Environmental Research Letters

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OPEN ACCESS

RECEIVED
13 September 2018

REVISED
13 December 2018

ACCEPTED FOR PUBLICATION
20 December 2018

PUBLISHED
15 March 2019

LETTER

Just don't call it climate change: climate-skeptic farmer adoption of climate-mitigative practices

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Keywords: agriculture, climate mitigation, farmer behaviour, agricultural production

Abstract

Despite low levels of agreement that climate change is caused primarily by humans, respondents to a survey of climate change beliefs and adoption of climate-mitigative practices among beef and grain producers in Alberta, Canada, indicate a high level of adoption of several agricultural practices with climate-mitigative benefits. Respondents' motivations for adoption of climate-mitigative practices rarely include the belief that climate change is caused by humans, but rather expectations for economic benefits, improvements in soil quality, and biodiversity, among other things. The strongest predictor of mitigative practice adoption is a *learning orientation*, defined as valuing improvement, research, learning, and innovation, followed by a *conservation orientation* that values land stewardship. Predictors are not consistent across practices; however, in some but not all cases adoption is predicted by *climate change norms*, or assumption of personal responsibility to address climate change, and other predictors vary by practice as well.

Introduction

Research exploring the factors that contribute to practices that emit greenhouse gases has offered some rather pessimistic observations. First, skepticism or denial among the public is notably higher than that expressed by the scientific community. Second, even among the concerned, researchers have documented a disconnect between level of concern and the adoption of environmentally favourable practices, an observation termed the value-action gap [1, 2]. This body of research is focused primarily on general public samples, however, and there are other segments of society that may warrant particular scrutiny. Farmers, for example, make up a tiny proportion of the populations of developed countries, yet their production decisions and related choice of management of practices have significant implications for both emitting and sequestering greenhouse gases in large volumes. Worldwide, food systems are responsible for 19%–29% of global anthropogenic greenhouse gas emissions, although this contribution varies widely by region [3].

We present the results of a survey of farmers in a technology-intensive, high-yield agricultural environment in Western Canada (Alberta). Agriculture, and particularly livestock production, has historically been an important sector to the Canadian Prairies. The province of Alberta, heavily reliant on fossil fuels as well as agriculture, has also been historically quite conservative, embracing neoliberal policy approaches to economic development and environmental regulation. Even in comparison to the rest of North America, climate skepticism is high in Alberta [4]. Today the agricultural sector in Alberta consists of over 40 000 large-scale farms with an average size of over 1230 acres, half of which produce livestock, bringing the provincial beef herd up to 5.4 million [5], accounting for 2.3% of provincial employment in 2017, and 71% of these workers are male [6].

The survey sought information on the adoption of a large suite of recognized climate-mitigative practices, and several control variables informed by previous research. Specifically, we investigate [1] how climate change beliefs vary in this population [2], what types of climate-mitigative practices farmers are adopting and at what rate [3], what are the stated motivations for these practices, and [4] to what extent do demographic characteristics and identity factors such as learning orientation, conservation ethic, and climate change norms, offer effective predictors of adoption. Respondents express low agreement with anthropogenic climate change, yet these beliefs do not correspond with adoption of management practices with climate-mitigative attributes. Farmers are motivated to adopt such practices for other reasons, including economic benefits, as well as expected co-benefits for soil quality and biodiversity. These findings suggest that strategies to encourage farmer adoption of climate-mitigative practices through climate change education campaigns will have limited success, and there may be far more effective strategies that align better with farmer identity and decision matrices.

Climate change and farmer behaviour

There are good reasons to expect that studies of attitudes and behaviours regarding climate change among the general public may not apply to the farming population [7]. Farmers are far more likely to reside in rural communities, whereas the majority of the population, including those people typically sampled in social scientific attitude studies, live in cities. One study comparing farmers with the general public in Europe found farmers to be less open to change and more oriented toward conservation than the general public [8]. Farmers are also in a unique position in that they interact intimately with the land and must necessarily pay attention to weather. Farmers thus have a heightened awareness of weather patterns, and both the compulsion and opportunity to observe changes in those patterns. A number of studies indeed indicate that farmers agree that the climate is changing; however, even in comparison to general public samples, farmers also stand out in their particularly high levels of climate skepticism, preferring to attribute observed changes in climate to natural causes [9–13]. Farmers might thus be quite willing to invest in adaptation [11, 14], but mitigation is another matter [9, 12]; if climate change is deemed a natural process, then there is no reason to reduce greenhouse gases [14], particularly if doing so comes with a cost.

The premise of much of this research is the expectation that beliefs directly underlie practices: low agreement that climate change is human caused will lead to low support for mitigation [12, 13, 15]. By extension, only that minority of farmers who believe that climate change is occurring and human caused, are likely to support greenhouse gas reduction actions, and indeed this premise has received empirical support [12, 16]. However, relationships between beliefs, motivations and practices are complex, particularly in the context of land use management. A practice with mitigative benefits, for example, may also be associated with improvements in soil quality, or cost reductions—two traditional outcomes that commonly drive farmer decision making. A meta-analysis of US farmer management practices highlights the large impacts of access to information and capital, offering a highly instrumental view of farmer behaviour [17].

Research that delves deeper into the pathways between beliefs and pro-environmental practices among farmers, including studies utilizing the expectancy-value model [18], the theory of planned behaviour [19], and the Values-Beliefs-Norms theory [20], confirm a more complex picture of farmer decision making [21–23]. One overarching implication of this research is that, counter to many popular preconceptions, not all or even many farmers are purely rational utility maximizers [24–26]. To the contrary, research has revealed a diversity of farmer identities [13, 26–28]. Some are oriented toward maximizing economic benefits, which is associated with lower levels of adoption of environmental measures, but not all farmers fit this mold [8, 16, 29]. This leads to the importance of social identity, which has been linked to support for certain practices, including in some cases environmental or mitigative measures [7, 30]. Researchers have incorporated identity theory developed in sociology and psychology into studies of farmer identities to great effect, highlighting the extent to which farmer identities are neither singular (e.g. conservationist) nor static [31], and importantly emphasizing the capacity for farmers to express agency to both support and resist structural forces [29]. Some social identities of farmers are driven by the desire to act consistently with group goals [32], which in turn offers the benefits of inclusion and positive reputation [13, 33, 34]. Borges and Lansik [23], for example found perceived social pressure within a particular group to be a strong indicator of willingness to adopt conservation practices. Thus, a message can be rejected or accepted entirely on the basis of the group allegiance of the messenger.

Among the more consistent findings is a strong relationship between adoption of environmentally-beneficial practices and a conservation orientation [26]. While studies provide disappointing results in terms of rates of adoption of *prescribed* measures [27, 35], some farmers do invest in conservation practices voluntarily [36], particularly when the environmental benefits, such as water quality, are observable [37]. Recent research has also revealed the relevance of learning styles among farmers, which can be quite heterogeneous [38, 39].

Overall, this body of research raises more questions than it answers regarding the complex relationships between identity, beliefs, motivations and practices. We attempt to unpack these relationships by associating climate change beliefs, demographic variables and identity factors with rates of adoption of specific climate-mitigative practices. Our working hypothesis is that climate change beliefs may have limited bearing on adoption decisions in the farming community, while demographic and identity variables may play a larger role than commonly assumed.

Methods

Choice of method always comes with certain trade-offs, and our survey-based method is not an exception. While survey methods have limited utility for exploring some of the more complex nuances of certain conceptual categories, such as identity, they are highly useful for testing some well-established theories, and also to identify broad patterns of relationships in populations. Our panel-based survey of 301 livestock and grain producers in Alberta was administered by *Kynetec*, an agricultural market research firm. Producers were to have made at least \$10 000 in annual sales, and be geographically distributed across the province. We targeted a minimum of 100 beef producers; the remainder of the sample consisting of grain producers. Survey items measuring farm characteristics were based on questions from the Census of Agriculture.

Our comprehensive list of agricultural practices associated with climate-mitigative benefits, either in the form of greenhouse gas reduction or carbon sequestration, was based on mitigation research conducted by Smith *et al* [40]. This initial list was then expanded upon through consultation with colleagues, within Agriculture and Agri-food Canada. We generated a final list of 21 practices. Respondents were then asked which practices they have adopted, had not but would be willing to, or had not and are not willing to. For adopted practices, respondents were asked to indicate the reasons that motivated them from a list that included a range of environmental and economic considerations.

The survey included four items each to measure our three predictive factors (appendix A, table A1). To measure beliefs about climate change, we used a question developed by Arbuckle *et al* [41], asking respondents to choose one of five statements regarding the existence of climate change, and whether humans are partially or mostly the cause. Items measuring climate change norms were developed based on values-beliefs-norms theory and work by Stern *et al* [42], regarding the perceived importance of individual, sectoral, and societal contributions to climate change mitigation, and whether climate change poses a serious problem for society. Conservation Orientation was measured using a scale developed specifically for farmers by Maybery *et al* [26]. Items measuring learning orientation were adapted to the agricultural context from a scale aimed at measuring learning and innovation in firms [43].

A probit model using adoption as the binary dependent variable was employed to identify the probability of adoption for each practice while controlling for other factors, with the dependent variable representing each individual adoption decision. The equation below represents the adoption decision for farmer f evaluating action i. The utility associated with adoption is represented by U_{fi}, and A_{fi} represents the observed adoption outcome, where $A_{fi} = 1$ if adoption occurs, and $A_{fi} = 0$ if it does not. If U_{fi} is positive, the farmer is better off by adopting the action and $A_{fi} = 1$, while $A_{fi} = 0$ if utility is lost by adopting the action. X_f contains producer and operation characteristics meant to control for the social, personal, and farm-level factors affecting adoption, while β represents parameters relating X_f to U_{fi}. X_i contains observable characteristics of the recommended practices meant to indirectly measure practice-related factors affecting the adoption decision and α is a vector of coefficients. The error term, e_{fi}, is normally distributed with a mean of 0, and u_f represents farm and producer specific effects not accounted for in X_f.

$$U_{fi} = (\beta' X_f + \alpha' X_i) + e_{fi} + u_f$$

$$\text{where } A_{fi} = 1 \text{ if } U_{fi} > 0, \text{ and } A_{fi} = 0 \text{ otherwise.}$$

Due to the presence of the unobserved error term, a standard binary choice model will be biased since one may not assume that the overall model error ($e_{fi} + u_f$) is independently distributed. Thus, a probit model with robust cluster-corrected standard errors was estimated. This model employs a modified version of the Huber–White 'sandwich estimator' [44, 45], allowing for cluster-correlated variances and providing robust standard errors. This method allows for the error of each observation for a farmer to be correlated, but also implies that each cluster itself is independent [46].

A second step involved the estimation of ordered probit models for five mitigative practices associated with different types of energy and land use-based practices, all of which present significant capital-investment barriers to adoption, while also yielding the highest greenhouse gas savings potential across crop and livestock farm types (bioenergy, wetland restoration, solar power, cover crop, covered manure facility), with the dependent variables representing an ordered likelihood (definite no, no but willing, yes) of adoption of the selected practices.

Findings

Our survey sample consists of producers in Alberta's large-scale, commercial beef and grain sector (appendix B, table B1), with an average farm size of 3599 acres and median of 2000 acres. Two-thirds of the sample are primarily grain producers, and the remaining third primarily livestock producers. 89% of respondents are male, the average age is over 54 years, and respondents have managed a farm for 29 years on average. 25% of the sample has a university degree, and the vast majority of respondents receive at least some family income from off-farm. Over half of the respondents, finally, have completed an Environmental Farm Plan (EFP), administered by the Agricultural Research and Extension Council of Alberta, on behalf of the

Table 1. Farmer beliefs about climate change ($N = 301$).

Belief	Percent of responses
Climate change is occurring, and it is caused mostly by human activities	10
Climate change is occurring, and it is caused more or less equally by natural changes in the environment and human activities	36
Climate change is occurring, and it is caused mostly by natural changes in the environment	28
There is not sufficient evidence to know with certainty whether climate change is occurring or not.	19
Climate change is not occurring	2
Prefer not to answer	4

Table 2. Percent of farms that have adopted, would consider adopting, or have not and would not consider adopting each greenhouse gas mitigative practice.

	Percent of respondents			
Practice	Have adopted	Would consider	Have not adopted	*N*
Leave/spread crop residue in fields after harvest	97	2	1	260
Zero tillage	82	12	6	252
Use GPS, precision agriculture, and/or variable rate technology for fertilizer application	81	16	3	250
Installed LED lights	80	19	1	299
Manure composting	79	19	2	148
Make animal breeding decisions to improve feed efficiency	79	15	5	156
Include perennial, forage, and/or legume crops in rotations	71	23	6	231
Improved the energy efficiency of buildings	68	30	2	289
Introduce legumes or other nitrogen fixers into grazing lands	67	29	3	147
Maintain wetlands (do not graze or harvest permanent wetlands; delay haying or grazing seasonal wetlands)	62	23	14	222
Fenced off riparian areas and sensitive ecosystems to protect them from livestock	60	27	12	139
Planted tree belts or lots	58	26	16	267
Converted cropland to pasture or other vegetation	52	24	24	250
Planted permanent/perennial vegetation on marginal lands and edges of fields	51	33	16	250
Supplement feed with ionophores, lipids, oil seed, or bacterial supplements	39	39	21	132
Reduce slaughtering age of cattle by 2+ months	39	49	12	116
Plant cover crops	36	46	18	192
Restored wetlands	33	42	25	209
Installed solar panels	19	67	14	276
Production of bioenergy	10	61	29	165
Built a covered manure storage facility	5	41	54	99

Government of Alberta. The EFP is a voluntary, whole farm, self-assessment tool that assists producers in identifying on-farm environmental risks and develop mitigation plans for which governmental programme funding is available. Our sample represents larger farms than the provincial average of 1200 acres, according to the last agricultural census administered by Statistics Canada (https://statcan.gc.ca/eng/ca2016). Other features of our sample that depart from the provincial average include a slightly higher proportion of males and larger number of farmers who have adopted the EFP (provincial average is 24%).

Climate change beliefs

In response to our first research question, we found a very low level of belief in anthropogenic climate change (table 1). While only 2% of respondents do not believe that the climate is changing at all, understanding of the causes of changes that are believed to be occurring among the remaining 98% are quite diverse. Only 10% of the sample agree with the consensus opinion of climate scientists, that climate change is caused mostly by human activities.

Adoption of mitigative practices

Despite the low level of agreement with anthropogenic climate change, there are varying levels of adoption of several practices that offer mitigative benefits (table 2). Not all of the practices are relevant to all types of farms, so the *N* for each practice varies.

Motivations for adoption

Farmers are motivated to adopt climate-mitigative practices for a variety of reasons, many of which reflect

Table 3. Motivating factors in adopting greenhouse gas mitigative practices.

		Percent of respondents who were motivated to adopt practices for the following reasons						
Practice	*N*	Wildlife and Biodiv.	Water quality	Soil quality	Reduce GHGs	Reduce cost	Increase efficiency	Increase revenue
Leave crop residues on field	253	5	9	87	6	22	25	29
Zero-till	207	4	12	70	10	54	55	45
Precision agriculture	203	2	5	18	11	54	76	46
LED Light	240	1	1	3	8	65	47	19
Manure composting	117	3	16	48	4	40	33	14
Improve feed efficiency	124	2	2	5	4	44	59	55
Crop rotation	163	13	13	69	4	27	36	47
Improve energy efficiency of buildings	196	2	2	3	10	70	46	21
Plant legumes in pasture	99	6	6	48	4	32	51	52
Maintain wetlands	138	63	49	16	1	9	12	7
Riparian Fence	84	56	64	24	2	5	14	11
Plant tree lots, shelterbelts	155	61	14	39	9	8	8	5
Convert cropland to pasture	130	21	18	43	4	32	42	26
Plant marginal vegetation	128	39	23	38	2	30	27	23
Feed supplements	52	2	6	10	6	38	71	44
Reduce slaughter age of cattle	45	7	7	9	4	47	44	40
Cover crops	70	9	17	66	3	11	36	29
Restore wetland	70	54	53	20	3	11	11	11
Install solar panels	52	4	33	6	12	42	42	15
Bioenergy production	16	0	0	13	25	44	13	38
Covered Manure	5	0	0	20	60	40	20	20

Underlined values are the most commonly selected reason for adopting a given practice.

the multiple co-benefits offered by those practices (table 3). Economic factors—reducing costs, increasing efficiency, and increasing revenues—were the leading motivating factors of adoption for less than half (9 of 21) of the practices, but cited on average four times more often (37%) than greenhouse gas reductions (9%). Conservation factors were the most common leading motivators (11 of 21 practices), led by soil conservation and improvement (5 practices). Only one practice was highly motivated by a desire to reduce greenhouse gases—the construction of a covered manure facility—but that practice also has the smallest number of adopters. Even among those respondents who produce bioenergy, the top stated reason for doing so was cost reduction rather than greenhouse gas mitigation.

Predictors of adoption behaviour

Having an EFP, followed by learning orientation and conservation orientation were the strongest predictors of adoption in our full model of aggregated practices (table 4). Importantly, climate change beliefs had no bearing on adoption decisions: those respondents expressing belief in anthropogenic climate change were no more likely to adopt mitigative practices than others, and those who disagreed with the science of climate change were no less likely to do so. Climate change norms (ascription of responsibility to mitigate climate change), differentiated in the model from climate change beliefs, were not significant either. The size of farm operation matters, with larger farms more likely to be associated with the adoption of a greater number of mitigative practices. A production focus on livestock as opposed to crop farming appears to be associated with adoption of a larger number of practices. This may simply reflect the fact that a greater number of mitigative practices would be relevant to mixed grain and livestock operations, whereas many of the practices included in the survey would not be relevant to grain farmers without livestock.

When all of the factors in the model are controlled for, however, we find that for most practices, producers are more likely to choose not to adopt, as expressed in the second half of table 4, suggesting that while identity factors such as learning orientation are relevant to adoption decisions overall, the level of investment required clearly still matters. While installing LED lights is a low-cost and low-effort investment that has been widely adopted, many climate-mitigative

Table 4. Association of farm and farmer characteristics with adoption in the full model of aggregated practices.

Farm/farmer characteristics	Coef.	S.E.	*p*	Marg. Eff.
Gender: male	0.008	0.151	0.961	0.003
University degree	−0.008	0.094	0.937	−0.03
College diploma	−0.04	0.090	0.633	−0.016
% income coming from farm	0.117	0.175	0.505	0.045
Income primarily from crops	−0.337***	0.100	<0.001	−0.129
Acres (1000 s)	0.026***	0.011	0.017	0.099
Cattle (100 s)	0.00	0.002	0.910	0.000
Environmental Farm Plan completed	0.204***	0.080	0.007	0.078
Climate change beliefs				
Mostly caused by humans	−0.063	0.173	0.716	−0.024
Equally natural and human caused	0.073	0.113	0.518	0.028
Caused by natural changes	0.115	0.102	0.518	0.044
Climate change norms	0.035	0.051	0.486	0.014
Conservation Orientation	0.103***	0.045	0.021	0.038
Learning Orientation	0.125***	0.050	0.013	0.048
Practices				
Zero tillage	0.099	0.173	0.716	0.038
Cover crop	−1.208***	0.134	0.000	−0.464
Leave residuals on field	1.134***	0.195	0.00	0.435
Crop rotation	−0.292**	0.134	0.029	−0.112
Precision agriculture	0.056	0.125	0.657	0.021
Manure composting	−0.132	0.145	0.364	−0.051
Bioenergy production	−2.179***	0.179	0.000	−0.837
Maintain wetlands	−0.578***	0.126	0.000	−0.222
Feed supplements	−1.239***	0.147	0.000	−0.476
Breeding decisions for feed efficiency	−0.063	0.151	0.676	−0.024
Legumes in grazing land	−0.479***	0.142	0.000	−0.184
Reduce slaughter age	−1.242***	0.151	0.000	−0.477
Restore wetland	−1.341***	0.128	0.000	−0.515
Convert cropland to pasture	−0.817***	0.128	0.000	−0.314
Plant marginal vegetation	−0.825***	0.125	0.000	−0.317
Plant trees/shelterbelts	−0.698***	0.117	0.000	−0.268
Install solar panels	−1.791***	0.127	0.000	−0.688
Improve energy efficiency of buildings	−0.420***	0.106	0.000	−0.161
Covered manure facility	−2.624***	0.224	0.000	−1.008
Riparian fencing	−0.688***	0.140	0.000	−0.264
Constant (Installing LED lights)	0.781***	0.230	0.001	0.781
N practices = 3787; N individuals = 263				
McFadden's R^2 = 0.22; Log-pseudolikelihood = −2017.39				

practices involve significant upfront financial or marginal production costs.

Considering the low probability of adoption overall, we were interested in looking more closely at factors that influence adoption decisions among farmers who have adopted five practices on our list considered to have the highest level of mitigative benefits. We specifically sought to include a spectrum of practices, with some associated directly with renewable energy production, others with land management, and one with management of manure—a potent source of greenhouse gases from intensive livestock operations. As with the full model above, respondents' expressed beliefs about climate change do not affect the likelihood of practice adoption, except in one case, albeit not in the expected direction: climate-change believers are significantly *less* likely to adopt wetland restoration. The findings for cover crops are not unexpected—a practice that makes the most sense for larger livestock operations, but conservation orientation also matters. Livestock operators are also more likely to support wetland restoration and solar power. Other findings are more surprising. Interestingly, while climate change norms were not significant in the aggregate model, they do significantly increase the likelihood of adoption for some of the most effective mitigative practices (table 5). Demographic factors like farming experience, education and farm size affect the likelihood for adoption of each practice differently. Primary crop farmers are significantly less likely to adopt capital-intensive mitigative practices. Increasing years of farming experience significantly affects the likelihood of adoption of more substantial practices such as covering a manure facility. Finally, while conservation and learning orientations were strong predictors in the aggregate model, they are not significant

Table 5. Ordered probit models of adoption decisions for five mitigative practices.

	Bioenergy		Wetland restoration		Solar power		Cover crop		Covered manure	
Variable	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Farming experience	−0.00	0.01	0.01	0.01	−0.05	0.01	0.01	0.01	−0.03**	0.01
Post-secondary education	0.71***	0.22	0.00	0.20	−0.12	0.17	0.20	0.21	0.45	0.32
% farming income	0.01	0.01	−0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Primary crop income	−0.28	0.25	−0.53***	0.19	−0.75***	0.18	−1.03***	0.24	0.00	0.36
Acres (1000 s)	0.05*	0.03	0.05*	0.03	−0.06***	0.02	0.08***	0.03	0.05	0.04
Environmental Farm Plan	−0.05	0.21	0.46**	0.18	0.66***	0.17	−0.26	0.20	0.45	0.30
Climate change norms	0.29***	0.11	0.36***	0.09	0.26***	0.09	−0.01	0.10	0.10	0.19
Climate change beliefs	0.37	0.26	−0.47**	0.23	−0.33	0.20	−0.06	0.25	0.75	0.31
Conservation Orientation	0.10	0.12	0.27**	0.11	0.12	0.10	0.27**	0.12	0.25	0.18
Learning Orientation	0.25**	0.13	0.09	0.11	0.09	0.11	−0.12	0.13	0.63***	0.21
Cutpoint 1	0.37	0.59	−1.01	0.44	−2.01	0.43	−1.12	0.53	0.74	0.65
Cutpoint 2	2.51	0.63	0.29	0.43	0.24	0.40	0.41	0.53	2.59	0.72
N	147		181		242		166		85	
Chi-square	34.66		43.96		46.35		37.75		30.60	
McFadden's R^2	0.13		0.11		0.11		0.11		0.21	

predictors for all practices, with conservation orientation associated with wetland restoration and cover crops, while learning orientation is associated with bioenergy production and covered manure facilities.

Discussion

Several notable findings emerge from this study. First, a sizable proportion of farmers have already adopted climate-mitigative practices. They are motivated to do so for many reasons, but neither agreement with climate science, nor an ascription of responsibility for mitigation, are among the motivators, a finding that departs from several other studies identifying climate change beliefs as a strong predictor of adoption [9, 29, 41] (beliefs that climate change is human caused have been found to be relatively less significant in studies of adaptation behaviours [47]). Rather, farmers recognize numerous co-benefits of mitigative practices, such as soil quality improvement, and wildlife and biodiversity enhancement. To the extent that numerous (but not all) mitigative practices also offer co-benefits the contribute to conservation, efficiency, and importantly, climate change adaptation, this finding is encouraging. Second, no single model of farmer behaviour has consistently strong predictive value for all decisions. Rather, the influence of both instrumental factors (e.g. size of farm, source of income) and identity factors (e.g. learning orientation) on farmer decision making is practice-specific. Finally, agreeing that climate change is human caused and viewing mitigation to be an important responsibility operate independently of each other, suggesting that agreement with the science of climate change is not a necessary pre-requisite for supporting mitigation strategies.

What may be happening here? For one thing, empirical research is always limited by the number of belief and practice measures included. In agriculture, major proposed strategies to induce mitigation have focused on collective, government-led responses including legislative mandates to reduce emissions, taxes, and cap and trade regimes, and much empirical research has been devoted to evaluating farmer support for such initiatives. But focusing on willingness to support a set of policies linked to an explicit climate change political mandate opens up a host of conflating issues, and perhaps does not provide an accurate picture of farm-level decision making, leading to a miscalculation of the potential contribution of farmers to mitigation. Attempts to garner support for such political mandates may trigger cognitive dissonance, leading to rejection of those mandates. Perhaps what we have uncovered suggests that value-action gaps do not necessarily prevail in all circumstances. To the contrary, our findings suggest the potential for action-value gaps as well—in other words, evidence for adoption of practices with climate-mitigative benefits despite the absence of climate change beliefs, or mitigative norms. More precisely, the depiction of the values and actions of relevance often ascribed to by academics and policymakers may be too narrow.

Relatedly, findings of low agreement that climate change is human caused are usually followed by calls for educating farmers about climate change, based on the expectation that doing so is necessary to secure higher levels of support. However, many studies find that education and awareness-raising campaigns rarely affect attitudes and/or behaviours [48, 49]. Continuing to presume that the only way climate-mitigative actions can be motivated is through changing beliefs about climate change implies a dim future, given what we know about how beliefs are formed, and the stability of those beliefs [50]. Trust also factors into acceptance of new information, as would be implied by identity theory. Belief in anthropogenic climate change is strongly associated with environmental groups, in which few farmers ascribe trust [12]. On the other hand, certain aspects of farmer identity may have even more relevance than the aversion of some farmers to an environmentalist identity. In short, a disproportionately large segment of the farmer population in western countries is older, white, male, and politically conservative—precisely that population segment found elsewhere to have the strongest affinity to climate skepticism [51].

Our findings, however, emphasize the extent to which neither such narrowly described identities, nor singular beliefs, are sufficient predictors of practice, lending credence to those scholars who emphasize the multifarious and dynamic nature of identity [31]. Farmers do tend to be older, conservative white males, but in many other respects bear very little resemblance to conservative white males outside the farming population, and thus express several identities, as well as knowledge and experience, that are brought to bear on farming practices. While such insights pose challenges to researchers, it also presents opportunities for applications: if farmers express the tendency to adopt strong climate change norms despite their disagreement that climate change is human caused, or in many cases adopt mitigative practices for other reasons entirely, this opens up an entirely new range of avenues for encouraging policy support. Farmers' beliefs about climate change are immaterial if they are adopting climate-mitigative practices for other reasons. Rather than stymie response, thus, an action-value gap suggests ambiguity or multiple interpretations, which can cause actors to converge in their responses but for entirely different reasons [52–54]. Recognizing this, policy making and messaging may purposefully include strategic ambiguity—'the deliberate use of ambiguity in strategic communication in order to create a 'space' in which multiple interpretations by stakeholders are enabled'—to facilitate collaboration [55].

Given our nonprobability sample, the generalizability of our findings to larger populations may be limited. On the one hand, as noted earlier, Alberta describes a unique socio-political context shaped by high levels of economic dependence on fossil fuels extraction and, perhaps relatedly, high levels of climate skepticism. On the other hand, our sample of large, industrialized operations is representative of modern industrial farming practiced in several other regions around the globe, and we are confident that this study has generated the potential for theoretical generalizability with application not only to other agricultural regions, but to other occupations and industries as well. For example, within Alberta, professional engineers and geoscientists working for oil and gas companies have also been quite skeptical of anthropogenic climate change [56]. To bypass this skepticism, the researchers recommended that a 'risk frame' had the discursive potential to bridge economic, environmental, and anti-/pro-regulation framings, given its ambiguity and interpretive plasticity to these respondents.

Appendix A

Table A1. Factor analysis results of responses for learning orientation, conservation motivation, and climate change norms scales.

Item	Climate norms	Conservation orientation	Learning orientation
The basic values of my farm include learning as a key to improvement	0.05	0.31	**0.67**
Learning on my farm is seen as a key commodity necessary to guarantee survival	0.03	0.21	**0.66**
We adopt farming practices and innovations based on research results	−0.02	0.17	**0.58**
Innovation is readily accepted on our farm	0.06	0.20	**0.63**
Good farmers regularly make land stewardship improvements to their land	0.06	**0.63**	0.27
The most important thing is leaving my property in better shape than I found it	0.18	**0.70**	0.16
Land stewardship by farmers is more important than anything else about farming	0.17	**0.67**	0.10
Managing environmental problems on my farm is a very high priority	0.25	**0.70**	0.23
It is important for me to take steps towards mitigating climate change	**0.89**	0.08	0.00
It is important for the agricultural sector to take steps towards mitigating climate change	**0.84**	0.06	0.05
It is important for society to take steps towards mitigating climate change	**0.91**	0.06	−0.01
Climate change is a serious problem for society	**0.83**	0.11	0.02
Variance extracted	3.16	2.06	1.79
Cronbach's α	0.77	0.81	0.93
$N = 293$; LR test χ^2 (66 d.f.) $= 1847.14$			

Appendix B

Table B1. Descriptive statistics of farms sampled.

Variable	N	Mean	SD	Min	Max
Farm size (acres)	300	3599	5436	90	67 000
Income comes primarily from crops	301	0.69	—	0	1
Income comes primarily from cattle	301	0.31	—	0	1
Cattle herd size	301	393	1619	0	18 000
Environmental Farm Plan completed	297	0.55	—	0	1
Years farming experience	300	28.96	12.94	0	55
Farmer age	285	54.63	11.80	18	79
Gender: male	297	0.89	—	0	1
Trade school diploma	285	0.16	—	0	1
College diploma	285	0.28	—	0	1
University degree	285	0.25	—	0	1
Have accessed assistance when adopting new practices	301	0.57	—	0	1
Percent of off-farm income:	297				
0%–20%		0.02	—	0	1
21%–40%		0.06	—	0	1
41%–60%		0.14	—	0	1
61%–80%		0.14	—	0	1
81%–99%		0.28	—	0	1
100%		0.36	—	0	1

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