Differences between farmer and government official views of best management practices: cracks or canyons?

by

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Abstract

Introduction: The extensive environmental impacts associated with agriculture can be mitigated by farmers changing their management practices. Adoption of these types of practices, known as best management practices (BMP), are often slow and sporadic. Much work has rightly focused on understanding how farmers perceive BMPs. However, little is known about the consilience of farmer and government official views regarding BMPs. If the gaps between government officials' and farmers' views are too large, programs may be designed that theoretically help farmers increase BMP adoption but fail to deliver in practice.
Methods: Drawing from surveys of farmers (n = 166) and government officials (n = 30) in the British Columbian agriculture sector, we explore variation in preferences for BMPs, perceived barriers to BMP adoption, and interventions perceived as most effective at increasing BMP adoption. We end by examining how these differences in perspectives are reflected in a government funded cost-share program aimed at increasing the adoption of BMPs.
Findings: (1) *Funding preferences:* Farmers prefer biodiversity, emission, and nutrients classes of BMPs compared to government officials. Some of the differences observed between the two groups can be explained by government officials' higher preference for management plans. (2) *Barriers:* Government officials scored all 11 barriers higher than farmers, and for 8 of these barriers the difference was statistically significant. (3) *Interventions*: Farmers and government officials both rated financial incentives for increasing BMP adoption as the three most effective interventions among 12. (4) Government c*ost-share program:* Government officials' preferences for plans are reflected in the government's cost-share program that supports BMP adoption. Many BMPs preferred by farmers deliver direct benefits to their operation and the environment, but were funded at lower levels by the program.
Discussion: Despite differences between farmers and government officials, a synthesis of our results suggests that the government's 2017/18 BMP cost-share program is a compromise between government officials' preference for planning and farmers' preference for BMPs that deliver direct benefits. Our results also showcase the importance of considering multiple stakeholders in BMP adoption by providing the first comparison between farmers' and government officials' views on BMP adoption.

Lay Summary

Farmers who use best management practices (BMPs) have a lower impact on the environment, but many farmers do not use BMPs. Government officials design and implement programs to increase BMP adoption, yet no research exists focusing on their views of BMP adoption. We fill this gap in research by comparing the views of government officials and farmers in British Columbia. I find that compared to farmers, government officials prefer management plans, view barriers to BMP adoption as larger, and agree that financial incentives are the most effective intervention for increasing BMP adoption. Combining these results with an analysis of a current cost-share program reveals that the program is a compromise between government officials' preference for planning and farmers' preference for BMPs that deliver direct benefits to their farm and the environment. Our results support the need for research focusing on the role of people besides farmers involved in BMP adoption.

Preface

This dissertation is an original intellectual product of the author, A. L. Semmelink. The fieldwork reported in Chapter 2 was covered by UBC Ethics Certificate number H16-01348.

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1. Introduction

Agriculture covers 38% of Earth's terrestrial surface and is a dominant driver of climate change, habitat loss, and declining water quality (Foley et al., 2011). As demand for food rises, the percentage of Earth's surface covered by agriculture is expected to increase under most future scenarios (Schmitz et al., 2014; Tilman et al., 2011). The negative environmental impacts associated with agriculture may also increase. Agricultures contribution to global greenhouse gas (GHG) emissions and anthropogenic climate change has been estimated to be between 19% and 29% (Vermeulen et al., 2012). Climate change could in turn increase the impact of agricultural pests on crops as warming temperatures allow pests to move pole-wards (Bebber et al., 2013). Agricultures contribution to GHGs is in part a result of clearing large areas of land for agriculture, which also results in habitat loss. Further loss to habitat and species diversity can result from the use of pesticides. For example, Geiger et al. (2010) found that pesticides had persistent negative impacts on biodiversity across eight European countries. Agriculture can negatively impact biodiversity by increasing erosion and the input of excess nitrogen and phosphorus into waterbodies. Runoff from agricultural fields containing excess nitrogen can lead to algae blooms resulting in eutrophication and biodiversity dead zones (Beman et al., 2005; Rabotyagov et al., 2014). More locally, cattle entering streams can lower water quality for downstream users and alter habitat leading to loss of biodiversity (Belsky et al., 1999; Conroy et al., 2016). In many cases, these negative environmental impacts caused by agriculture also negatively impact the farmer, their operation, and their neighbours.

One set of solutions to the negative environmental impacts associated with agriculture is a suite of activities known as 'beneficial' or 'best' management practices (BMPs). The BC Ministry of Agriculture defines a BMP as "a structural, non-structural, or managerial technique recognized to be an effective and practical means to reduce or remove the risk of pollution occurring while still allowing the productive use of resources" (AGRI, 2010). Additionally, these practices aim to help "increase agricultural sustainability, contribute to a cleaner, healthier environment and adapt to environmental changes" (AGRI, 2017). More generally, BMPs mitigate negative environmental impacts or increase environmental benefits associated with agriculture. For example, riparian buffers and stream bank fencing can significantly reduce

sediment and nutrient runoff from agricultural lands (Polyakov et al., 2005; Stang et al., 2016). In addition, many of these practices can provide long-term economic and other benefits to farmers[1] (Valentin et al., 2004). For example, Jedlicka et al. (2011) demonstrated that installing nest boxes for Western Bluebirds (*Sialia mexicana*) in vineyards can increase the predation of some vineyard pests by 240%. In a follow up study, however, Jedlicka et al. (2014) did not find significant evidence that nest boxes alter avian communities at a landscape scale. Rather, riparian habitat alters avian community composition at a landscape scale, suggesting the need for farmers to complete other BMPs, such as restoring and maintaining riparian habitat.

Measuring the adoption of beneficial management practices is a complicated task. Floress et al. (2018) outlines two ways of measuring BMPs: (1) direct observation, which is highly reliable but expensive, and (2) self-reported behaviour or behavioural intention, which is generally completed via surveys and is less expensive. A major critique of measuring BMPs and other environmental actions via self-reporting can be traced to the social desirability bias, which argues that people will say that they do more pro-environmental behaviours as they perceive it as more socially desirable (Floress et al., 2018). However, this bias has little empirical support and the limited work completed on the subject either suggests a small effect or no effect at all (Milfont, 2009). A meta-analysis completed by Kormos and Gifford (2014) evaluated the influence of the social desirability bias on self-reported environmental behaviour concluding that "socially desirable responding does not exert a large influence on self-reported proenvironmental behavior," with the caveat that there are many 'inconsistencies' in the methods used to measure this relationship.

Studies that measure the adoption rate of BMPs find that the voluntary adoption of BMPs by farmers has been slow and sporadic, despite the environmental and economic benefits. For example, an analysis by Mackay (2010) estimated that adoption of possible BMPs ranges from 25% to 71% across Canada. Many different reasons have been identified to explain BMP adoption rates, yet little consensus exists as to the primary drivers. This is despite, or perhaps because of, the considerable body of work on BMP adoption around the world (Zhuang et al., 2016) and more specifically in North American agriculture (Prokopy, 2008).

[1] Anticipating an interdisciplinary audience, we use the colloquial term farmer instead of: 'producer' or the double barrelled farmer/rancher, to include all 'those persons responsible for the management decisions in operating an agricultural operation,' which is Statistics Canada's definition for farm operator (2016). The term producer is also used occasionally in the place of farmer.

To better understand why these practices are not adopted by more farmers, many theoretical frameworks can be applied to better understand the determinants of adoption. Unfortunately, as Baumgart-Getz et al. (2012) demonstrated in their meta-analysis, many BMP adoption studies do not apply theoretical frameworks consistently. Determinants of BMP adoption are generally studied from two opposing perspectives, either that (a) individual farmer attributes influence adoption or (b) larger-scale contextual or structural factors impact adoption. This divide is indicative of a fundamental fission in the social sciences over what explains changes in practice: individual agency or social structure.

(a) Individual agency as a driver of behaviour/social change in its current form finds its roots in the planned behaviour literature (Azjen & Fishbein, 1977). This body of literature argues that decision-making is best understood by determining how individuals make choices given a set of options (Darnton, 2008; Stern, 1999). In this case, a BMP is adopted because of an individual's values, attitude, knowledge, or cognitive ability.

(b) Arguably, the tradition of social structure as the driving force behind changes in practice was popularized by the work of Durkheim (1895). Durkheim argued that 'social facts' could be used to explain behaviour and exists independently of individuals. This same type of logic is present in the contemporary body of literature known as social practice theory, which endeavours to bring into focus the contextual or structural factors that impact adoption (Hargreaves, 2011; Shove, 2010). In contrast to the more individual based perspective described above, this thread of social sciences identifies the institutions – norms, rules, and regulations – and infrastructure that form an individual's environment as the primary unit of analysis to understand concepts such as the adoption of BMPs. This work highlights the importance of the "extent to which state and other actors configure the fabric and the texture of daily life" (Shove, 2010).

The social practice literature has been particularly abrasive towards attempts to combine the two perspectives, describing the approaches as "chalk and cheese" or incommensurable (Shove, 2010, p. 1279). However, Kollmuss and Agyeman (2002) suggest that applying both approaches to a particular problem could yield more complete answers. More specifically, Reimer et al. (2014a) argue that integrating these two disparate research foci is necessary to gain a sophisticated understanding of why farmers adopt best management practices.

Two recently proposed frameworks anchored in the BMP and stewardship adoption literature, draw from both perspectives and are helpful in further understanding BMP adoption. Mills et al. (2016) outline three groups of factors that explain BMP adoption: 'ability to adopt', 'willingness to adopt', and 'influences on farmer behavioural changes'. Another model for understanding environmental stewardship more generally, developed by Bennett et al. (2018), included three parallel factors: 'motivations', 'capacity', and 'interventions'. A quantitative meta-analysis of BMP adoption in the United States identified similar factors "as having the largest impact on adoption" highlighting the following variables: "access to and quality of information, financial capacity, and being connected to agency or local networks of farmers or watershed groups" (Baumgart-Getz et al., 2012). Although the definitions and arrangement of elements may vary, many frameworks include the following interacting elements: practice type (e.g., individual preference for BMP), motivations (individual-based), capacity or barriers (context-based), and interventions (context-based).

To increase the adoption of BMPs, governments have developed a variety of intervention strategies. Three common government approaches to increasing adoption are volunteerism, regulations, and incentives (Mills et al., 2016). Volunteerism, or allowing farmers to adopt practices on a voluntary basis while providing information or raising awareness, is generally acknowledged to be ineffective. Regulations can be effective at forcing farmers to adopt BMPs, but suffer from high monitoring costs and can be difficult to enforce (Greiner et al., 2016). In some cases, regulatory interventions are associated with lower adoption of BMPs in comparison to voluntary adoption (Barnes et al., 2013). Increasingly, incentive programs paired with awareness raising initiatives are perceived as a viable, if not preferred, option. For example, in B.C., a pair of programs, the Environmental Farm Plan & Beneficial Management Practices Programs, provide farmers with a free, confidential environmental assessment of their farm and the option to obtain cost-share funding for adopting BMPs.

An often-raised concern with incentive programs is the potential for the financial incentive to 'crowd out' or undermine individual's existing intrinsic motivations for adopting BMPs (Greiner and Gregg, 2011; Rode et al., 2015). However, there has been little evidence that 'motivational crowding out' applies to farmers from countries with similar economic and cultural backgrounds to Canada. For example, in Rode et al.'s (2015) review of crowding out the only paper cited as evidence of crowding out from a context similar to agriculture in B.C. –

Australian graziers - is Greiner and Gregg (2011). They speculate that crowding out could be a problem, mentioning the theory twice in their paper: once in the abstract and once in the results with a qualifier "may have experienced the crowding out of intrinsic motivation by financially driven policy programs".

In the cases where studies have been completed with farmers, researchers have not found evidence of crowding out. For example, Darragh and Emery (2017) completed a small qualitative case study of farmers' intentions to continue with BMPs following the termination of a funding scheme and concluded that farmers would continue to use the BMPs that they had used prior to the funding scheme. Another study found that public financial subsidies to landowners actually increased the likelihood of them completing unsubsidized work (Duncan et al., 2014). There are two related reasons for these discrepancies between the theoretical claims of motivational crowding out and the empirical findings in agricultural contexts like Canada. First, program design may not trigger motivational crowding out (Chan et al., 2017). For example, programs that provide cost-share funding for farmers to adopt BMPs require farmers to spend their own time and resources. These types of programs may not be providing as much of an incentive as they are reducing barriers to adoption. Second, and more broadly, motivational crowding out theory portrays economic and intrinsic motivations as "mutually exclusive" assuming that one motivation can crowd out another, which as Darragh and Emery (2017) show is not always the case. They argue that farmers can both be "financially incentivised and continue to "nurture non-economic motives" for the adoption of practices. Overall, financial interventions will likely continue to be an important tool for government officials to increase the adoption of BMPs.

Government officials, who are responsible for the design and implementation of government-led interventions to increase BMP adoption, have rarely been studied in the context of BMP adoption. Previous work on BMP adoption and potential interventions has not focused much on the different actors involved in BMP adoption. Although some frameworks acknowledge the importance of actors (e.g., Bennett et al., 2018), many of the studies quite rightly focus on a single group of actors: farmers. Some work exists on the other actors involved with BMP adoption. For example, there is work on farmer advisors who either provide support or advice to farmers adopting BMPs (e.g., Hejnowicz et al., 2016). Others have explored how farmers' knowledge and views differ from other actors. For example, Wilson et al. (2009) used a

comparison between farmers' and weed scientists to "identify gaps in knowledge" in integrated weed management. The results indicated that farmers understood integrated weed management but chose not to practice this set of BMPs. The authors suggested that this decision to not adopt could be a result of "their focus on the risks associated with weeds without recognition of their ecological benefits, and the tendency to overlook risks associated with management." However, the authors also suggested that 'educators' could do more to promote BMPs "within the frame of farmers' experience and belief structure". Still others have compared the views of the farmers and the public on the relationship between agricultural practices, conservation and ecosystem services (Bernués et al., 2016; Howley et al., 2014). These comparisons between farmers and other actors are focused on actors that do not directly influence the creation and implementation of government interventions aimed at increasing BMP adoption.

A dearth of work exists that compares farmers' views to government officials' views on BMPs. However, much work has focused on comparing the views of experts to the public. The Pew Research Center surveyed representative samples of 3,748 members of the American Association for the Advancement of Science (AAAS) and 2,002 U.S. adults on a range of views on Science and Society (Pew Research Center, 2015). The report compared the views of the scientists with the public on a variety of science-related issues, finding large differences between the groups. For example, 37% of U.S. adults said that it is 'safe to eat genetically modified foods' compared to 88% of AAAS scientists; 68% of U.S. adults said that 'childhood vaccines such as MMR should be required' compared to 86% AAAS scientists; and 50% of U.S. adults said that 'climate change is mostly due to human activity' compared to 87% of AAAS scientists. Other studies measure experts and the publics views on the risk posed by technologies such as nanotechnologies (Scheufele et al., 2007). However, these comparisons between experts and the public tell us little about comparisons between farmers' and government officials' views both groups have expertise. As Collins (2014) and others have argued, expertise based on experience can be as valid as expertise gained through scientific training in specific circumstances. Collins describes how scientists can "work from an oversimplified version of the world and fail to take account of expertise based on experience". Collins describes a case where scientists failed to account for experience based expertise: Scientists told farm workers that the 245T, a herbicide, was safe to use so long as they followed

"the appropriate safety precautions". However, the farm workers, who had experience working with the herbicide, claimed it was impossible to follow these precautions and therefore was "not safe in the way scientists said it was". As the farm workers did not have professional qualifications their views were ignored. Farmers are experience-based experts, while government officials who work in agriculture are also experts and often train as agrologists. Jones et al., (2013) embraced this logic if not this language of expertise, by asking farmers to score a set the practicality of a set of BMPs, while asking experts to score the effectiveness of the same set of BMPs in mitigating a negative environmental impact. The study found "a higher degree of certainty and agreement on which measures are ineffective and impractical, but less certainty and agreement on which measures are the most effective and most practical" with high heterogeneity amongst farmers and no clear category of mitigation practices agreed upon by farmers and experts.

If we are to incorporate both an agency and a structural approach to studying BMP adoption, understanding the role of actors involved in designing the structures that influence farmers is essential. A lack of alignment of views between those who design the programs, government officials, and those who are supposed to use them could also lead to programs that do not cater to the needs of farmers or allow farmers to express agency over their own land. Programs that are proscriptive, inflexible, and do not allow farmers to actively manage their land can lead to rejection of said program (Chan et al., 2017b). To address this gap, I explore broadly how farmer and government officials' views align and differ on BMPs. Specifically, I investigate and compare government officials' and farmers' views regarding their preferences for BMPs, perceived barriers to adoption, and perceived effectiveness of interventions for increasing adoption. I end by evaluating how these views are reflected in a current government cost-share program in British Columbia.

2. BMP Adoption in British Columbia: A Case Study

A comprehensive review of agricultural BMP adoption across Canada showed that BC farmers lagged in BMP implementation (MacKay, 2010). To increase the adoption of BC farmers, the BC Ministry of Agriculture and Agriculture and Agri-Food Canada jointly fund programming targeted at increasing the adoption of BMPs. The adoption of BMPs is particularly important as approximately 50% of Canadian farms reported having woodlands and wetlands on their property (Jeswiet et al., 2015). The programming is supported through the Governments of Canada and B.C. on a cost-shared basis and includes two linked programs: Environmental Farm Plan and Beneficial Management Practices Programs.

The BC Agricultural Council (BCAC), an industry association representing the majority of BC farmers, administers these two programs through the Agricultural Research and Development Corporation (ARDCorp). The Environmental Farm Plan Program (EFP) is a confidential, no-charge, agri-environmental assessment that, along with supplementary management plans, helps producers access information regarding the possible benefits of BMPs to their operation. The EFP is administered by an independent consultant hired by ARDCorp to ensure confidentiality of the farmer. The EFP requires farmers to meet some minimum standards and helps the farmer identify which BMPs are relevant to their operations and should be prioritized. As of 2011, 21% of BC producers were enrolled in the Environmental Farm Plan program, the lowest provincial percentage in Canada (Statistics Canada, 2015).

Farmers who complete an EFP can access the Beneficial Management Practices Program, which provides farmers with funding and technical guidance to implement specific BMPs (BC Agriculture Council, 2014). Access to the BMP Program also requires that farmers have a valid business (GST) number and land designated by as 'Farm Class' by the BC Assessment Authority or a First Nation. For example, farmers can receive 60% of the cost of establishing a riparian buffer through the program. The program has a funding cap of $70,000 per agricultural operation (farm). However, before farmers can receive much of this funding, they must complete 'management plans', which can also be framed as BMPs. These management plans are paid upfront by farmers and are completed by an independent consultant (often the EFP advisor) who visits their farm and conducts a more detailed

assessment of a specific area (e.g., nutrient management plan or biodiversity management plan). The costs of these plans are fully reimbursed through the BMP program (up to a cap of $1,000 or $2,000). In comparison, BMPs such as establishment of riparian buffers are partially reimbursed. These practices are either funded at 30, 50, or 60 percent.

The funding levels are set via an ad hoc process but in principle practices that are thought to mitigate more environmental risk or increase more environmental benefits receive more funding. An Industry Committee reviews requests for BMPs to be added to the program, with a final review by BC Ministry of Agriculture staff. The program also focuses on project based funding and therefore practices that require ongoing funding such as “cover or companion cropping” are not funded (although there are some exceptions).

Both the Environmental Farm Plan and Beneficial Management Practices Programs have no formal mechanism for farmers to provide feedback to government officials on their views of BMPs and the structure and effectiveness of these programs. To address this gap, the BC Ministry of Agriculture (AGRI) contracted me via Kai Chan’s research group to complete a needs assessment of beneficial management practices with stakeholders including relevant government officials and BC farmers. The data from this needs assessment is used to better understand the differences between farmers and government officials views of beneficial management practices.

3. Methods

Surveys were conducted to better understand the differences between farmers and government officials views of beneficial management practices (BMPs). An online platform was used to survey farmers and government officials, while farmers were also reached by mail. Government officials and farmer surveys were completed from January to April 2017. Both surveys included questions on 59 different BMPs, barriers that prevent BMP adoption, interventions to increase adoption, and demographics. The 59 BMPs were reduced into 7 BMP groups. The analysis focused on comparing the results from the government official and farmer surveys. Methods were approved by the University of British Columbia's Behavioral Research Ethics Board (H16-01348). A detailed summary of the procedure, measures, and analysis follows.

3.1. Procedure

3.1.1. Government officials survey

The government officials survey was conducted online using the platform Fluid Surveys. The BC Ministry of Agriculture provided an email list of 109 government officials that worked with farmers in B.C. (approximately ten of these email addresses returned errors or auto-responses indicated that government officials were unavailable – e.g., 'on vacation'). These included employees from the BC Ministry of Agriculture, BC Ministry of Environment, and Agriculture and Agri-Food Canada. Two reminders were sent the following two weeks. The survey was closed two weeks later with a 30% response rate.

Table 1: Summary of Collected Data.

Target group	Responses	Response Rate
Farmer surveys		
Mail	102	27%
Online	64	-
Government officials survey		
Online	30	30%

3.1.2. Farmer survey

Farmers were contacted through mail and online. For the mail survey, the Agriculture Research and Development Corporation (ARDCorp), who facilitate the Environmental Farm Plan program (EFP), provided a list of 1637 farmers who had participated the in the EFP from Jan 1st, 2012, to Dec 31st, 2016. We randomly selected 400 farmers from this list. An introductory letter

was sent to all 400 farmers in January 2017 stating that they would receive a survey in a month. A small portion of those mailed had incorrect or out-of-date addresses (22). For the remaining 378 farmers, we mailed the survey in February, enclosed was a postage due envelope that could be used to return the survey via Canada Post. The farmers were also given the option to complete the survey on an online platform (Fluid Surveys). For those who did not respond, we mailed a final reminder and survey in March. The response rate from these 378 farmers was 27%. Only 19 farmers chose to complete the survey online while the remaining 83 responses were returned via the postage due envelope.

To reach farmers who had not participated in the Environmental Farm Plan we also conducted an online survey. We invited BC industry and regionally based agricultural groups to help facilitate the survey. The BC Ministry of Agriculture emailed an introduction to these groups asking that they assist with the survey. Despite these efforts only a small portion of the groups participated. Once groups expressed interest in the research we sent them a statement and invitation to share the survey with their members. As with the government officials survey, the survey was hosted on the online platform Fluid Surveys. Because we could not access the member lists of the groups sharing the survey, we could only track number of responses and could not record response rates. We received 64 online responses. Where possible we asked the groups to send reminders.

Overall, 130 respondents had completed or were in the process of completing an Environmental Farm Plan, 32 had not completed and Environmental Farm Plan, and 4 respondents did not provide a response. Of the 130 respondents who had completed an Environmental Farm Plan, 70 indicated that they received funding through the Beneficial Management Practices Program, while 65 farmers received no funding and, 31 farmers did not provide a response.

To ensure that it was suitable to combine the farmer survey data from the online and mail surveys, we compared several demographic variables across the data sets (Table 2). The mean ages of respondents for the mail and online surveys were 56 and 55 years respectively. The percentage of females were also relatively similar across the mail and online survey. Given the similarity of age and gender across the samples, we combined the mail and online farmer survey data for analysis.

Table 2: Demographics of farmers. Summary statistics for age, sex, gross income from mail and online farmer surveys. Median gross income is reported in CAD. Statistics Canada data provides a population estimate of demographics.

Variable	Mail		Online		Statistics Canada	
	Value	Sample size (n)	Value	Sample size (n)	Value	Sample size (n)
Mean Age	56 years	n = 98	55	n = 62	56	N = 26,430
Percentage Female	30%	n = 97	29%	n = 58	38%	N = 26,430
Median Gross Income	$65,000 CAD	n = 81	$130,000 CAD	n = 55	$10,000 to $24,999 CAD	N = 17,528

We also compared our data to BC farmer population data available from Statistics Canada (2017). Table 2 shows that the average reported age and gender breakdown recorded by Statistics Canada was similar to our mail and online samples. Given that these demographic variables match broader population trends from Statistics Canada (2017), we did not adjust or weight the data. Larger differences between the mail and online samples, as well as the Statistics Canada data were observed for gross income. The difference between our two samples for median gross income was large. However, the median gross income for farmers from both samples could still both be considered low-income farms by Statistics Canada which defines low income farms as farms with gross incomes between $10,000 and $250,000. In many cases, farmers would rely on off-farm income. To more accurately assess how the incomes of farmers would impact farmer decision-making would require information we did not collect regarding other sources of household, total expenses, and number of hours worked off-farm. This information would allow one to delineate between whether the farm was a sole source of income which could impact farmer views of BMPs. The large number of lifestyle farmers in B.C. could be responsible for the relatively low median gross income reported by Statistics Canada.

3.2 Measures

3.2.1. Beneficial management practices

To work with BMPs most relevant to the BC context, we selected most practices identified by the BC Ministry of Agriculture (AGRI) in their Beneficial Management Practices cost-share program and their guide on biodiversity practices (AGRI, 2017). We included practices from their biodiversity guide as few biodiversity practices are funded through their Beneficial Management Practices program. We supplemented the practices identified by AGRI with three practices present in many BMP studies: ‘cover/companion crops’, ‘soil sampling’, and ‘conservation tillage’. We used these 59 practices to measure farmers and government officials’ preferences for future adoption of different groups of BMPs.

To measure government officials' preferences for future adoption of BMPs by farmers, I asked: "Given additional financial and/or technical resources, which BMPs do you think farmers should prioritize over the next 5 years?" Possible responses on a scale of 1 to 5 were: "Very low, Low, Medium, High, Very high, NA." Government officials were instructed to select NA if they were unfamiliar with the BMP.

To measure farmers' preferences for future use of BMPs, I asked farmers: "Given additional financial/technical resources how likely would you be to implement or further implement the BMP in the next 5 years?" Farmers were provided with a scale from 1 to 5 from "not at all likely" to "completely likely." Farmers were also asked about their past use and given the option to respond with 'not applicable' or 'don't know'. Farmer's response to their past use for a particular practice was used as a filter for the data collected on their future preferences in the following way: for farmers who indicated that the BMP as 'not applicable' for their past use (e.g., riparian buffer establishment for a farm with no riparian zones) or were unknown to them, we removed their responses for future preferences.

3.2.2. Barriers

To assess the barriers to BMP adoption, interventions that increase BMP adoption, and goals of farmers, we drew on work already well developed in this domain. This was a protocol from Greiner and Gregg (2011), focused on an Australian rancher system, adapted to the BC context. Farmers were asked: "How much do the following factors currently prevent you from undertaking environmentally beneficial management practices?" Government officials were asked "How much do think that the following factors currently prevent farmers from undertaking environmentally beneficial management practices?" Participants were then provided with a qualitative frequency scale: 'Not at all', 'A little', 'Somewhat', 'Quite a bit', 'A great deal' for 11 different barriers such as 'Loss of productivity and/or profitability' or 'Not enough time or staff/labour' (a full list is provided with results).

3.2.3. Interventions

Perspectives on interventions were derived using judgements of efficacy also based on Greiner and Gregg (2011). Farmers were asked: "How effective or ineffective would the following measures be in removing those impediments and helping YOU undertake (more) environmentally beneficial management practices?" Government officials were asked: "How effective do you think the following measures would be in removing barriers to BMP adoption

and helping farmers undertake (more) environmentally beneficial management practices?" All participants could respond with: 'Very ineffective', 'Ineffective', 'Neutral', 'Effective', 'Very effective' to 12 possible interventions such as 'Cost-sharing program for one-off BMP projects' or 'Environmental regulation' (a full list is provided with results).

3.2.4. Demographics

Farmers were also asked to provide information on their age, gender, education, farm income, region, production type, and Environmental Farm Plan status. Government officials were asked to provide information on their age, gender, education, region, and government organization affiliation. Government officials were on average 10 years' younger compared to farmers with an average age of 46 years old. A larger proportion of government officials were also female (48%) compared to farmers (30%). Table 3 shows that government officials had generally attained higher levels of education compared to farmers.

Table 3: Level of education of farmers and government officials (percentage). Sample sizes: 30 Government officials and 163 farmers self-reported their level of education. Percentages were rounded and therefore do not total 100%.

Level of education	Government officials	Farmers
High school and less	0%	23%
Technical school	3%	29%
Bachelor studies	43%	26%
Post graduate studies	53%	21%

3.2.5 Open-ended questions

Respondents were given the opportunity to provide open-ended answers at the end of each section (e.g., after practice preferences, barriers and interventions). The responses to these questions were used to help interpret numerical results from the above measures. Thirty follow-up interviews were also completed. Although not the focus of this paper, we used some of these results to help with interpretation.

3.3. Analysis

3.3.1 Survey analysis

Collation, analysis, and display of data was performed in RStudio (Version 1.0.147). RStudio is a free, open-source, and powerful data science tool used across many academic disciplines. Base R and the 'tidyverse' R packages were primarily used to collate data which included tasks such as removing duplicate and incomplete responses, combining survey responses from mail and online surveys, and converting demographic data for more convenient analysis (e.g., converting year of birth to age).

To better understand BMP preferences and evaluate if there were any emergent variables, we completed an exploratory factor analysis. Similar to principal component analysis (PCA), the aim of exploratory factor analysis is data minimization, however, it differs in that instead of a linear combination of variables as with a PCA, it is a measurement of the latent or emergent variables. We used the data from the farmer survey on BMP preferences ($n < 112$) to conduct the exploratory factor analysis. We chose not to use the government survey in an exploratory factor analysis as the sample size for BMP funding preferences was relatively small ($n < 28$). Best practices for exploratory factor analysis were followed (Costello and Osborne, 2005). To determine the number of factors to use in the factor analysis, a parallel analysis was completed "that compares the scree of factors of the observed data with that of a random data matrix of the same size as the original" (from R Statistics, 2017 version). The parallel analysis identified 8 factors. Next, a principal factor solution with an oblimin rotation was performed. The oblique oblimin rotation method was chosen as this method can produce correlated factors, unlike varimax and other orthogonal rotations. As Costello and Osborne (2005) argue, we expect some factors to correlate in social sciences and therefore using oblique methods are preferable, as orthogonal rotations result in the loss of potentially valuable information. After running the principal factor solution, we dropped coefficients less than 0.40 after which only 7 factors remained. These factors were used to explore differences in farmer and government official preferences.

For comparing farmer and government official preferences for 59 BMPs, we first calculated the mean preferences for the farmer and government samples. Government official mean scores were subtracted from farmer scores resulting in positive scores when farmers preferred practices and negative scores when government official preferred practices. Mean scores for each group of practices (derived with exploratory factor analysis) were also calculated for government and farmers. To test whether differences between farmers and government officials were statistically significant, we used Mann–Whitney–Wilcoxon tests as data was not parametric. The 'ggplot2' R package was used to plot the differences between BMP preferences between government officials and farmers.

Mann–Whitney–Wilcoxon tests were also run to compare the views of barriers and interventions to BMP adoption. However, for barriers and interventions the 'ggridges' R

package was used to create graphs to showcase the distribution of responses between farmers and government officials.

3.3.2 Beneficial Management Practices Program analysis

The degree to which farmer and government official preferences for BMPs were reflected in BC's Beneficial Management Practices Program was investigated by comparing funding levels with stated preferences. The funding level for each BMP was determined by the level of funding that the Beneficial Management Practices program provided for each practice based on the BC Ministry of Agriculture's list from 2016/2017 (AGRI, 2017). We used the same 45 practices as selected in the factor analysis and combined them by funding level. These practices are either funded at 30, 50, 60, or 100 percent. Mann–Whitney–Wilcoxon tests were run to compare farmer and government preferences. These results were also depicted graphically using the 'ggplot2' R package.

4. Results

We show how government officials and farmer views of beneficial management practices (BMPs) differ and how these views relate to the structure of a government-funded BMP adoption program. Relative to government officials, farmers prefer the following BMP classes: biodiversity, emissions, animals, and nutrients. Whereas, government officials prefer management plans. Government officials perceived 8 of 11 barriers as significantly larger in comparison to farmers. Less difference emerged between potential interventions to increasing BMP adoption, with government officials and farmers both rating financial interventions as the three most effective interventions among 12 options. Overall, funding levels for a province-wide cost-share BMP program are more in line with government officials' preferences than farmers'.

4.1 BMP preferences

Comparing farmers and government officials, farmers prefer BMP classes such as biodiversity, emissions, animals, and nutrient, while government officials prefer management plans.

4.1.1. Seven BMP classes

Seven BMP classes emerged from the factor analysis explaining more than 50% of cumulative variance. The seven classes of BMPs were named as follows: riparian, integrated pest management (IPM), emissions, animals, nutrients, biodiversity, and water/irrigation. After removing low coefficients, seven factors emerged (dropping 14 of the 59 BMPs). The seven factors each explained more than 0.1 of the proportion of variance and cumulatively explained 0.52 of the variance. The sum of squared loadings varied from 1.52 to 5.43. Cronbach alpha scores for each class were all above 0.85.

Each of these seven classes included a management plan, although in the case of biodiversity, the plan was dropped as its coefficient was below 0.40. The management plans are a good indicator of the BMP class and were used to name the factors. For example, the IPM plan was categorized as part of the IPM class of BMPs as all these practices could be classified as IPM practices such as the monitoring of pests or the use of biological or cultural pest controls. Animals was another class where the 'grazing plan' helped in the naming of the class.

Table 4: Results of the exploratory factor analysis of 59 beneficial management practices (BMPs). For each of the 59 BMPs, coefficients are provided for each of the 7 factors (columns). Coefficients less than 0.30 were removed to enable a more readable table. Coefficients less than 0.40 are indicated in red and were removed from further analysis. The remaining coefficients in black form the 7 classes of BMPs: riparian, IPM, emissions, animals, nutrients, biodiversity, and water.

	Riparian	IPM	Emissions	Animals	Nutrients	Biodiversity	Water	Other
Bird/bat boxes						0.49		
Connect grasslands						0.62		
Connect woods						0.66		
Wildlife avoidance with equipment						0.44		
Species at Risk practices						0.46		
Agroforestry						0.5		
Biodiversity plan						0.34		
Alternative energy			0.66					
Efficient lighting			0.52					
Electrostatic precipitators			0.44					0.35
Monitor/control energy use			0.77					
Fuel to electric motor			0.6					
Thermal efficiency improvements			0.63					
Energy plan			0.48					
Recovery of nutrients from waste water			0.3					
Farmyard runoff control				0.37				
Relocate feed/alley from riparian				0.59				
Relocate livestock facility from riparian				0.63				
Cross fencing				0.34				
Manure distribution feeding				0.74				
Grazing in forest/perennial				0.64				
Restore/establish native range				0.48				
Grazing plan		0.3		0.51				
Biological/cultural controls		0.7						
Spray efficiency equipment upgrade		0.72						
Hedgerow establishment		0.53						
Pest monitoring		0.79						
Rotary or flail mowers		0.6						
IPM plan		0.78						
Precision farming applications					0.5			
Solid/liquid manure treatment			0.31		0.37			
Specialized manure application equipment					0.54			
Nutrient plan					0.47			
Conservation tillage					0.75			
Cover/companion crops					0.57			-0.3
Drainage improvements					0.41			
Shelterbelt establishment					0.39			
Straw mulch to prevent soil erosion					0.49			
Alternative watering systems	0.71							
Connect riparian habitat	0.63					0.31		
Riparian buffer maintenance	0.68							
Riparian buffer establishment	0.84							
Riparian erosion structures	0.64							
Riparian fencing	0.6							
Stream crossing improvements	0.57		0.32					
Riparian plan	0.65						0.3	
Vegetative buffer plan								0.31
Compost agricultural waste								
Improve on-farm processing								-0.3
Livestock mortality incinerators								
Orchard/vineyard mulching mowers								
Wood residue management (e.g. chipper)								
Soil sampling							0.36	
Irrigation infrastructure efficiency improvements			0.33				0.46	-0.35
Ditch to pipe irrigation							0.45	
Weather station / scheduling equipment							0.61	
Well protection or closure							0.37	
Irrigation plan							0.77	
Water plan							0.69	

4.1.2. Differences between government officials and farmer preferences for BMPs

Significant differences between government official and farmer preferences were observed for the following BMP classes: biodiversity, emissions, animals, and nutrients. In all 4 of these cases, farmers had higher mean preference scores than government officials as indicated by the positive values in the 'mean difference' column in Table 5. We also ranked the BMP classes for farmers and government officials based on their mean scores, revealing that even when there were significant differences between farmers and government officials the relative ranking of the BMP classes was similar. For example, the two largest mean positive differences (i.e., farmers preferred these classes of practices) were for biodiversity (0.19) and emissions (0.16), farmers and government officials scored these relatively similarly in terms of within-group rankings. Biodiversity and emissions were 'ranked' by farmers and government officials as the lowest and second lowest group of practices, respectively. The largest difference between rankings was for the water BMP class, which farmers ranked 5th out of 7 and government officials ranked 1st.

*Table 5: Comparing farmer and government preferences for seven BMP classes. For each BMP class, the mean was calculated for farmers and government officials using all responses from all the practices within each class. The number of practices is indicated in brackets next to each class (ranging from 5 to 8). The total number of responses is denoted by n. The 4th column shows the differences in means between farmers and government officials. Mann-Whitney-Wilcoxon tests were used to test whether differences between farmers and government officials were significant (p-values): *: p <= 0.05; **: p <= 0.01; ***: p <= 0.001*

BMP classes (# Practices)	Farmer - Mean (# Responses) - Ranking	Government officials - Mean (# Responses) - Ranking	Difference between means	p-value
Animals (6)	3.64 (n = 385) – 3rd	3.56 (n = 145) – 5th	0.080	0.032*
Biodiversity (6)	3.32 (n = 550) – 7th	3.13 (n = 156) – 7th	0.190	0.020*
Emissions (7)	3.39 (n = 652) – 6th	3.22 (n = 157) – 6th	0.164	0.031*
IPM (6)	3.67 (n = 493) – 1st	3.60 (n = 131) – 3rd	0.074	0.061
Nutrients (7)	3.65 (n = 645) – 2nd	3.58 (n = 179) – 4th	0.071	0.004**
Riparian (8)	3.63 (n = 528) – 4th	3.64 (n = 190) – 2nd	-0.019	0.088
Water (5)	3.58 (n = 425) – 5th	3.78 (n = 108) – 1st	-0.197	0.864

A closer examination of the practices within each BMP class revealed that management plans, present in nearly all the classes, could explain some of the observed differences between farmer and government preferences for BMP classes. Government officials preferred all seven management plans. This pattern is evident in Figure 1, where the red bars next to each management plan indicates that government officials preferred the practice relative to farmers. Whereas, blue bars indicate that farmers prefer a particular practice. The three longest red bars (all with a mean difference below -0.5) were all management plans. The only BMP class that

government officials meaningfully preferred was the 'water' class. This class contained two management plans: 'water' and 'irrigation' as well as three practices that reduce water use. In contrast, the BMP class that farmers most preferred compared to government officials, was the 'biodiversity class', which contained no management plans. Of the 6 practices aimed at improving biodiversity only one was significantly different between farmers and government officials: bird boxes (farmers viewed these more positively). Although there were no significant differences between government officials and farmers for the other five practices, three of the five practices were scored higher by farmers compared to government officials. Figure 2, shows how nearly all the management plans were scored on average above 3.5 by government officials and below 3.5 for farmers.

Overall, although some statistically significant differences exist between the classes of practices farmers and government officials prefer, the relative rankings are roughly similar. For those few these differences in both mean and ranking, the role of management plans in explaining these differences is important (e.g., differences between biodiversity and water classes can be explained by the lack of management plans in the former and the presence of multiple management plans in the latter class).

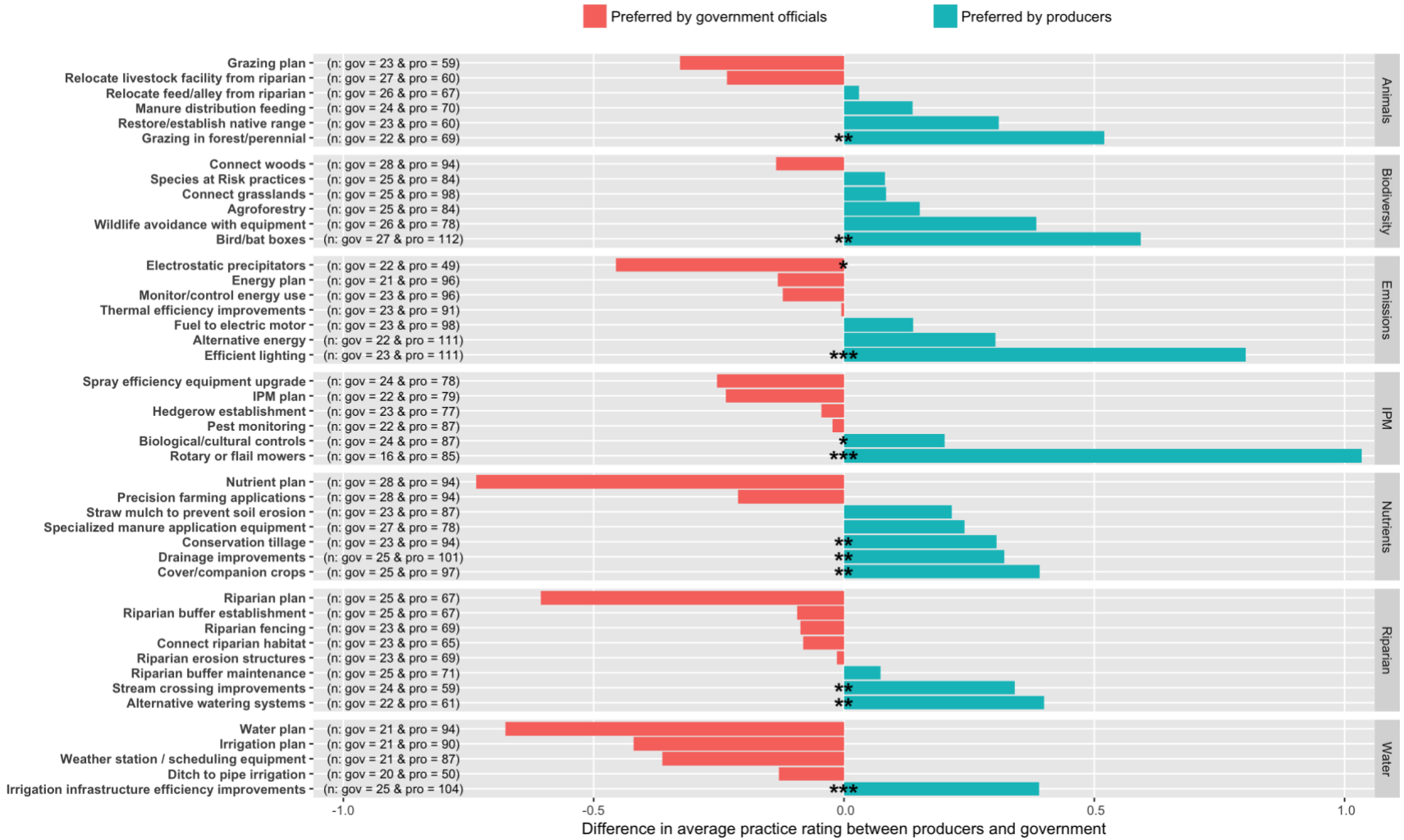

*Figure 1: Beneficial management practices by BMP class. The left-hand y-axis shows the 45 BMPs with 'n' indicating sample size for government officials (gov) and farmers (pro). For each practice, the means for farmers and government officials were calculated and then subtracted from one another. These means were derived from the 1-5 scale measuring preference for BMPs. Red bars indicate that government officials prefer the practices relative to farmers, whereas blue bars indicate that farmers prefer the practice. The right-hand axis shows the 7 BMP management classes. Mann-Whitney-Wilcoxon tests indicate whether differences between farmers and government officials were significant (p-values): *: p <= 0.05; **: p <= 0.01; ***: p <= 0.001*

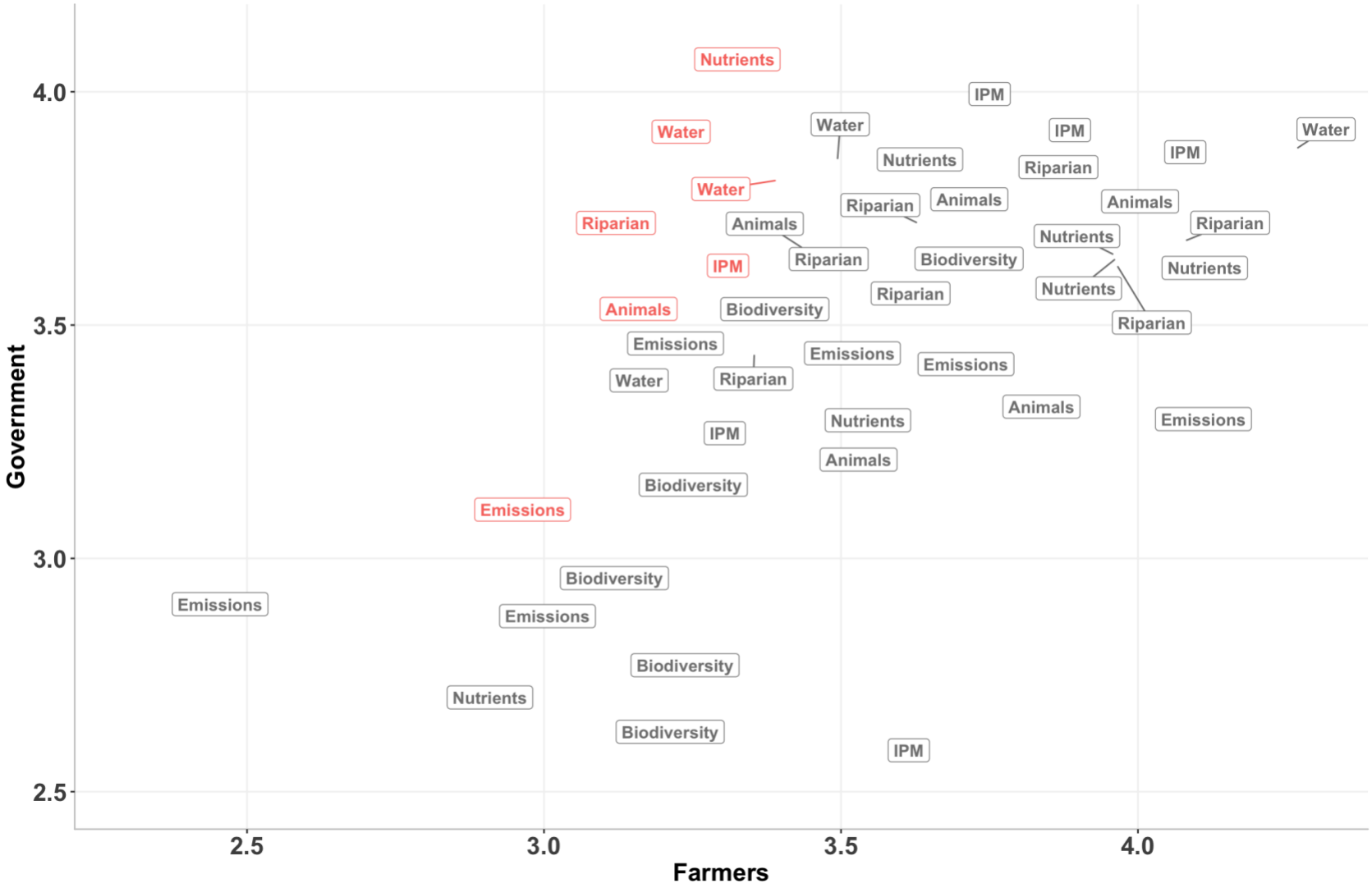

Figure 2: Mean preferences of government officials and farmers for 45 BMPs, categorized by BMP classes: riparian, integrated pest management (IPM), emissions, animals, nutrients, biodiversity, and water/irrigation. Y-axis indicates the average preferences of government, while the x-axis indicates the average preferences of farmers. Red indicates management plans.

4.1.3. Management plans and 'other' BMPs

Government officials' preference for individual management plans was even more apparent when preferences for all seven plans were averaged and compared to other BMPs. Government officials not only preferred plans in comparison to farmers, they also preferred management plans in comparison to all other BMPs (Table 6).

For both government officials and farmers, there was a significant difference between management plans and other BMPs. However, on average, government officials preferred management plans (3.71) to other practices (3.44), whereas the converse was true for farmers. Government officials scored plans much higher (3.71) than did farmers (3.25).

*Table 6: Average scores for management plans and other BMPs for both farmers and government officials. The total number of responses is denoted by n. Significance of the difference across groups and practices determined via Mann-Whitney-Wilcoxon significance test: *: p <= 0.05; **: p <= 0.01; ***: p <= 0.001, ****: p <= 0.0001*

	Plans	Other BMPs	Mean differences
Farmers	3.25 (n = 579)	3.57 (n = 2,845)	- 0.323***
Government officials	3.71 (n = 161)	3.44 (n = 833)	0.272**
Mean differences	- 0.459**	0.136****	

Farmers' lower preference for management plans was also reflected in their written responses to the surveys as well as the 30 follow-up interviews completed with farmers. Many farmers expressed written and verbal dissatisfaction with the process and implementation of these management plans. Many farmers doubted the utility of management plans, which some respondents described as 'cookie-cutter' or 'hoops to jump through'. Another perceived problem with the management plans was the upfront cost. As one farmer wrote: "It seems pretty complicated and it was [a sizable] cost upfront to [have] the last Nutrient Management Plan." This upfront cost could be particularly problematic for smaller producers with less capital. Finally, several farmers described a perceived conflict of interest as the EFP advisors, who identify what BMPs farmers could apply for, can receive payment for completing the management plans which are required for the farmers to receive support for many other BMPs.

Government officials written responses regarding management plans were less negative. One official wrote that nutrient management plans should be approached differently as nutrient management plans are "designed around providing enough nutrients to the crops and do not address excesses". Whereas, another government official responded that the "issue with these management plans is that they are not enforceable." This official saw the management plans as useful but only if they could be enforced with regulatory interventions. Another official reiterated this argument that management plans only work if they are legally enforceable: "environmental management plans are only useful if they are following them, otherwise they pour money into making them and then within a month they are back to their old ways. If you go the route of [environmental management plans] then you need to make it a legal requirement for them to follow their plan."

4.2. Barriers to BMP adoption

Government officials perceived greater barriers to BMP adoption than did farmers. This trend was true for all 11 barriers that we asked government officials and farmers to score on a scale from 1 to 5 (Figure 3). Of these 11 barriers, 8 were scored significantly larger by government officials compared to farmers (three were non-significantly larger). The barrier identified by farmers with the highest average (3.73) was "lack of government financial

incentives", while government officials scored it similarly on average (3.83) but gave "Not enough time or staff/labour" (4.38) and "Loss of productivity and/or profitability" (4.07) higher average scores.

Farmers' average scores for these barriers only exceed 3.00 for three other barriers: 'Not enough time or staff/labour' (3.53), 'Lack of industry support' (3.15), and 'Uncertainty about where to obtain financial/technical help' (3.03). In contrast, government officials' average scores exceeded 3 for 10 of the 11 barriers. The only exception is "BMPs are not necessary to improve the environment", a statement which farmers also viewed as a relatively minor barrier to increasing BMP adoption.

Two barriers showcase the significant difference between how farmers and government officials view BMPs. In contrast to the average score of 4.07 by government officials for 'Loss of productivity and/or profitability', the average farmer score was 2.66. This higher average score by government officials is reflected by one officials' written response: "I think a major barrier is the short-term risk of investment without guarantee of benefit in the long-term (and often no benefit in the short-term)." Like the 'Loss of productivity and/or profitability' statement government officials scored the statement, 'BMPs are not practical and would complicate property management' higher on average (3.10) compared to farmers (2.26). In both cases, government officials view these barriers as larger than do farmers. If we reverse the wording of these barriers, relative to government officials, farmers view BMPs in general as practical and profitable.

We also checked that our sample, which included 130 farmers enrolled in the Environmental Farm Plan Program, was not biasing the results in favour of farmers whose major barrier was a 'lack of government financial incentives'. We compared the responses for the 11 barriers between the 32 farmers who were not enrolled in the EFP and the 130 farmers who were enrolled. Mann-Whitney-Wilcoxon non-parametric tests revealed no significant differences between these two groups for each of the 11 barriers. The mean scores for each barrier also did not differ by more than 0.50 between farmers who were enrolled in the EFP and those who were not.

*Figure 3: Government officials' and farmers' views about barriers to BMP adoption. Eleven barriers are displayed on the left-hand y-axis. Participants scored each barrier on a scale of 1 to 5 on the degree to which the barrier prevented the adoption of BMPs. The relative distribution of these scores are displayed in red for government officials and blue for farmers. The means for each barrier were also calculated in their respective coloured boxes on right-hand y-axis (n denotes sample size). Mann-Whitney-Wilcoxon tests indicate whether differences between farmers and government officials were significant (p-values): ns = not significant; p > 0.05; *: p <= 0.05; **: p <= 0.01; ***: p <= 0.001.*

4.3. Interventions for increasing BMP adoption

Farmers and government official views diverged less about the 12 interventions for increasing BMP adoption compared to barriers (Figure 4). Farmers and government officials both ranked three financial interventions as the most effective interventions for increasing BMP adoption: “Income tax incentives”, “Cost sharing program for one-off BMP projects”, and “Ongoing payments for maintenance costs related to BMP adoption”. All three financial interventions had average scores of 4 or above (‘Effective’). The cost-sharing program best describes the Beneficial Management Practices program. Compared to the cost-sharing program, ‘on-going payments for maintenance costs’ was scored marginally higher by farmers and marginally lower by government officials. The only other average score of 4 was government officials’ view of research and extension, which farmers also favored (3.72).

Farmers and government officials differed significantly in their views for three interventions: “Increased public acknowledgement of environmental achievements”, “Community involvement in on-ground works”, and “Environmental regulations”. For the first two of these interventions the difference in means was 0.61 and 0.58, respectively. Government officials viewed these interventions as more effective. This belief that recognition could be effective was captured by one officials’ written response: “understanding and showcasing all the beneficial management practices that the majority of farmers/ranchers do and have done over generations would be the single largest incentive to motivate them to support new BMP or initiatives”, explaining that “[the] lack of appreciation for how much [farmers] do in terms of environmental benefits (vs negative impacts from other industry & residential activities) has resulted in some apathy or frustration in thinking they can make a difference :(“. However, the largest difference between government officials (3.59) and farmers (2.68) was for “Environmental regulations”. Some government officials included written responses that current environmental regulations required “more teeth in the legislation” most of these government officials who mentioned regulatory interventions were concerned with manure runoff and the large impact it can have on others as one official explained: “We recently had a case where the manure from 3 horses over the course of only 5 months impacted the water supply for an entire family and now they cannot use their well and their pond.”

Government officials on average scored ‘environmental management plans’ and ‘property management plans’ as 3.56 and 3.11. Whereas, farmers on average scored ‘environmental management plans’ and ‘property management plans’ as 3.31 and 3.19. In both cases, these scores are well below the scores for the most effective interventions, which were financial. Despite the broad support for financial interventions one government official argued that although they are very effective they should be used in combination with other interventions: “Incentives in the form of providing tools, support, expertise, research would be very effective. Financial incentives are important but on their own not so effective.”

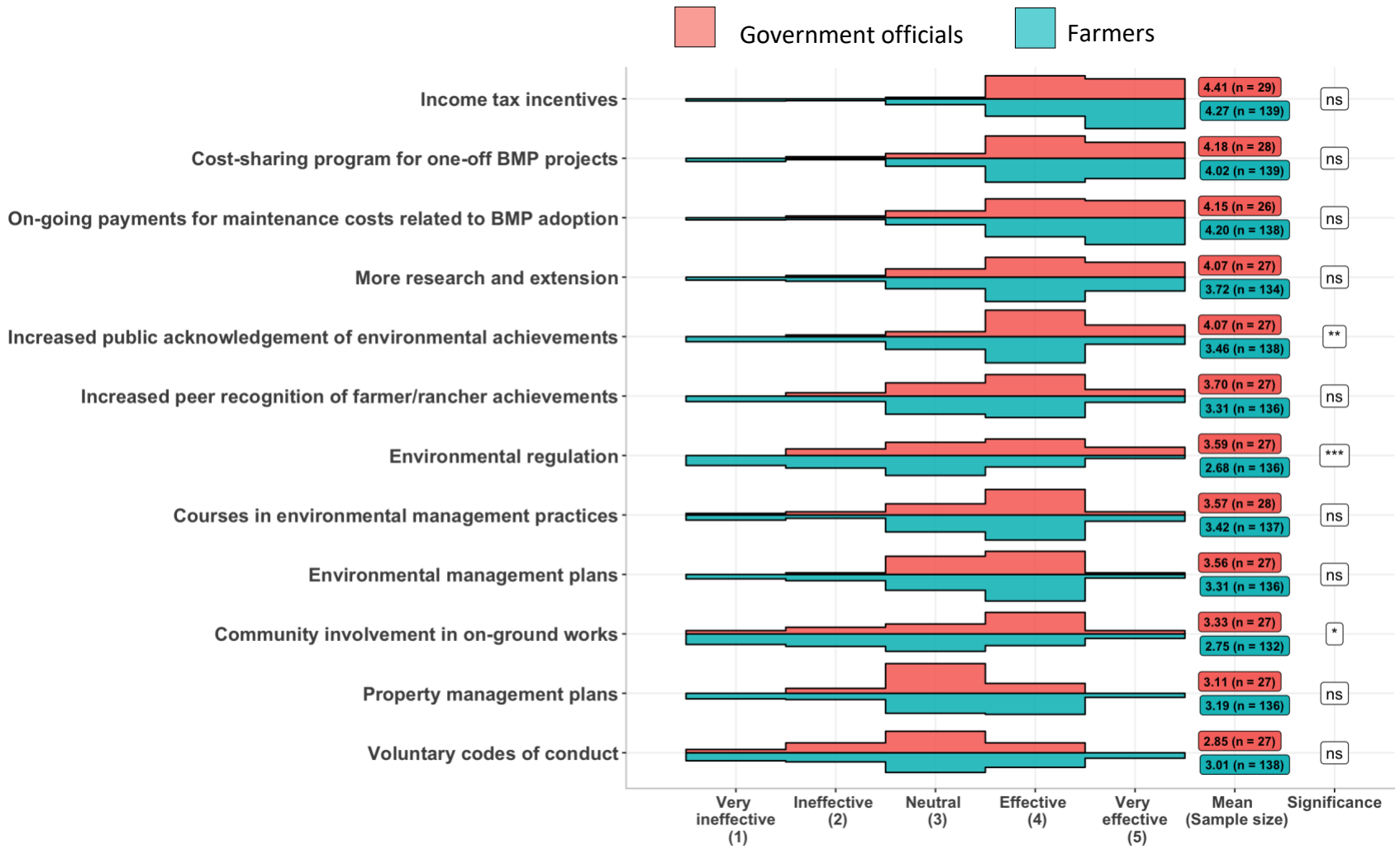

*Figure 4: Government officials' and farmers' views about interventions for increasing BMP adoption. Twelve interventions are displayed on the left-hand y-axis. Participants scored each intervention on a scale of 1 to 5 on the degree to which the intervention prevented the adoption of BMPs. The relative distribution of these scores are displayed in red for government officials and blue for farmers. The means for each intervention were also calculated in their respective coloured boxes on right-hand y-axis (n denotes sample size). Mann-Whitney-Wilcoxon tests indicate whether differences between farmers and government officials were significant (p-values): ns = not significant; p > 0.05; *: p <= 0.05; **: p <= 0.01; ***: p <= 0.001.*

4.4. Funding level

Government official and farmer preferences for financial interventions are reflected in BC's 2017/18 BMP cost-share program. We demonstrate that BMPs preferred by government officials are funded at higher levels compared to BMPs preferred by farmers. For BMPs funded at 0% and 30% of costs, farmers scored these practices higher on average than did government officials with mean differences of 0.22 and 0.18 respectively. In contrast, for BMPs funded at 100%, government officials scored the practices higher by an average of 0.46. For the 50% and 60% funding levels, there was no significant difference between farmers and government officials.

*Table 7: Farmer and government preferences for BMPs funded at five levels (from 0% to 100%). For each funding level, the mean was calculated for farmers and government officials using all responses from all the practices within each class. The number of practices is indicated in brackets next to each class (ranging from 5 to 8). The total number of responses is denoted by n. The 4th column shows the differences in means between farmers and government officials. Mann-Whitney-Wilcoxon tests were used to test whether differences between farmers and government officials were significant (p-values): *: p <= 0.05; **: p <= 0.01; ***: p <= 0.001*

Funding level (# Practices)	Farmers – Mean (# responses)	Government officials – Mean (# responses)	Mean difference	p-value
0% (11)	3.54 (n = 946)	3.32 (n = 274)	0.22	0.0002***
30% (12)	3.67 (n = 925)	3.49 (n = 232)	0.18	0.0020**
50% (8)	3.46 (n = 571)	3.47 (n = 188)	-0.01	0.1488
60% (7)	3.58 (n = 403)	3.52 (n = 139)	0.06	0.1127
100% (7)	3.25 (n = 579)	3.71 (n = 161)	-0.46	0.0086**

Further scrutiny of the different funding levels reveal that the classes of BMPs identified in section 4.1 (BMP preferences) and management plans drive much of the observed difference between farmers and government officials. The red bars in Figure 5 show that all seven practices funded at 100% are preferred by government officials. All seven of these practices funded at 100% are management plans. The larger number of blue bars in the 0% and 30% funding levels demonstrate farmers' preferences for these practices. In the case of the 0% funding level, 6 of the 11 practices are from the biodiversity class identified in section 3.1. The biodiversity class of practices received significantly higher average scores by farmers compared to government officials (Table 5).

We also received written and verbal feedback from farmers on their views of the EFP and BMP Programs. The most common complaint was lack of funding, with over 20 respondents providing written feedback requesting more funding. These requests are particularly stark in some cases: "We have EFP here @ farm, have applied for funding and help

but never received any. I was denied on 7 different projects due to lack of funding, [but] we went ahead with the projects." These frustrations are tied to how the funding is structured to promote management plans over other BMPs: "We have only received funding for management plans (4 of them!), but no actual project funding yet- which is very frustrating."

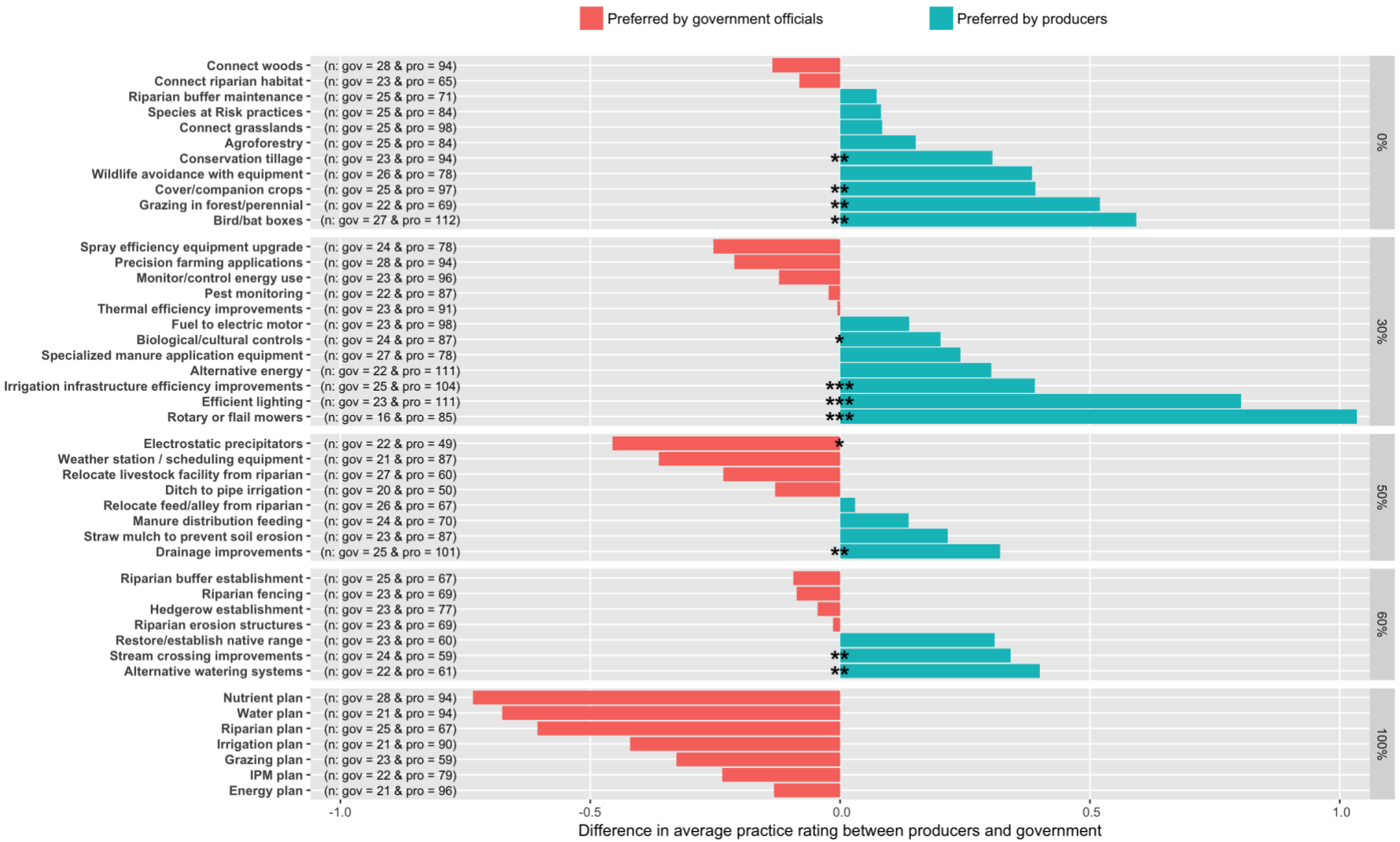

*Figure 5: Beneficial management practices by funding level. The left-hand y-axis shows the 45 BMPs with 'n' indicating sample size for government officials (gov) and farmers (pro). For each practice, the means for farmers and government officials were calculated and then subtracted from one another. These means were derived from the 1-5 scale measuring preference for BMPs. Red bars indicate that government officials prefer the practices relative to farmers, whereas blue bars indicate that farmers prefer the practice. The right-hand axis shows the five funding levels. Mann-Whitney-Wilcoxon tests indicate whether differences between farmers and government officials were significant (p-values): *: p <= 0.05; **: p <= 0.01; ***: p <= 0.001*

5. Discussion

Synthesizing across several different sets of results, this study suggests a broad suite of similarities and differences between farmer and government-official views of BMPs. Government officials can be roughly characterized as seeing BMP adoption as a difficult process requiring planning and focused on many uncertainties and drawbacks for farmers. Whereas, farmers view BMPs as opportunities for operational and environmental benefits limited by financial and resource constraints. We discuss how government officials' views of BMPs shape a BC BMP funding program which prioritizes planning and how farmers' views of BMPs differ.

5.1. Government officials prefer planning while farmers prefer more concrete practices

Farmers prefer BMP classes such as biodiversity, emissions, animals, and nutrients, while government officials prefer management plans, suggesting that farmers prefer tangible operational and environmental benefits whereas government officials view planning as an important investment. Farmers preference for practices that provide clear operational benefits is understandable. For example, 'efficient lighting' would decrease a farmer's monthly utility bills. However, our results also indicate that farmers preferred some biodiversity practices compared to government officials. In particular, farmers preferred installing bird and bat boxes which for most farmers the benefits would only be indirect (e.g., possible increase in pest control via natural enemies). This interest in non-economic benefits is supported by an increasing body of literature that shows many diverse motivations drive farmer behaviour (Maybery et al., 2005). In some cases, these motivations can even lead to farmers choosing stewardship over profit (Chouinard et al., 2008; Mzoughi, 2011). It is important to note, that although relative to government officials, farmers preferred bird boxes, this practice and other biodiversity practices were scored relatively low averages compared to other practices by farmers (see Figure 2).

Government officials may favour management plans as in theory they offer many benefits. Management plans can provide farmers with outside technical expertise to identify negative impacts or provide the best option for rectifying or improving environmental conditions. These plans could also be useful for government officials for reporting requirements associated with taxpayer funding and measuring program success. However, the farmers who

experienced a management plan seemed not to observe these benefits. This highlights the difference between experiential expertise versus other types of expertise (Collins, 2014). The former may focus on the practicality of a practice whereas the government expert may focus on its effectiveness at mitigating environmental impacts (e.g., Jones et al., 2013).

The farmers may have also viewed these management plans as redundant since 130 of our 166 farmers in our sample had completed an Environmental Farm Plan assessment, which would have included an outside consultant reviewing their operation. To access funding, they then need to complete an additional management plan, which could be viewed as unnecessary. The plans themselves were also described as 'cookie cutter' so the implementation of the plans may have also been an issue. BMP adoption programs that utilize management plans should take care in considering how these management plans will be carried out in practice and weigh this against the theoretical benefits.

5.2. Barriers

Government officials see a multitude of barriers preventing farmers adopting BMPs, while farmers view a few financial and resource-related barriers as the major reason for not adopting BMPs. Government official's view of BMPs as difficult to adopt may influence their view that management plans are very important. In comparison, farmers view these management plans as less important because they do not view adoption as a difficult or complex decision requiring planning. For example, if a vineyard is using overhead irrigation, is an irrigation management plan necessary to demonstrate that installing drip irrigation would greatly reduce water use? Or would installing the drip irrigation be a more valuable use of time and resources. Although this example is extreme, our results indicate that farmers view many BMPs as straight forward decisions with few barriers. The management plans themselves could be thought of as barriers to adoption as one farmer described them as 'hoops to jump through', to receive funding.

Government officials may also be perceiving these barriers as larger compared to farmers as their work includes responding to complaints. Government officials may be disproportionately hearing from the farmers who view barriers to BMP adoption as larger compared to the average farmer from this sample.

5.3. Interventions

Why did government officials and farmers agree that financial interventions would be the most effective set of interventions at increasing the adoption of beneficial management practices? The answer may be partially explained by the barriers identified by government officials and farmers. Government officials viewed 'loss of productivity/profitability' as a large barrier, whereas farmers did not, while both groups agreed that lack of financial incentives and lack of time/labour were significant barriers to BMP adoption. This may suggest that government officials view these financial interventions as necessary as a financial inducement to offset financial losses, whereas farmers view these interventions as helping them adopt practices that they would like to adopt but lack the capital.

The three preferred financial interventions would all operate differently. Farmers marginally preferred 'On-going payments for maintenance costs' in comparison to 'cost-share program for one-off BMPs' (no statistical difference). The reverse was true for government officials. Currently, BC's Beneficial Management Practices Program does not help with maintenance costs for BMPs. This lack of continued funding could be problematic as some practices do require ongoing maintenance. For example, maintaining 100s of kilometers of fencing to keep cattle from entering riparian areas can be a full-time job for a rancher. If these fences are not mended they can be a hazard for both wildlife and livestock which can entangle themselves in barbed wire.

Others have argued that more work needs to consider the long-term retention rates of BMP adoption rates as their motivations for starting a practice may be different then continuing to use it (Selinske et al., 2015). Riley (2016) argues that longer term participation in programs can provide an opportunity for 'constructive conversations' between program delivery staff and farmers thereby increasing farmers environmental disposition. Our results confirm that government officials and farmers both view on-going payments as effective as other financial incentives.

The argument against on-going payments is related to the argument of additionality in program design. Some economists would view these payments as paying for a practice already being completed, thereby viewing it as a loss to the administrators. Why pay for something that is already being done? Chan et al., (2017) vigourously disputes this view, arguing that

additionality should be considered at the scale of the program not the individual. Paying an individual for "actions that they already wished to do" such as maintainance of a practice, "is precisely how a program leverages small payments into full actions, and how it might build and consolidate stewardship".

Some individual farmers may not respond to financial interventions. As suggested by one government official, these financial mechanisms are most effective when used in conjunction with other mechanisms such as "providing tools, support, expertise, research". The government official notably did not include regulations as a possibility (although many government officials did view regulations as effective). Regulations may play an important role in increasing the adoption of these practices particularly in conjunction with other interventions. However, regulations should be used judiciously and the cost of non-compliance should be weighed against the cost of regulating to the public and to farmers. The calculation of cost should also include non-economic considerations involved with regulating a group that, as our results show, do not view environmental regulations as particularly effective. This non-economic cost, should include the possibility of an erosion of trust in current programs. In a report based on this same research, I demonstrated that these current incentive programs are highly trusted by farmers (Semmelink, 2018). Interventions aimed at increasing BMP adoption should aim to maintain and build this trust, not erode it.

5.4. Funding level

The views of government officials were better represented by BC's Beneficial Management Practices Program compared to farmers' views. This is not necessarily a negative outcome. After all, government officials are representing the public and may see some practices as more beneficial to the public compared to farmers who may be more concerned with private benefits, and incentive programs are aptly tailored towards BMPs yielding public benefits. However, arguably some of the practices preferred by farmers could provide more public than private benefits (e.g., biodiversity practices). Additionally, government officials may also not know the impact of the program in practice in comparison to farmers (e.g., even farmers who were positive about the EFP and had engaged in management plans did not see much benefit in them).

Within the BMP adoption literature there is also an acknowledgement that measuring and focusing on BMPs alone can miss the socio-ecological outcomes (Reimer et al., 2014b). By increasing the scope and including more stakeholders in these assessments of BMPs, we can draw out different viewpoints about what BMPs should be prioritized. In the case of the Environmental Farm Plan Program, including the views of the private consultants who work with farmers could increase our understanding of what BMPs should be prioritized. Comparisons between stakeholders can also serve as an indication for how programs work in practice, not only in theory or from one view point.

5.5 Limitations

Data was self-reported and collected at a specific point in time. Self-reporting environmental behaviours such as BMP adoption can lead to respondents over stating the degree to which they adopt BMPs as they view this response as more socially desirable (Floress et al., 2018). But as discussed in the introduction, little evidence supports this theory (Kormos and Gifford, 2014).

Of the 166 farmers who completed surveys, 64 responses were collected by convenience sampling. Although these results were compared to the 102 responses collected via a mail survey of a known population with a 27% response rate, further work could be completed to ensure that these results do not differ substantially for variables beyond age and gender. My sample over-represented farmers who received funding via Beneficial Management Practices Program. This may explain why farmers in my sample also had median gross farm incomes which were higher compared to the provincial average. As the Beneficial Management Practices Program is a cost share program focused on farm practices, hobby farmers with smaller operations and smaller gross incomes may not view the Program as that relevant.

Many of the results I reported were averages. As one former government official remarked in an informal conversation: ‘there is no such thing as an average farmer only a median farmer’. I attempt to mitigate that by using medians and reporting distributions where appropriate. But to engage with the official’s point more deeply, our conclusions are based on aggregate results and do not reflect the views of each and every farmer or government official I surveyed. In my work, my hope was to capture a perspective that was representative of my

sample, while providing enough context through individuals' written comments to show that farmers and government officials are individuals with differences.

5.6 Recommendations

5.6.1 Intervention design I: Do not prioritize planning over action

Theoretically planning can have a host of benefits to the farmer and the environment. But without a change in management or the adoption of concrete BMPs, the completion of management plans is a waste of limited resources. Deliver management plans that motivate rather than frustrate action.

5.6.2 Intervention design II: Use financial interventions to reduce key barriers agreed upon by most farmer, not the outliers

Most farmers do not view BMP adoption as a complex task with many barriers. My results suggest that farmers would like to adopt more BMPs but are limited by a lack of time and money. Programs may have more success if instead of attempting to incentivize farmers to change, they focus on reducing barriers to increased adoption. Major interventions should focus on these barriers, while other interventions should be used in combination to target other barriers.

5.6.3 BMP adoption research should consider views other than farmers

The views of government officials matter. By broadening the scope of inquiry, BMP adoption researchers may better account for the importance of roles that actors other than farmers have in increasing BMP adoption. In particular, government officials have an influential role in the design of interventions, which may explain why some interventions increase adoption while others do not. Including government officials and other actors will go some way to better incorporating the views of social theorists such as Shove (2010), who argue for the importance of acknowledging the role of the "state and other actors."

5.7 Conclusions

BMP adoption can be better understood by including the views of government officials who design and implement interventions to increase adoption. Comparing government officials views to the farmers, I show that government officials prefer management plans, view barriers to BMP adoption as larger, and agree with farmers that financial incentives are the most effective intervention for increasing BMP adoption. Government officials' views are well represented in an intervention designed to increase BMP adoption.

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