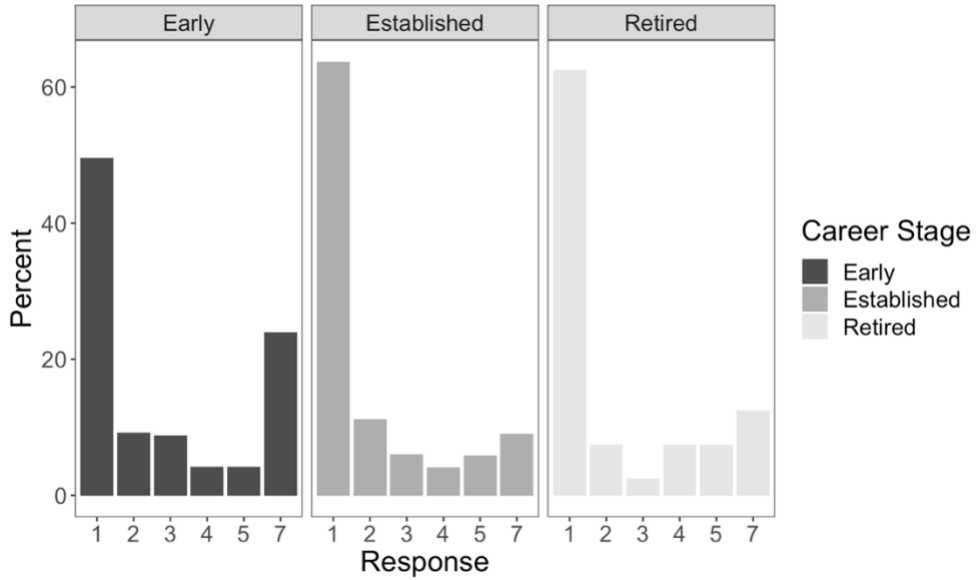


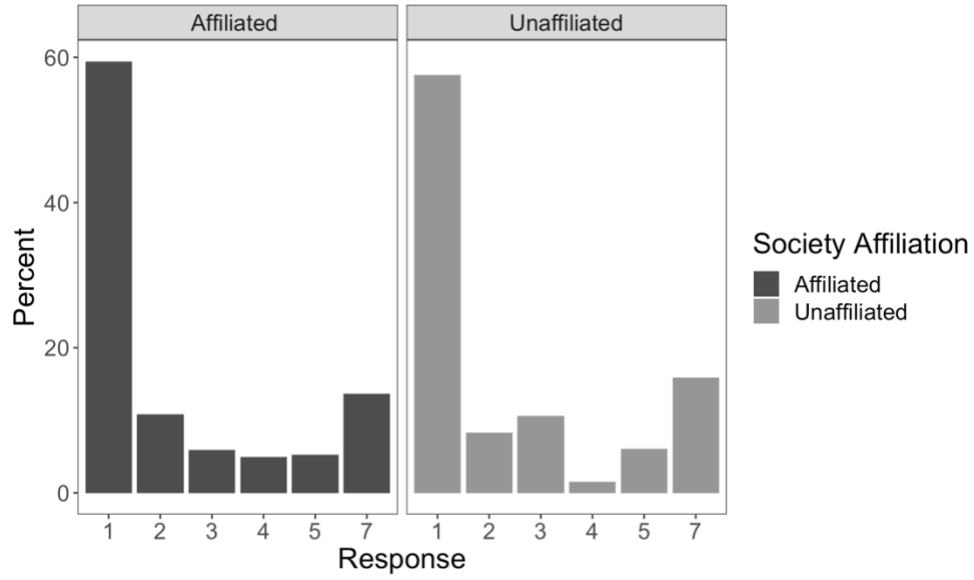


Q13. I have received a question from the public or media that I have the expertise to answer but have been prevented from doing so by my organization. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)

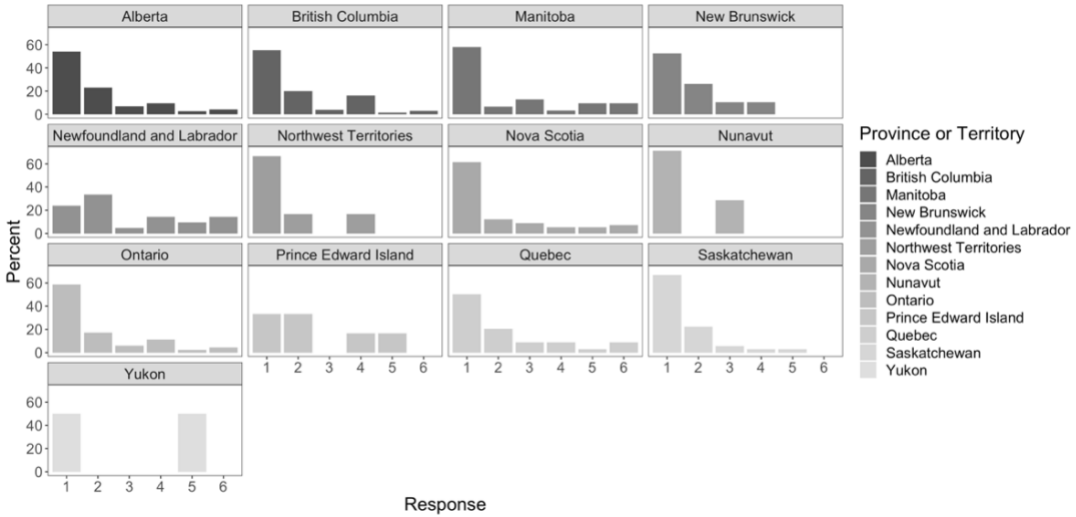


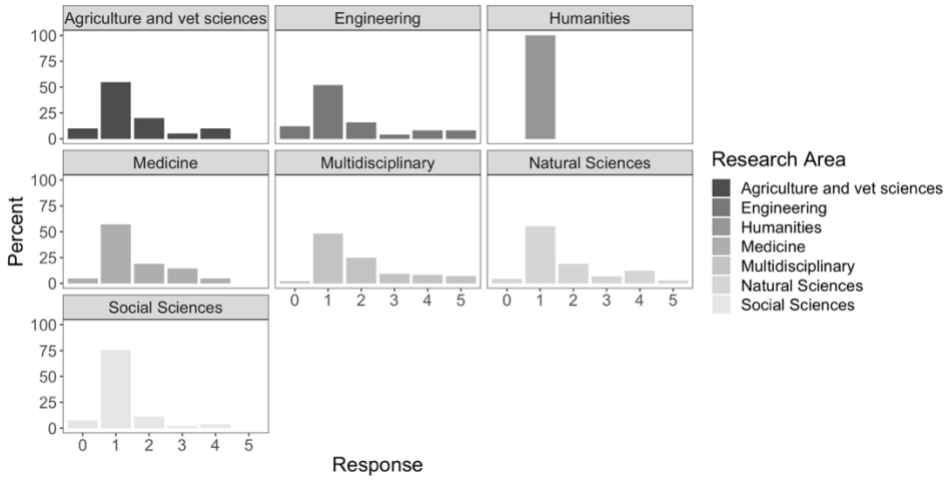


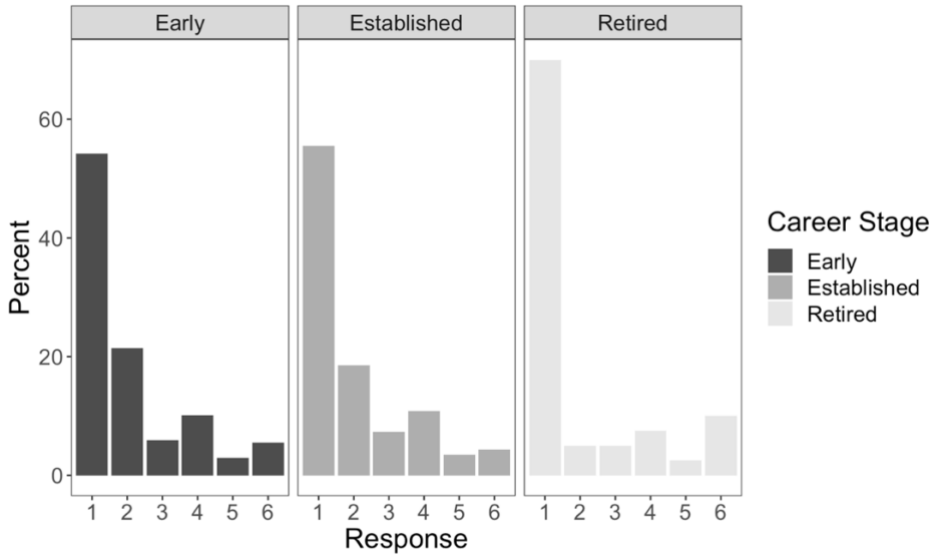


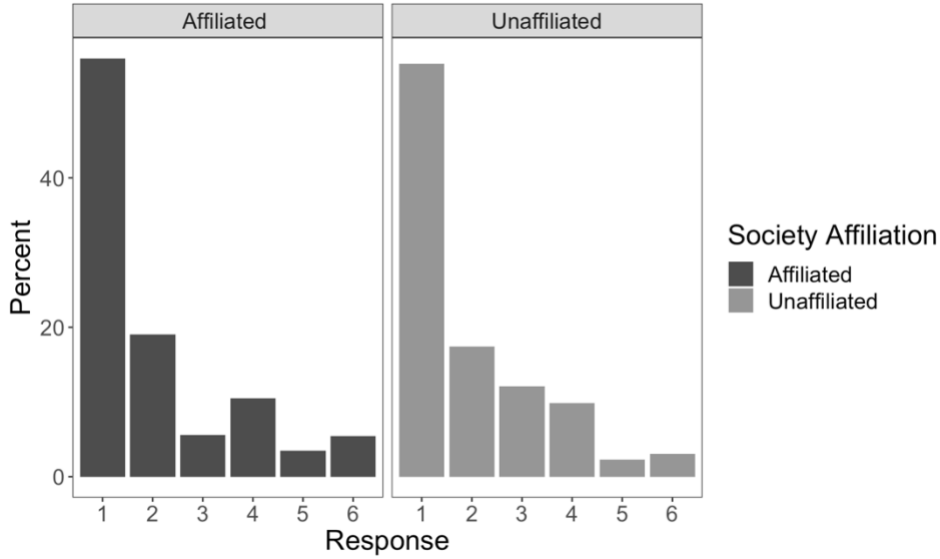


Q16[1]. My public commentary is constrained by my belief that scientists have no role in making public commentary beyond information provision. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)

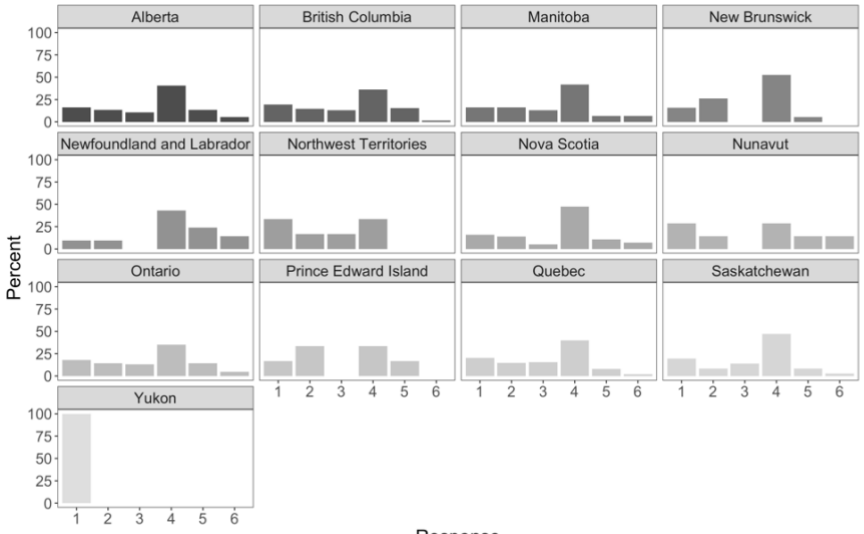


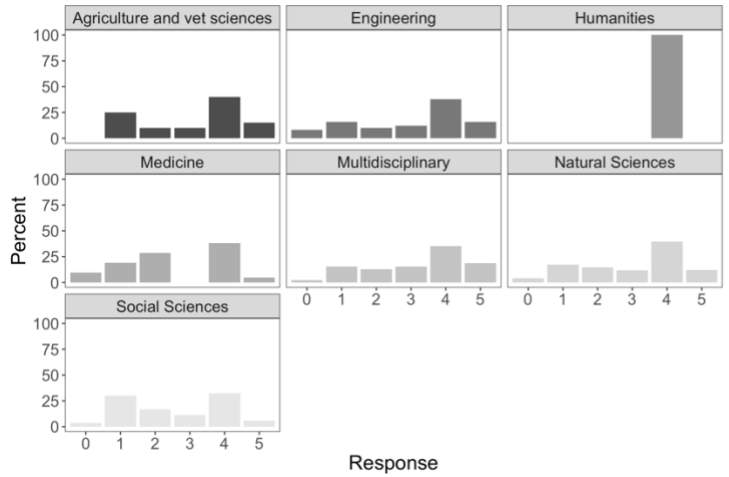


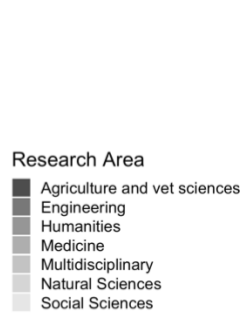


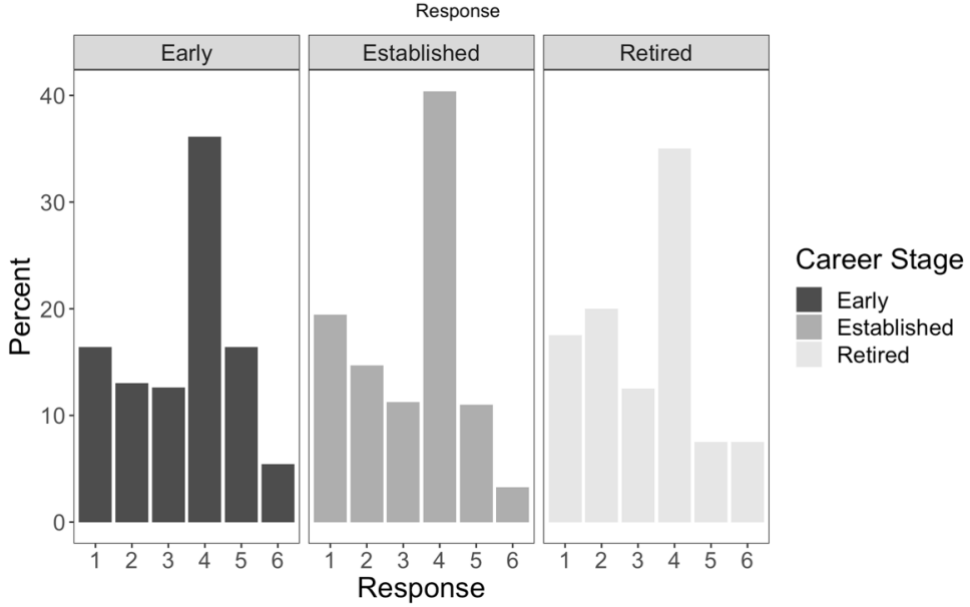


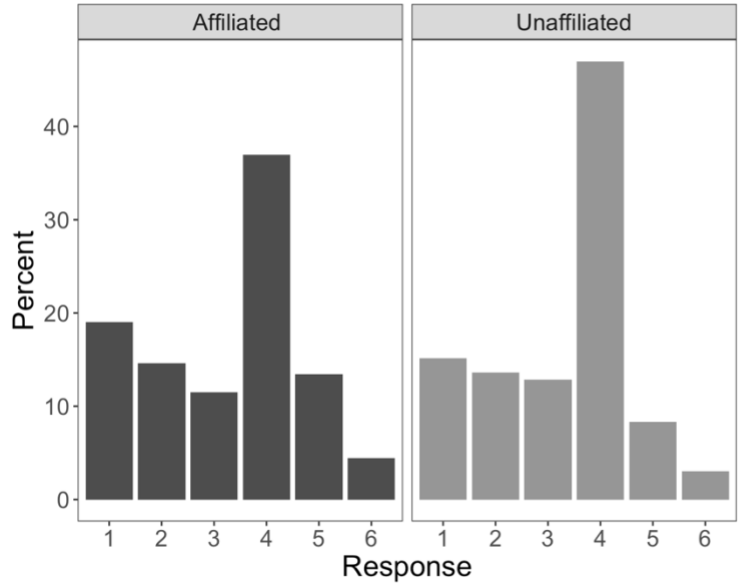
Q16[2]. My public commentary is constrained by my concern about how I may be represented by the media. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)



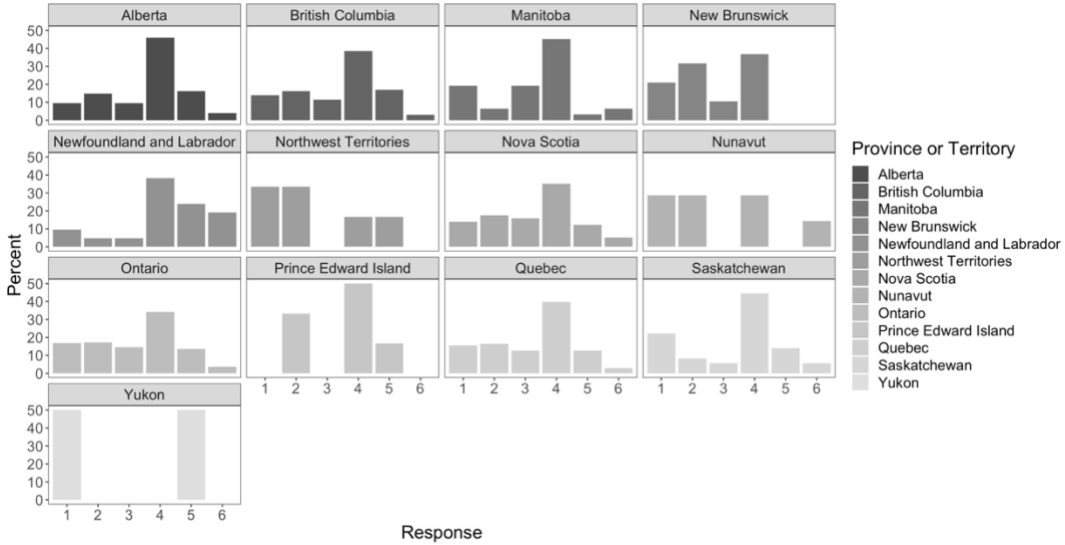


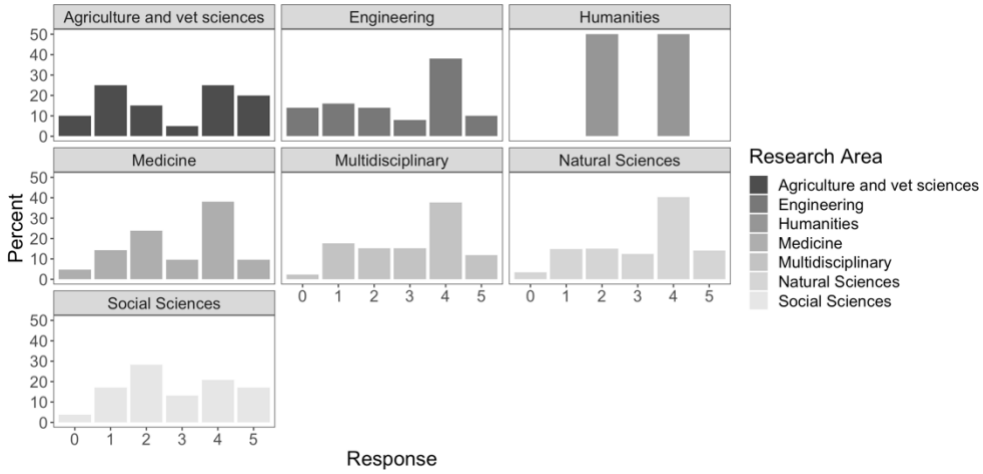


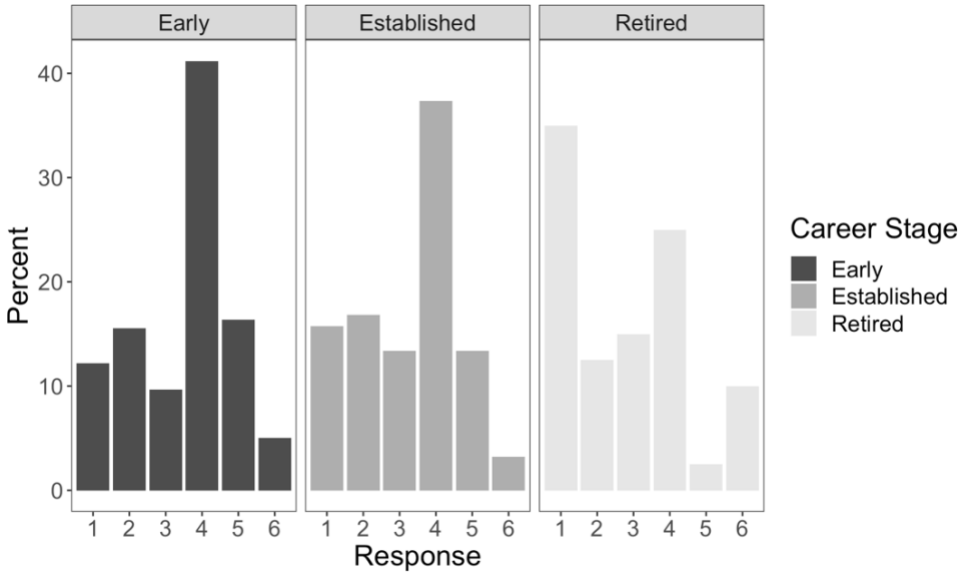


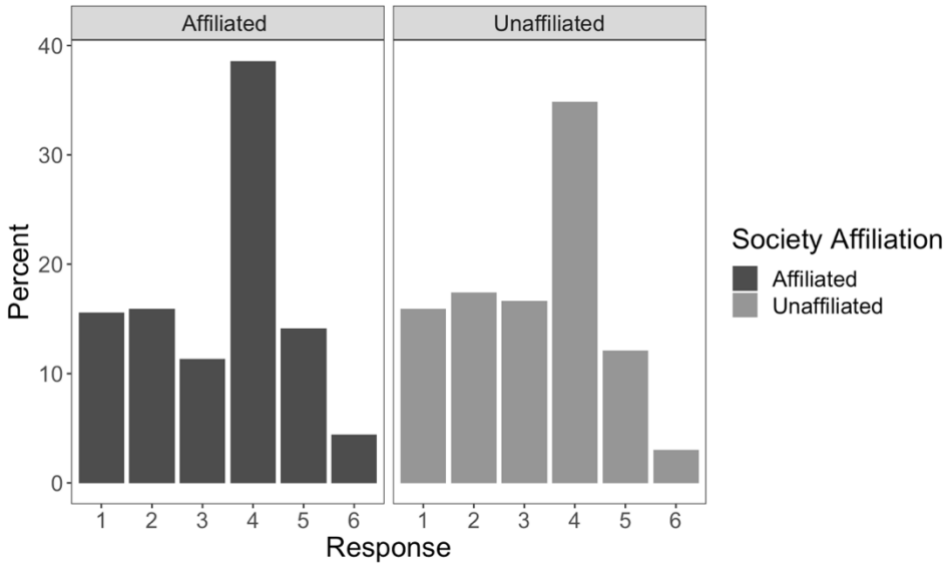


Q16[3]. My public commentary is constrained by my fear of being drawn to comment beyond the boundaries of my expertise. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)

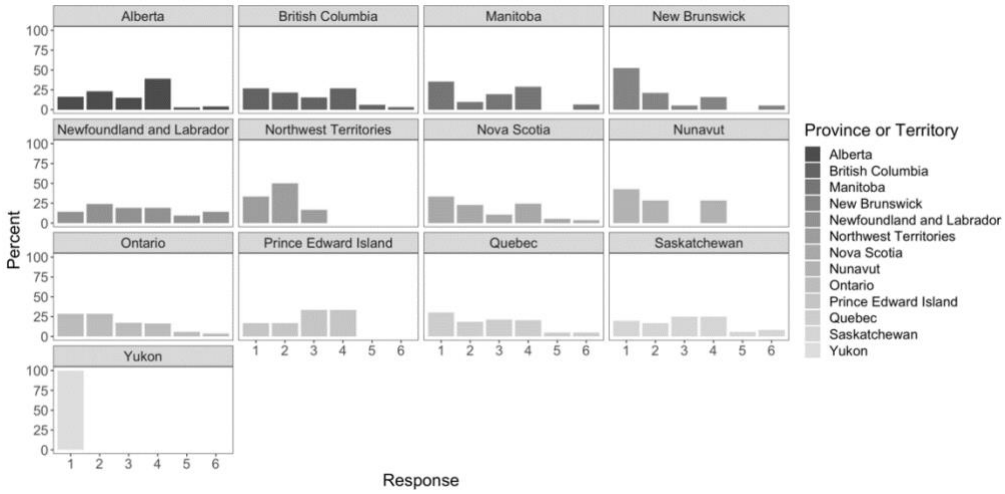


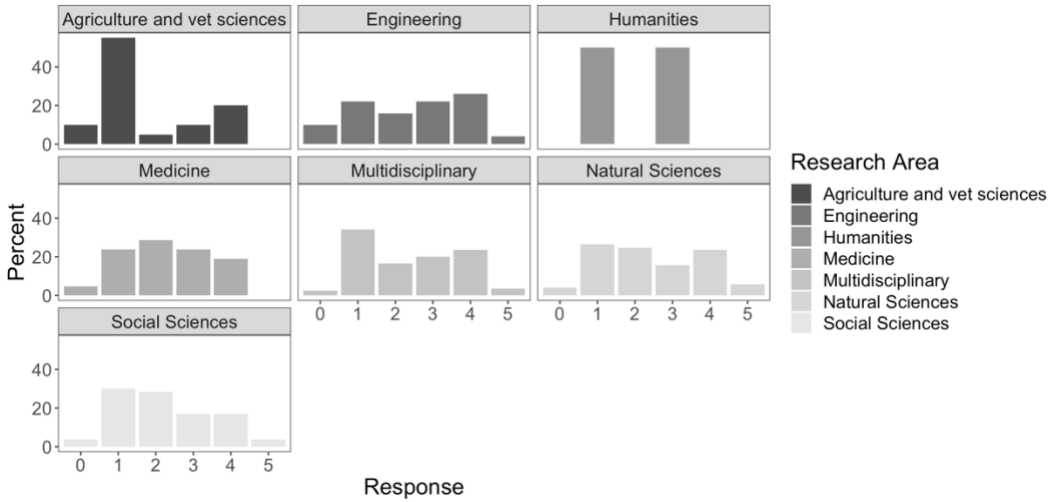


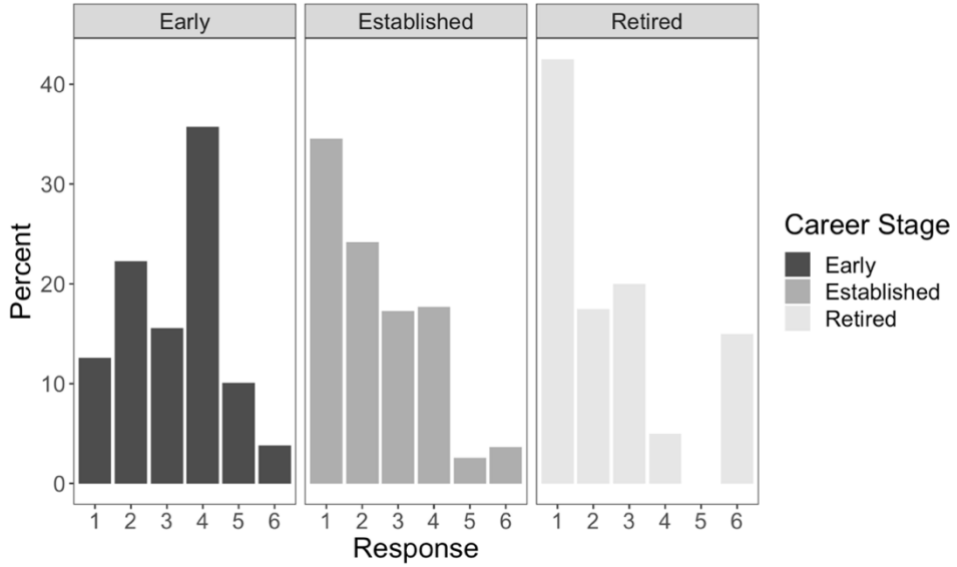


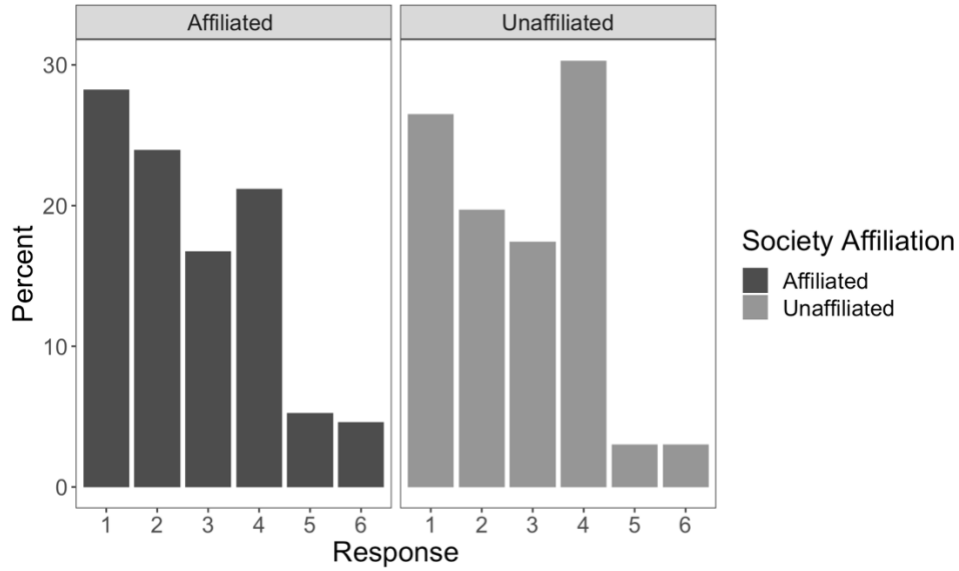


Q16[4]. My public commentary is constrained by my uncertainty about the boundaries of my expertise. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)

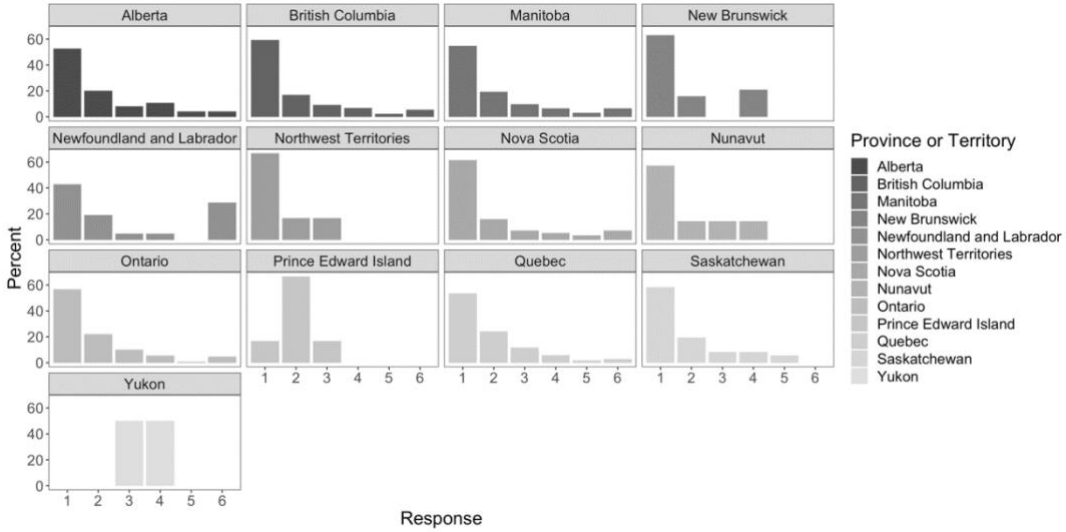


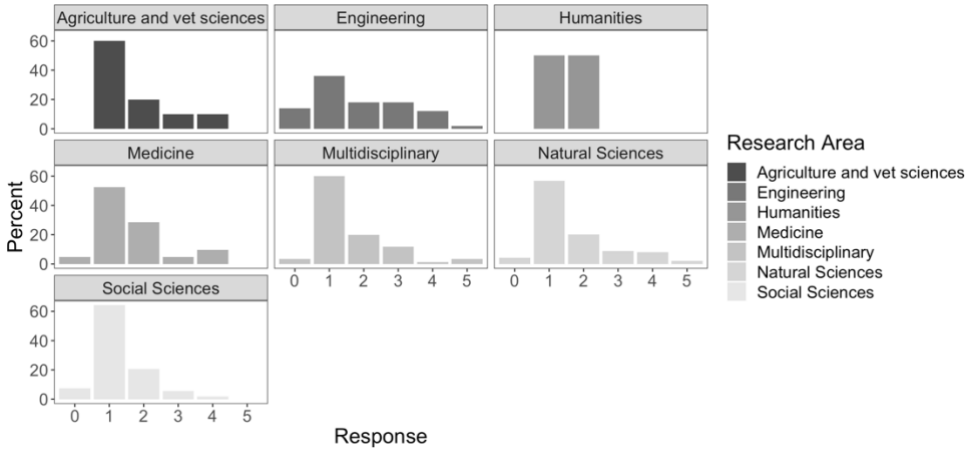


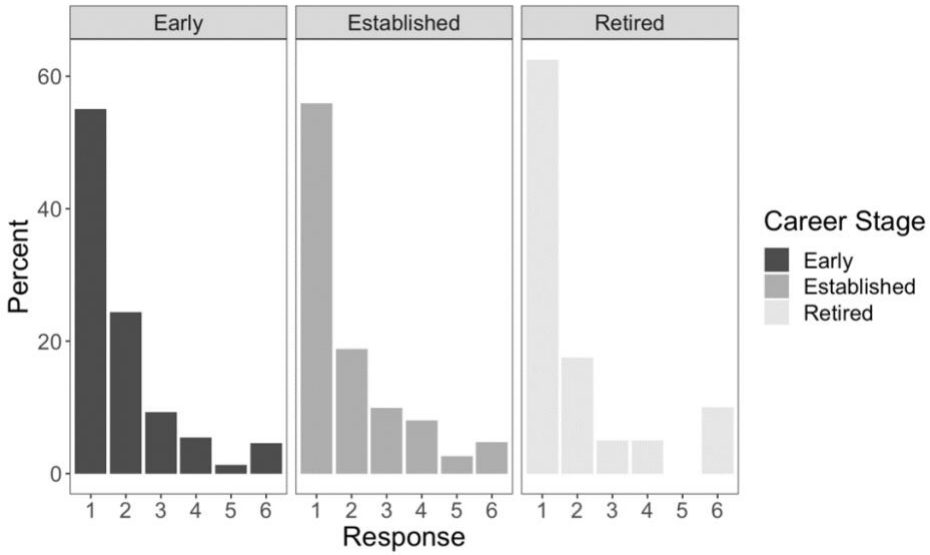


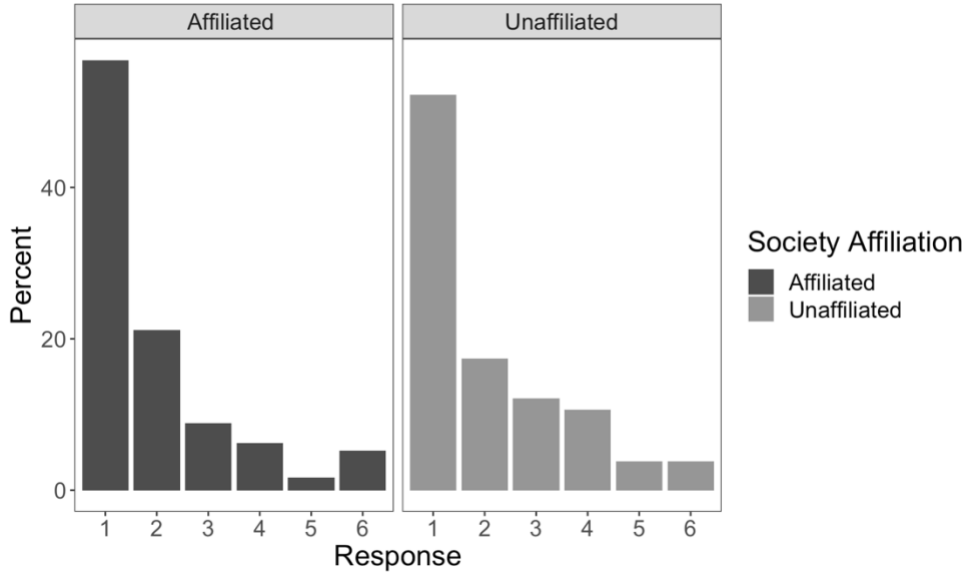


Q16[5]. My public commentary is constrained by my belief that my primary obligation is to my organization, rather than to the public. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)

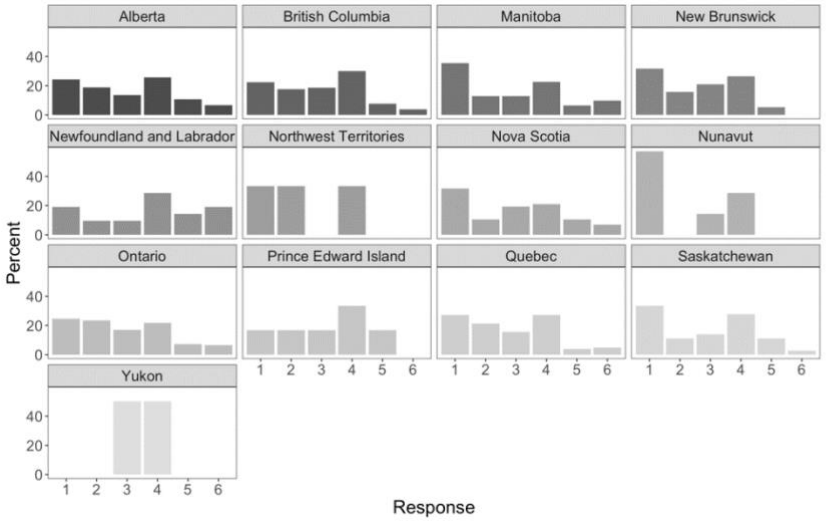


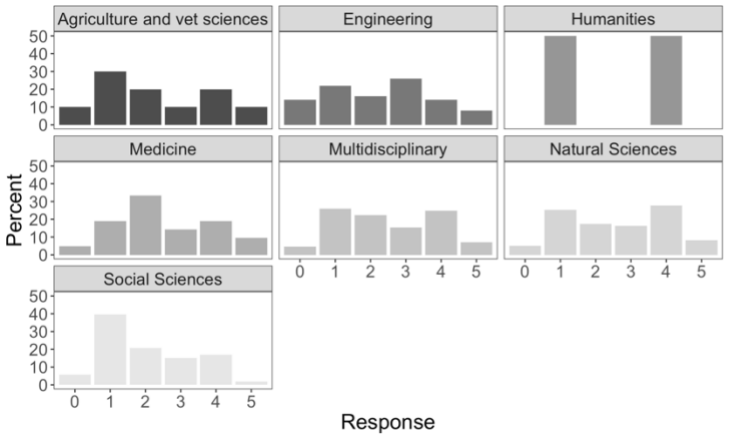


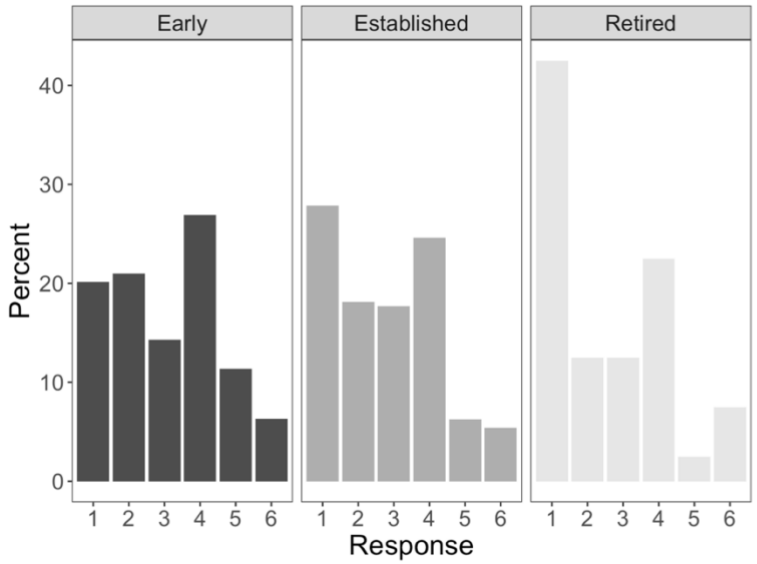


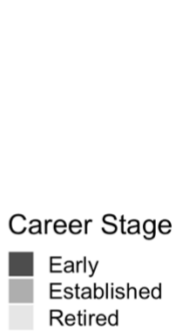


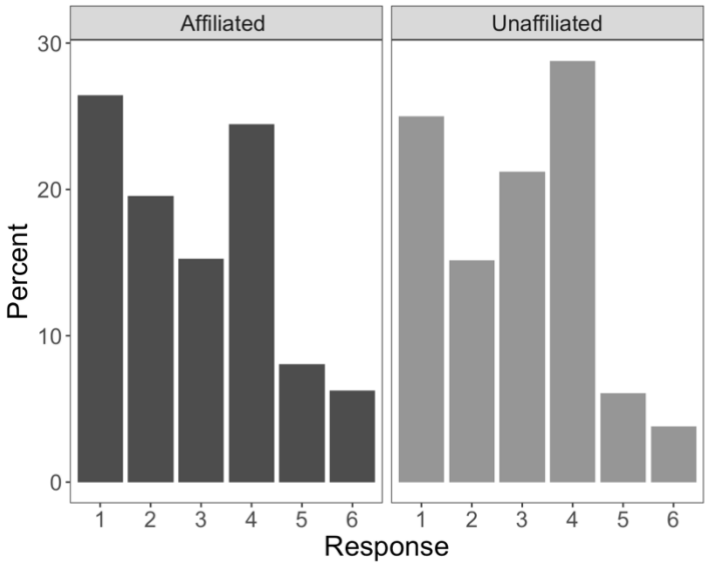
Q16[6]. My public commentary is constrained by my stress around discussing contentious issues. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)

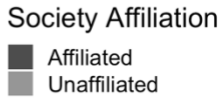




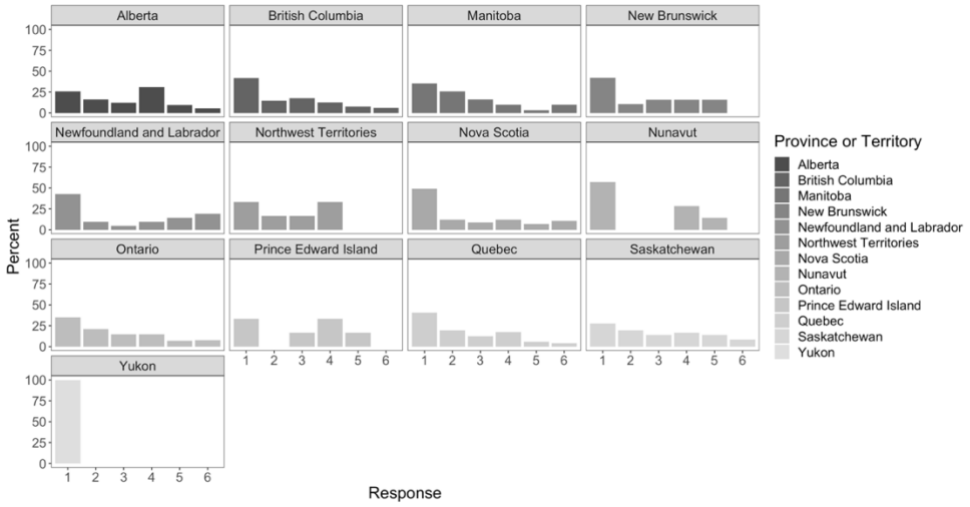


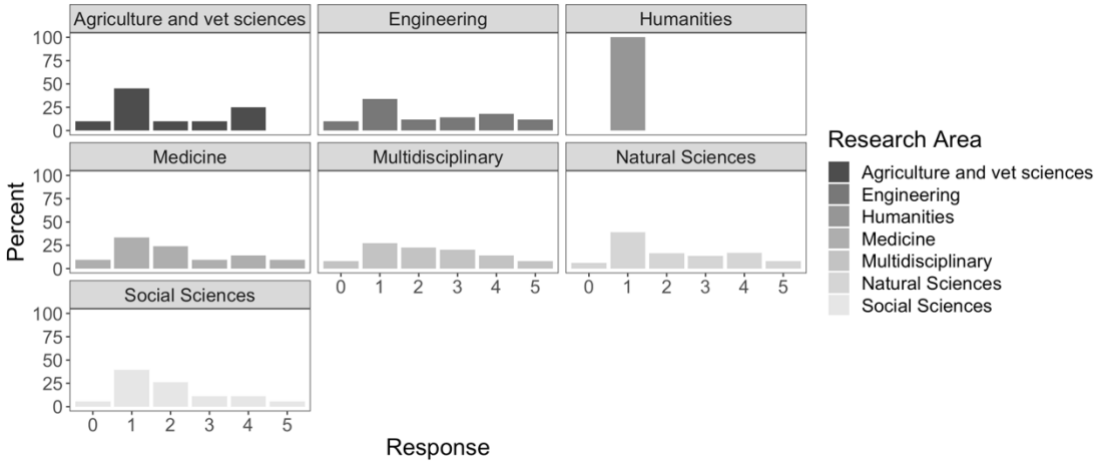


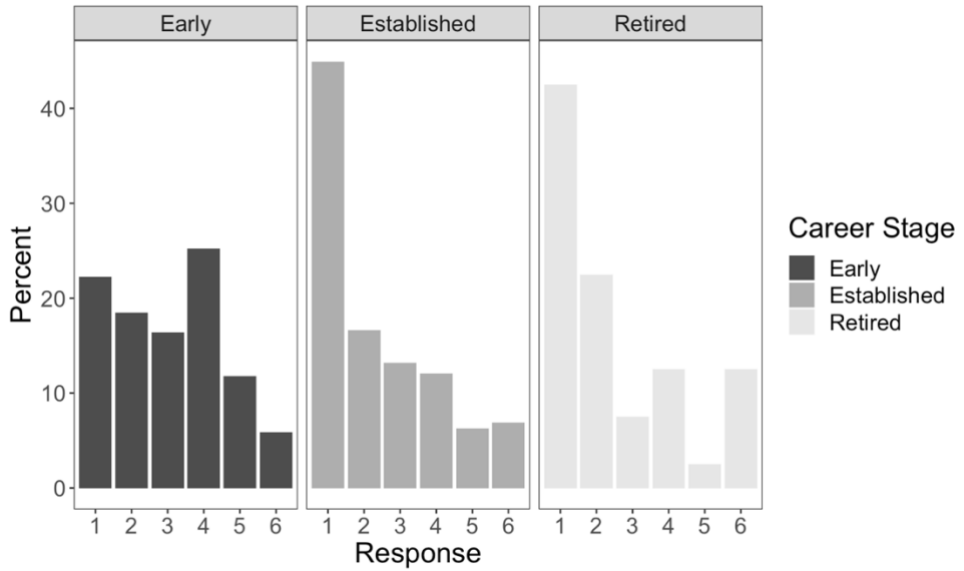


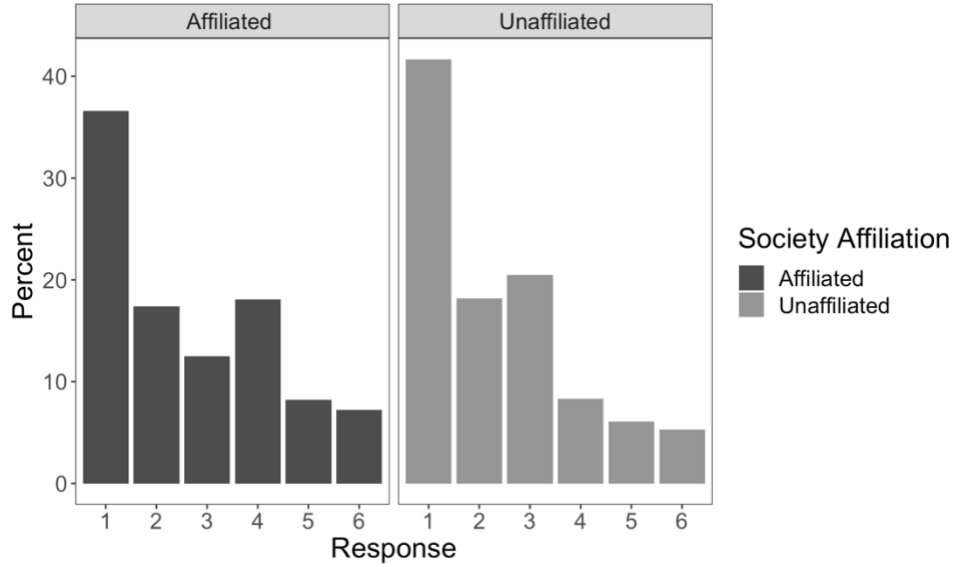


Q16[7]. My public commentary is constrained by my fear of risking funding opportunities. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)

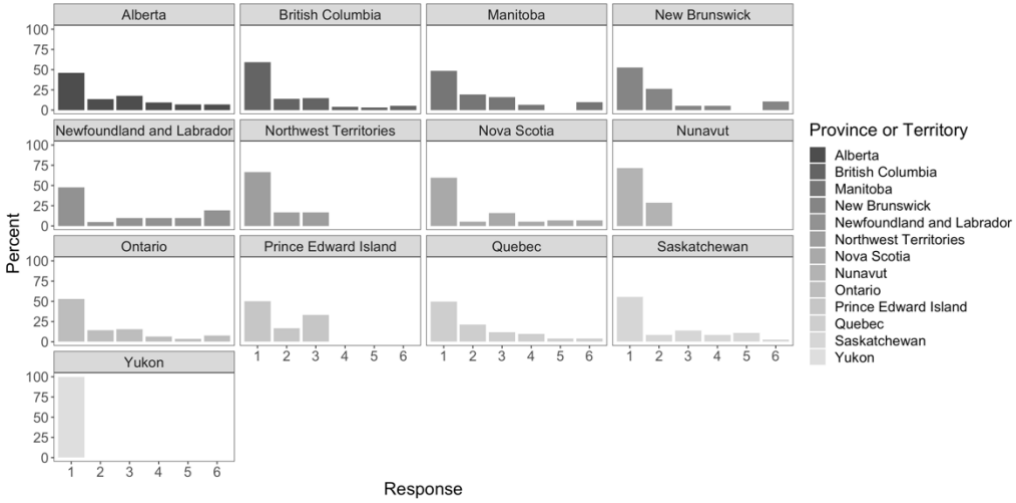


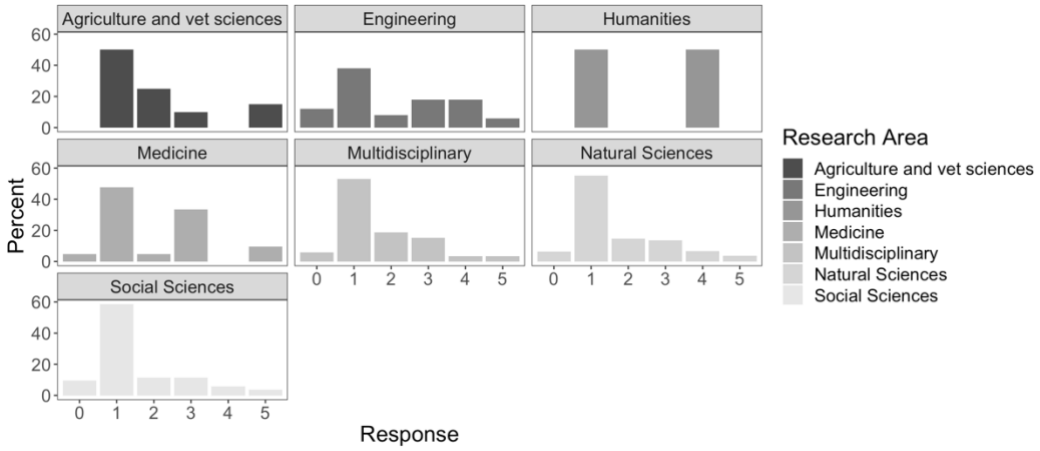


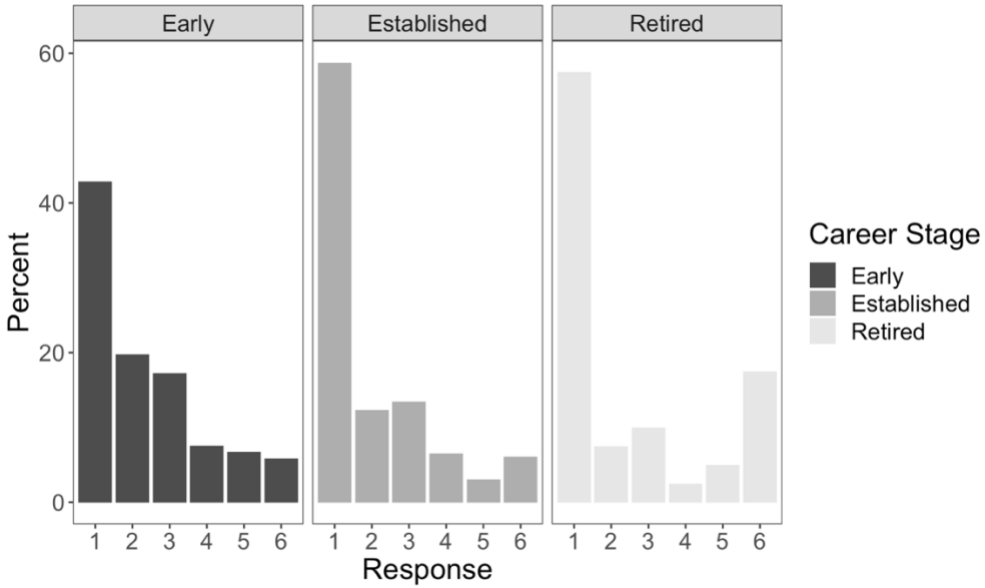


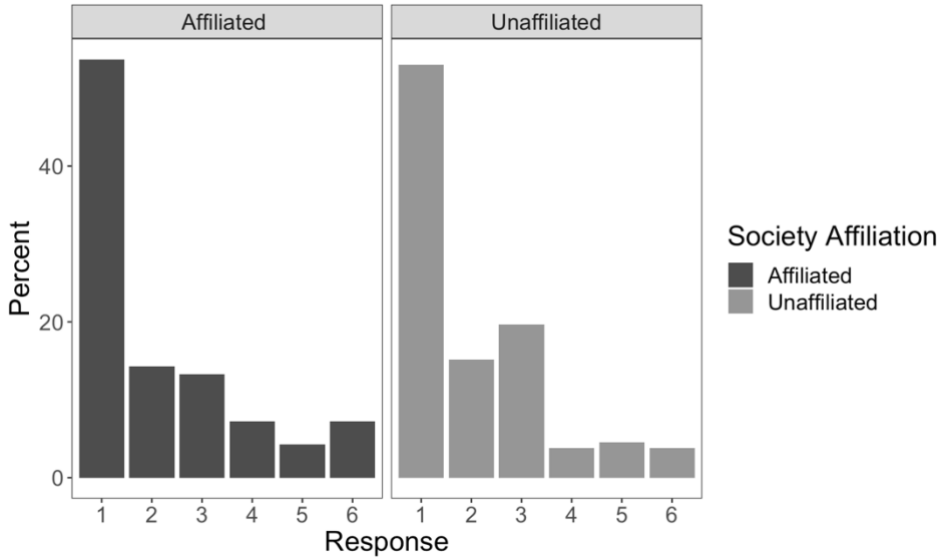


Q16[8]. My public commentary is constrained by my fear of being made redundant. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)

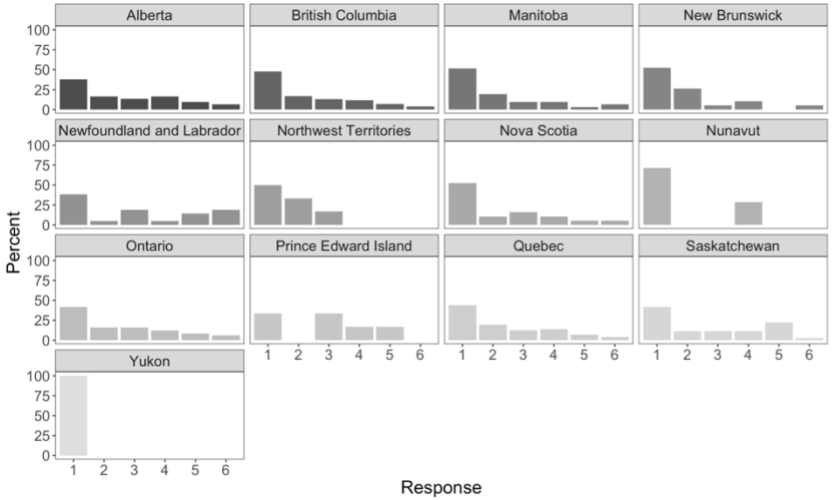


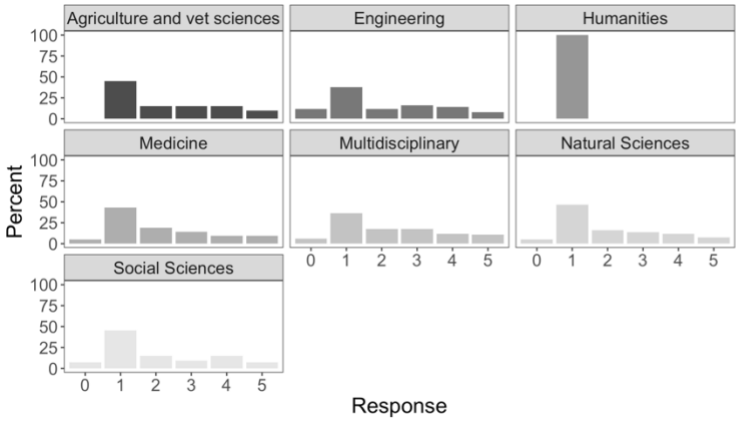


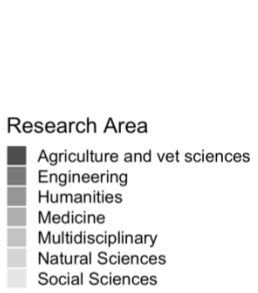


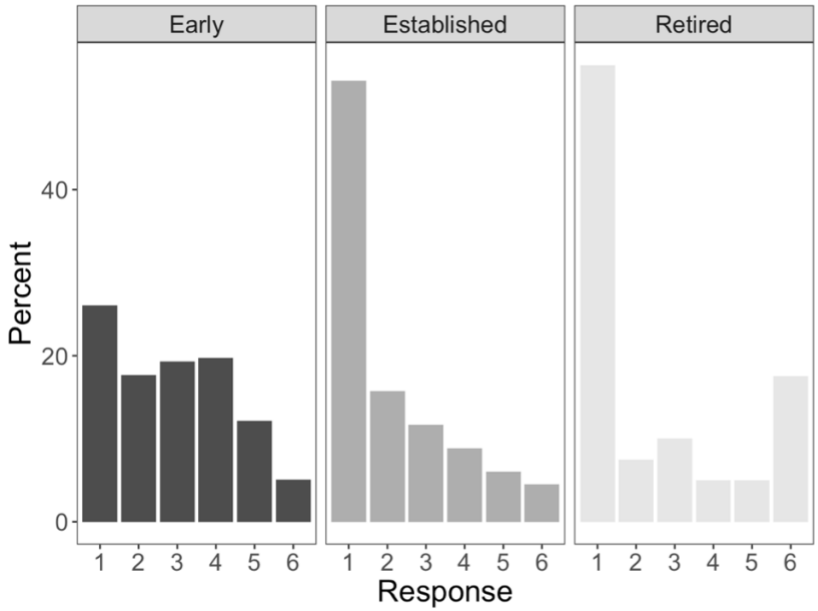


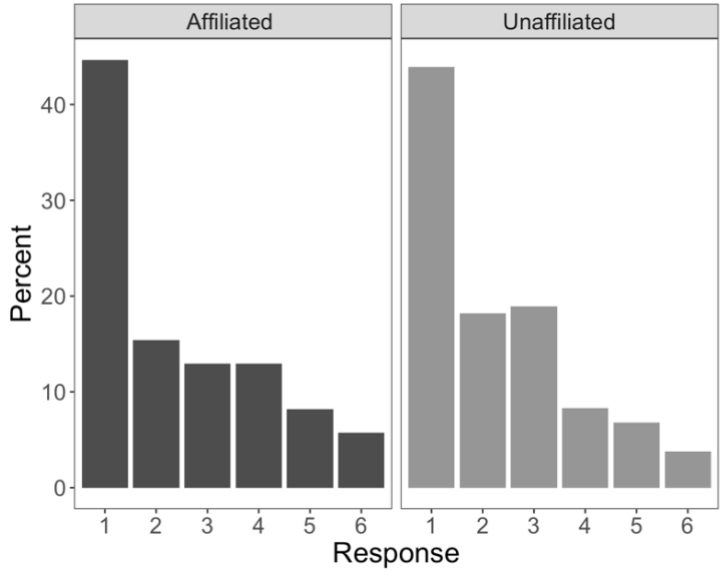
Q16[9]. My public commentary is constrained by my fear of reducing opportunities for advancement. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)



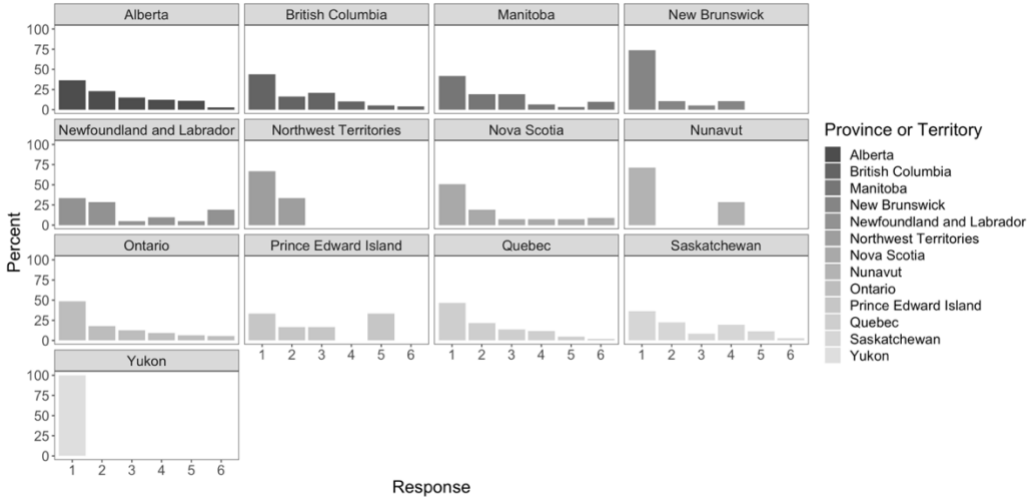


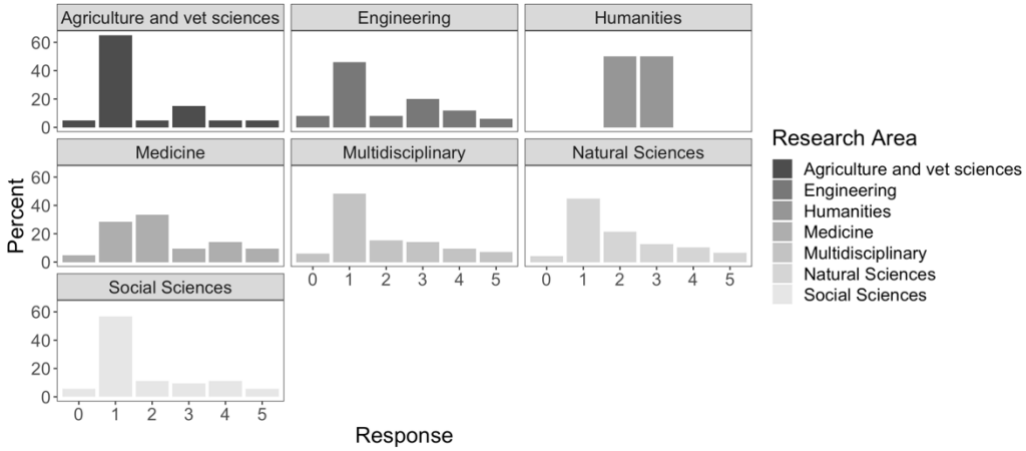


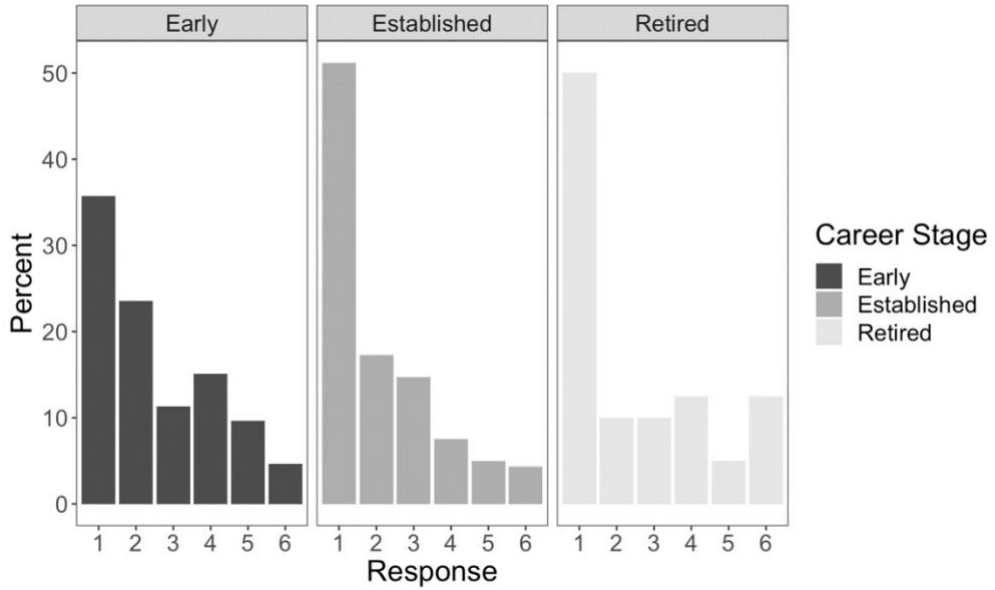


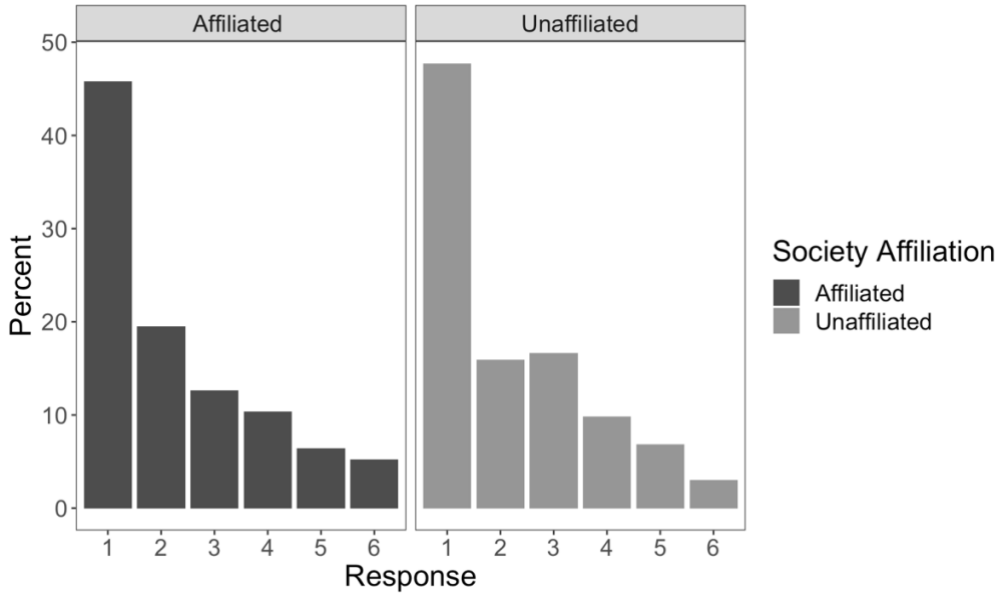


Q16[10]. My public commentary is constrained by my workplace colleagues / peer pressure / work culture. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)

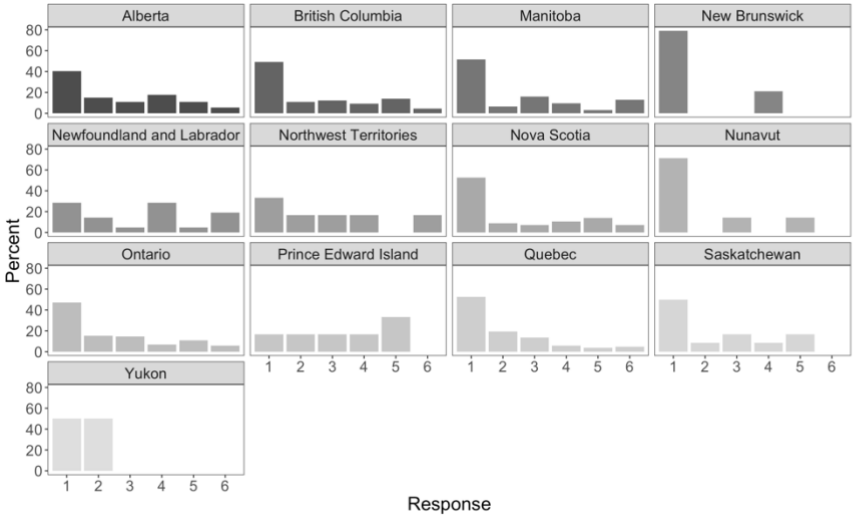


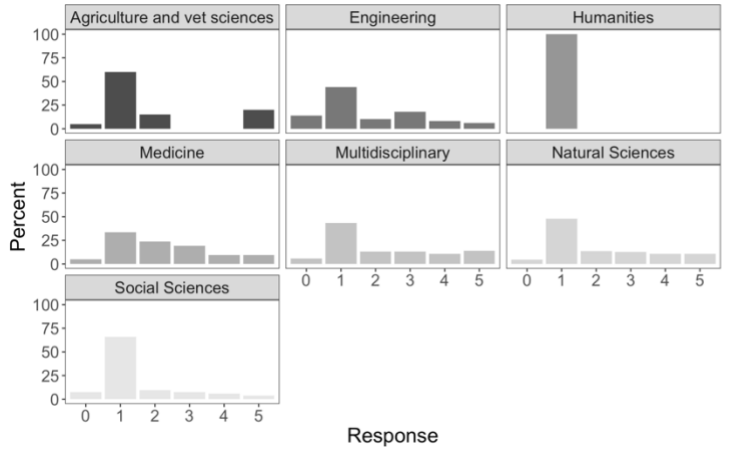


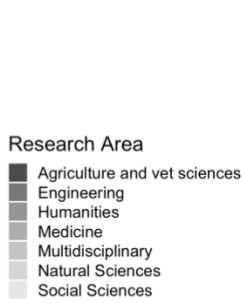


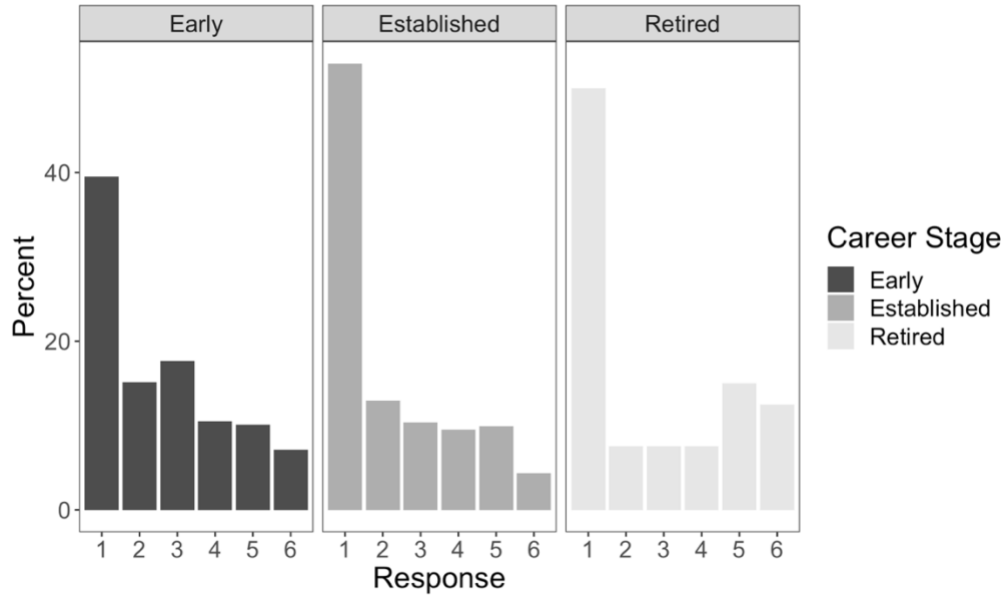


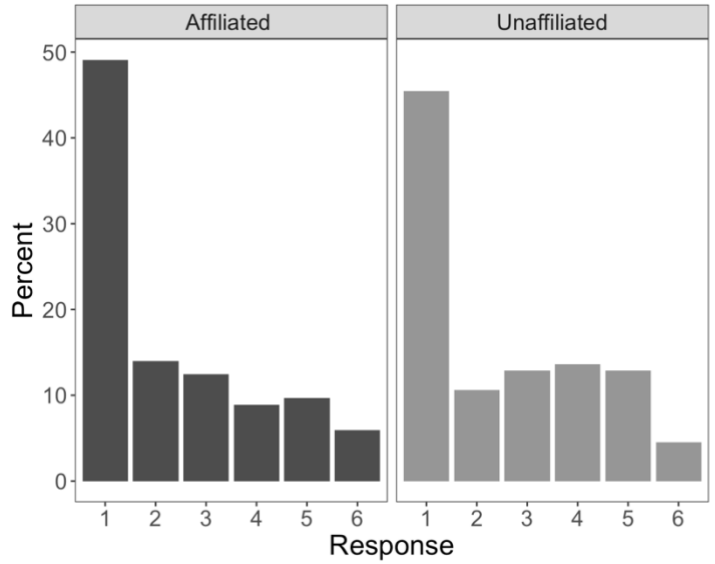
Q16[11]. My public commentary is constrained by my workplace policy. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)



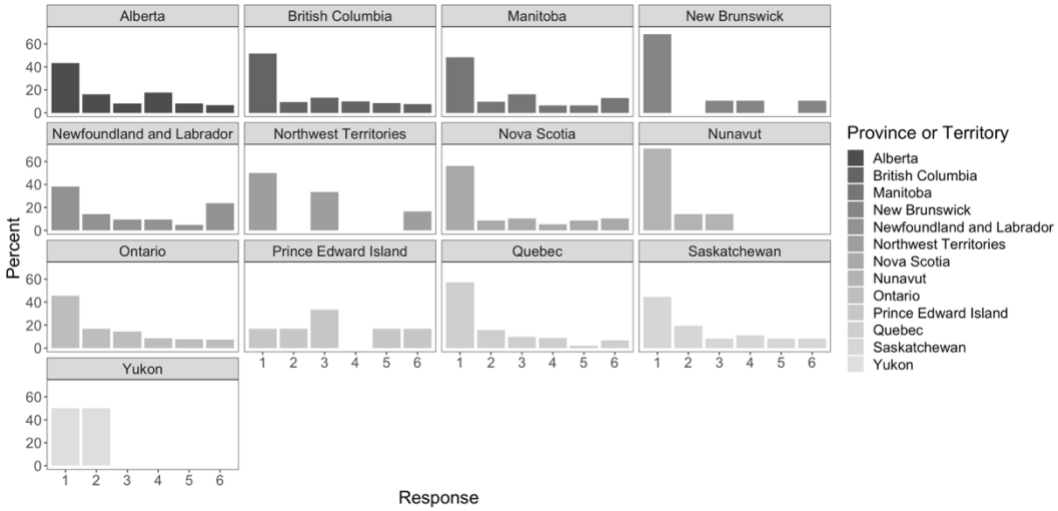


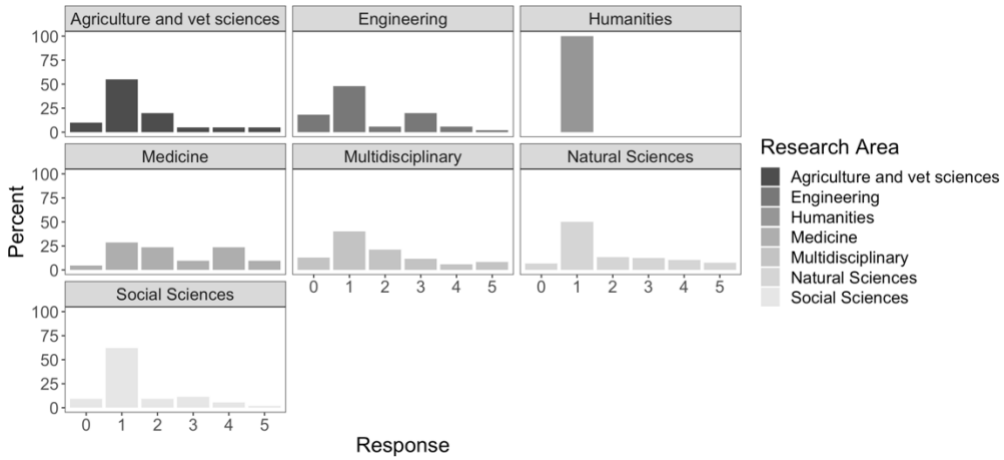


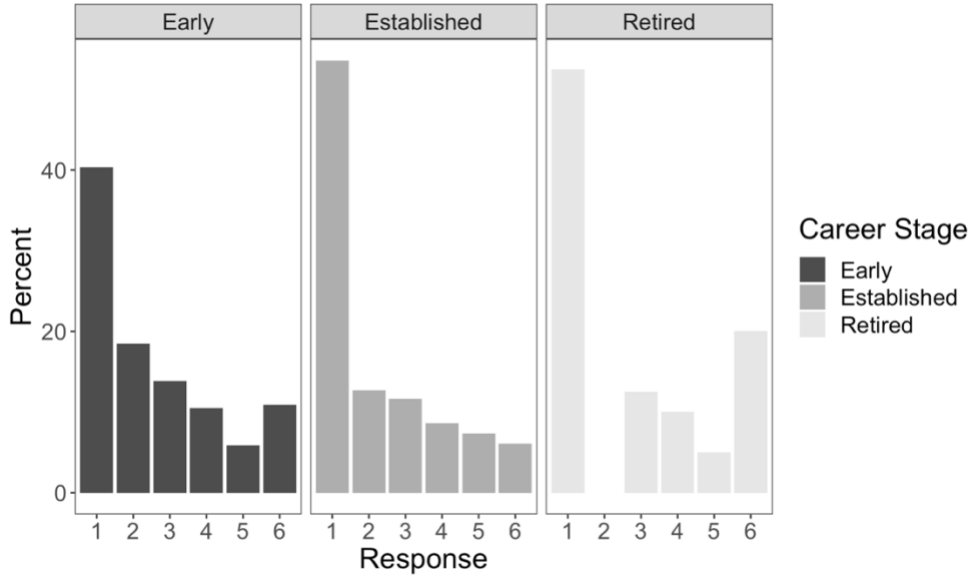


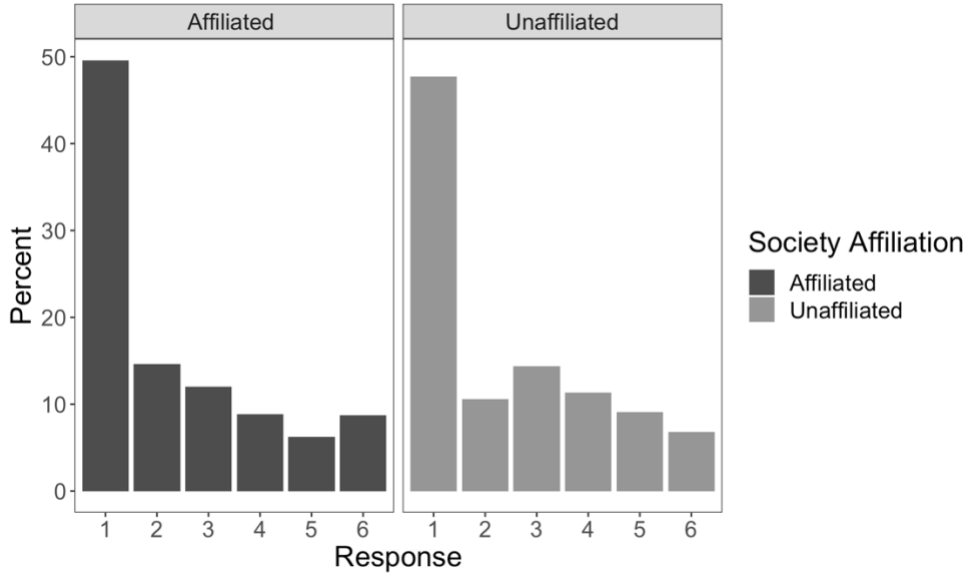


Q16[12]. My public commentary is constrained by my middle management. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)

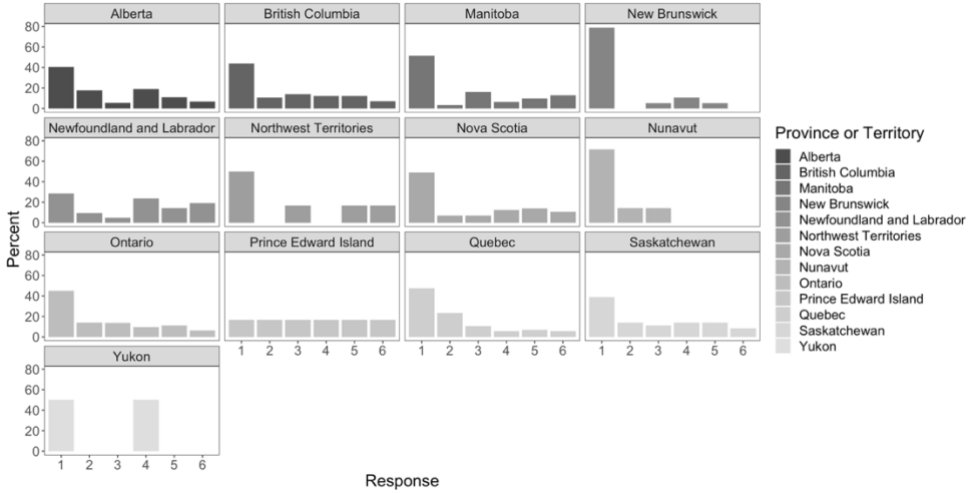


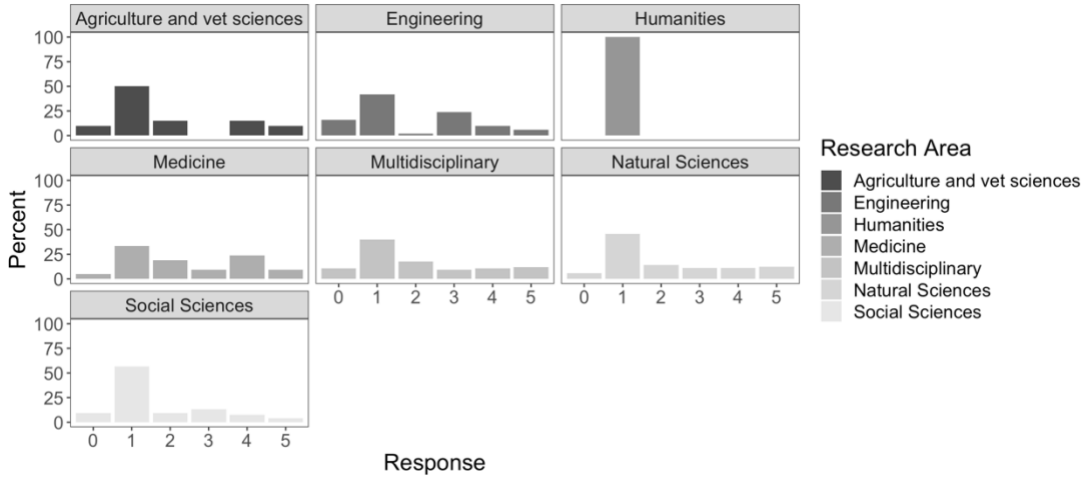


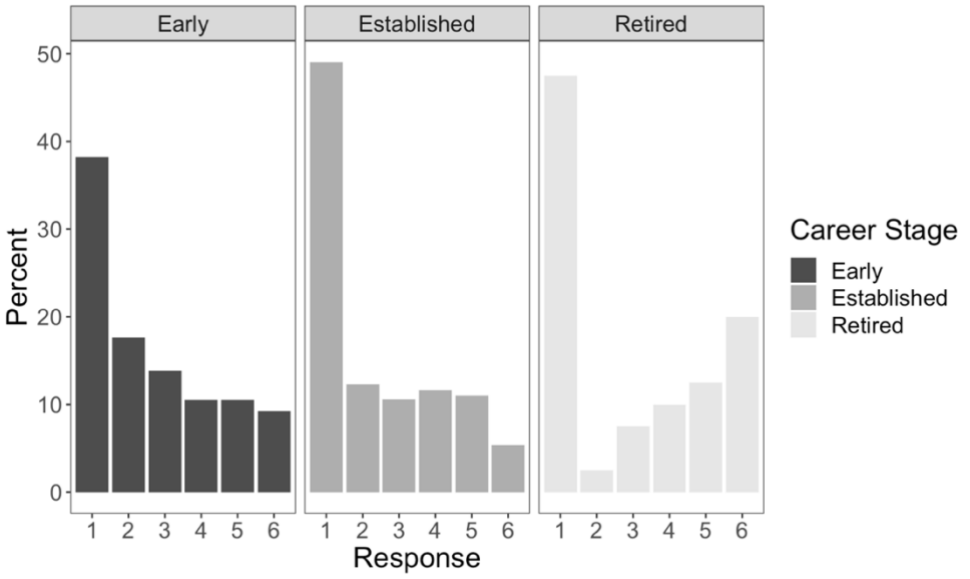


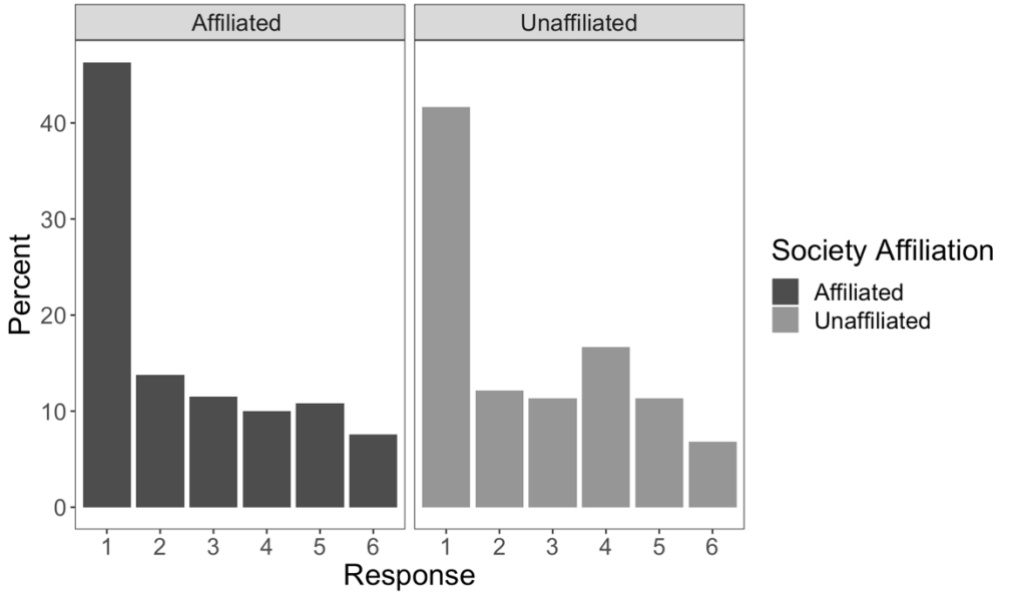


Q16[13]. My public commentary is constrained by my senior management. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)

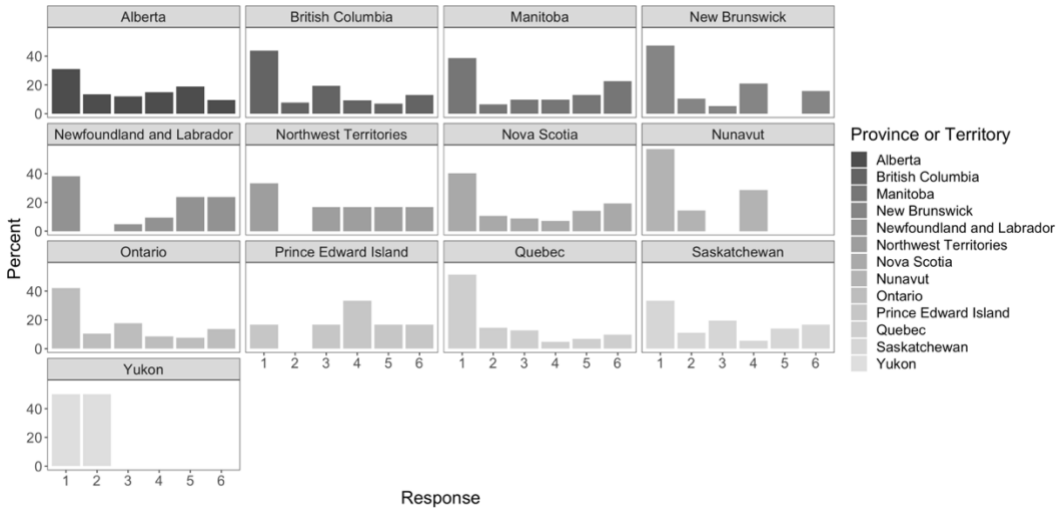


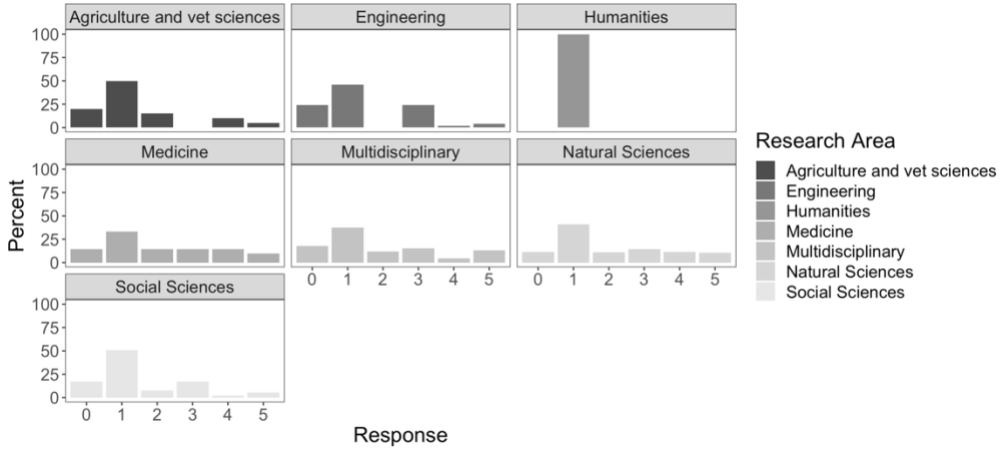


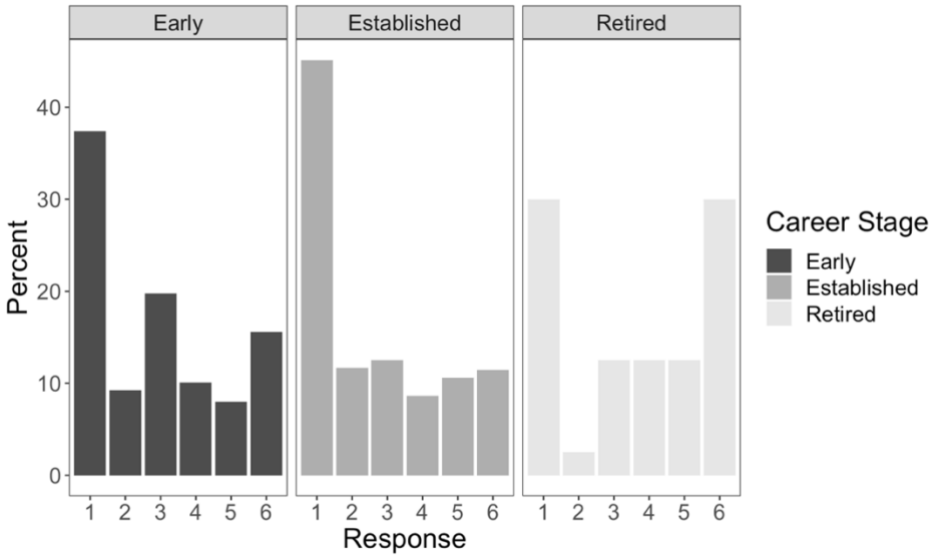


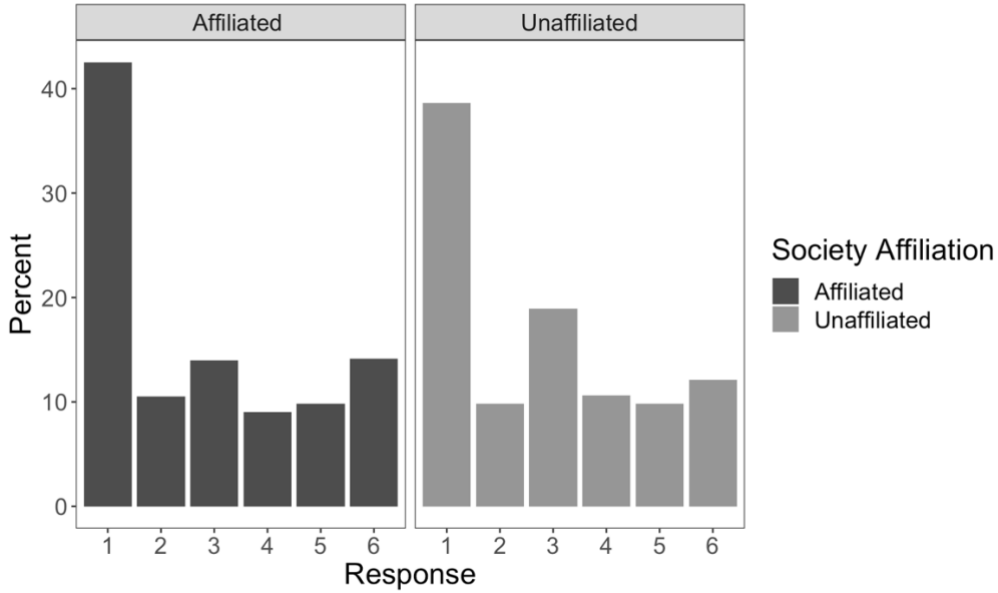


Q16[14]. My public commentary is constrained by the Minister's Office. (1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree; 6 = Not applicable; 7 = No response)

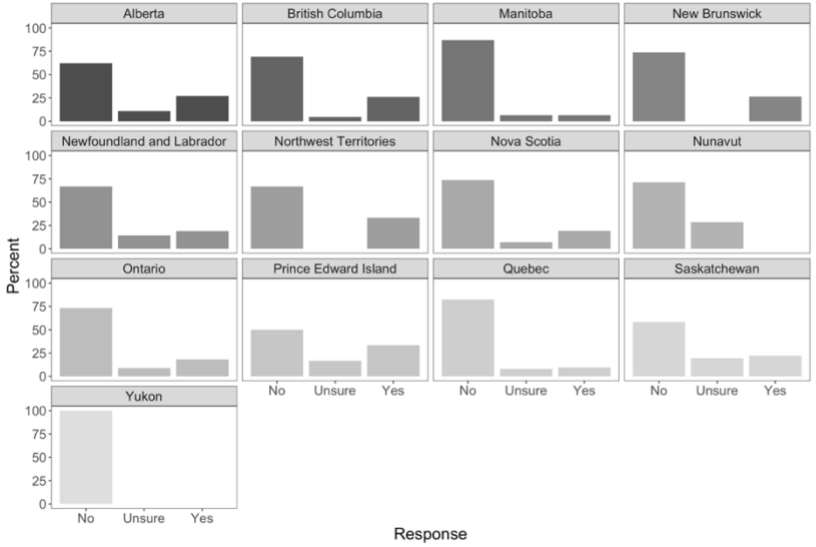


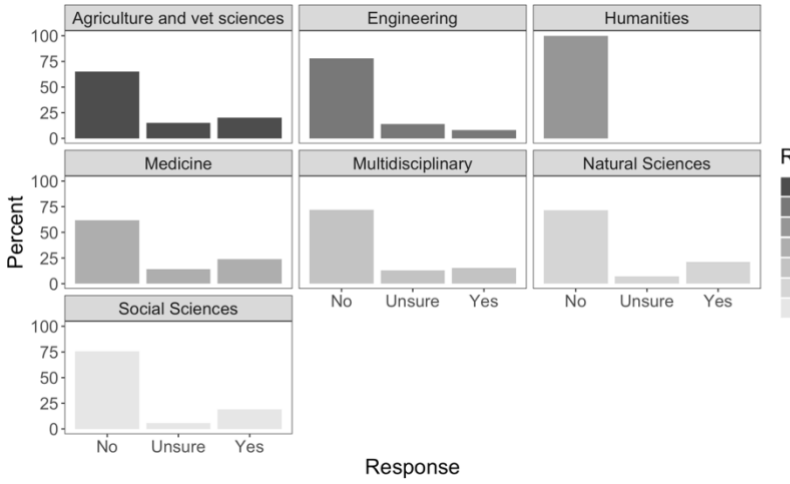


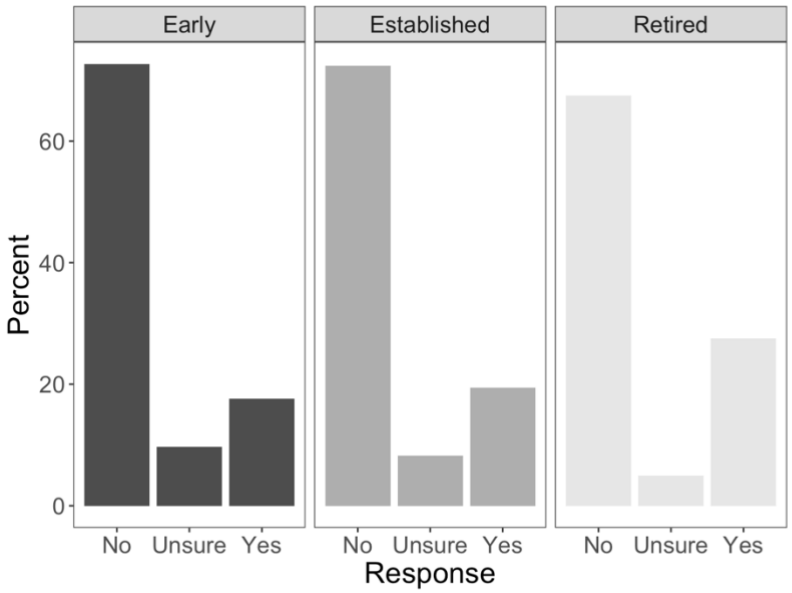


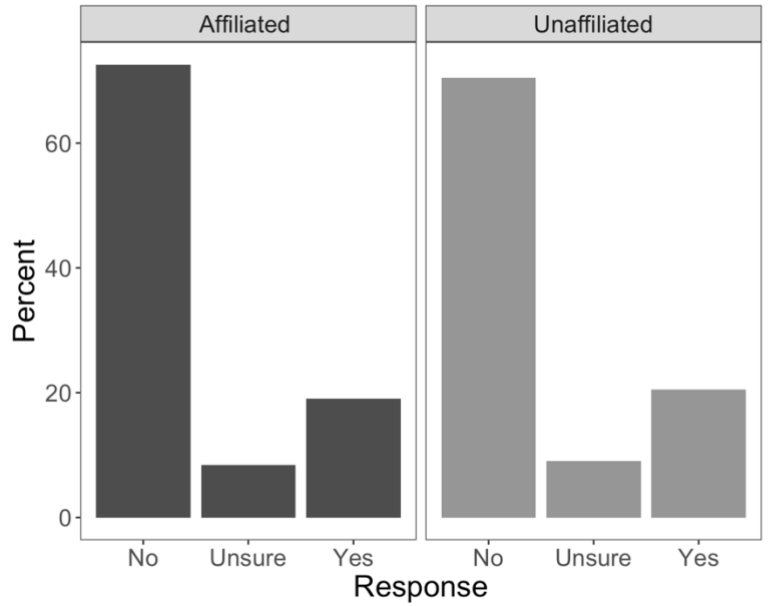


Q17. Has your job satisfaction ever been affected by restraints on public commentary and peer communication?









Q20. Are you aware of the Scientific Integrity Policies implemented in Canadian federal government department?