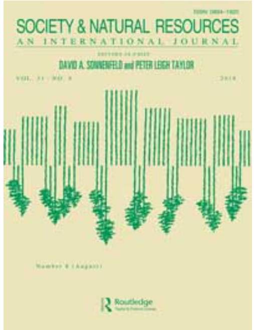

Society & Natural Resources
An International Journal

ISSN: 0894-1920 (Print) 1521-0723 (Online) Journal homepage: http://www.tandfonline.com/loi/usnr20

Conserving Biodiversity in Farm Animals: Do Farmer and Public Biodiversity Knowledge and Awareness Matter?

Albert Boaitey, Ellen Goddard & Getu Hailu

To cite this article: Albert Boaitey, Ellen Goddard & Getu Hailu (2018) Conserving Biodiversity in Farm Animals: Do Farmer and Public Biodiversity Knowledge and Awareness Matter?, Society & Natural Resources, 31:8, 960-976, DOI: 10.1080/08941920.2018.1450912

To link to this article: https://doi.org/10.1080/08941920.2018.1450912

SOCIETY & NATURAL RESOURCES
2018, VOL. 31, NO. 8, 960–976
https://doi.org/10.1080/08941920.2018.1450912

Routledge
Taylor & Francis Group

Check for updates

Conserving Biodiversity in Farm Animals: Do Farmer and Public Biodiversity Knowledge and Awareness Matter?

Albert Boaitey[a], Ellen Goddard[b], and Getu Hailu[c]

[a]Department of Agricultural Economics, University of Wisconsin-River Falls, River Falls, WI, USA; [b]Department of Resource Economics and Environmental Sociology, University of Alberta, Edmonton, AB, Canada; [c]Department of Food, Agricultural and Resource Economics, University of Guelph, Guelph, ON, Canada

ABSTRACT

Increases in biodiversity losses are a growing concern globally. In farm animals, related concerns about losses in genetic diversity have potentially increased with the emergence of breeding technologies that allow for faster genetic change in herds. Farmer and public acceptance of specific breeding practices can be influenced by a number of factors, including concerns about biodiversity and knowledge of biodiversity. The link between these factors and acceptance of new genetic technologies, if it exists, may help explain concerns about genetic technologies. This article examines the effect of attitudes and knowledge about biodiversity on the acceptance of genomic selection in livestock production using farmer and public survey data from Canada. Our results suggest that the link between biodiversity concerns and the acceptance of genomic selection is more robust for the public than for farmers. We also find that biodiversity knowledge and attitudes have opposite effects on acceptance of genomic selection.

ARTICLE HISTORY
Received 21 October 2016
Accepted 25 February 2018

KEYWORDS
Awareness; biodiversity; farmer; genomics; knowledge; public

Introduction

Worldwide, agricultural systems are faced with the daunting challenge of providing adequate food for a growing population without upsetting the delicate balance of nature (Foley et al. 2011). The ability to meet one's goal (e.g., food security) often comes at the expense of others such as biodiversity, water use efficiency, air quality, and the provision of ecosystem services. Reported assessments of biodiversity suggest relatively high potential risk of losses in many ecosystems. For example, only 14 species out of the 50,000 known bird and mammal species account for 90% of livestock production (Food and Agriculture Organization 1999). Globally, 17% (1,458) of livestock species are at risk of extinction (Steinfeld et al. 2006). North America has one of the highest global proportions of at-risk breeds due to the high degree of specialization that characterizes production (Food and Agriculture Organization 2015). In domesticated species, a key concern relates to the issue of overexploitation of particular genetic traits resulting from breeding practices of farmers. For example, the development of newer breeding technologies can speed up the rate of improvement in livestock traits linked to productivity, disease resistance, or greenhouse gas emissions at markedly higher rates as compared to conventional breeding methods.

CONTACT Albert Boaitey albert.boaitey@uwrf.edu Department of Agricultural Economics, University of Wisconsin-River Falls, 101 Ag Science Building, 410 S. 3rd St., River Falls, WI 54022, USA.
Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/usnr.

The downside of these practices is the potential loss in genetic diversity in domesticated livestock species from a higher emphasis on specific traits or on particular high-performing animals. In dairy cattle, for example, the selection for increased milk yields by breeders has come at the cost of increased susceptibility to lameness in cows, due to the negative correlation between milk yields and health (Haile-Mariam, Bowman, and Goddard 2004; Brotherstone and Goddard 2005). As a result of these concerns, several multinational initiatives have been launched to reduce biodiversity losses. For example, a key objective under the International Strategic Plan for Biodiversity 2011–2020 (Agard et al. 2005) is to minimize the loss of genetic diversity in farmed and domesticated animals.

A recent review of the progress toward these goals suggest that they are unlikely to be met by 2020. The review however noted that societal responses and attitudes toward biodiversity have improved (Tittensor et al. 2014). Implicit in this assertion is the notion that biodiversity knowledge and attitudes can play a role in reducing losses in biodiversity. In domesticated species, the effect of these factors can occur through multiple pathways. At one end of the food supply chain, there are farmers who make production decisions including the selection of breeding stock. These decisions can be motivated by a personal set of considerations. At the other end of the supply chain, there are consumers who are the end users of livestock products. The purchase decisions of these consumers may be motivated by an entirely different set of considerations. The two agents are linked by preferences for livestock products as expressed by the prices paid by consumers, and the public's support for specific regulations that can impact production (or biodiversity). Stated this way, public and farmer perceptions about biodiversity may be aligned or divergent. The relationship between farmer and public perceptions can have significant implications for products produced with specific practices, farmer uptake of these practices, and the conservation of genetic or biodiversity. For example, if farmers' concerns about biodiversity are relevant in their breeding decisions, then these concerns may mediate the risk of over selection for too narrow set of traits. A similar case can be made for public demand-driven losses in genetic or biodiversity.

Past studies on public attitudes and familiarity with biodiversity report low levels of knowledge about biodiversity among the public (Spash and Hanley 1994; Hunter and Brehm 2003; Hunter and Rinner 2004; Christie et al. 2006; Buijs et al. 2008). It seems that while the public is concerned and willing to support policies toward the conservation of biodiversity, these concerns are more nuanced toward "rare" species as compared to domesticated or local animals (Hunter and Brehm 2003; Christie et al. 2006). It is plausible that these disparities in the levels of concern are reinforced by gaps in knowledge. Other studies have looked at farmer decision making with respect to biodiversity (Farmer-Bowers and Lane 2009). However, the link between public and farmer attitudes and knowledge about biodiversity and the acceptance of livestock breeding practices that impact genetic diversity in domesticated species has not been previously addressed.

In this article, we examine the linkage between farmer and public knowledge and attitudes toward biodiversity and acceptance of new breeding technologies in Canada. Specifically, we focus on genomic selection as an example of a new breeding technology. Genomic selection relies on information from entire genomes and can accelerate the rate of genetic change through reductions in generation intervals (Goddard and Hayes 2007). Given genomic information, a large number of farmers selecting for a narrow set of identical traits could lead to losses in genetic diversity, possibly leading to increased vulnerability to new disease outbreaks, or other stresses (Boaitey 2016). The specific questions guiding this research are as follows:

1. How does the acceptance of genomics, awareness about biodiversity, and biodiversity knowledge compare between farmers and the public in Canada?
2. Is there a systematic linkage between public and producer attitudes and familiarity with biodiversity and acceptance of genomic selection for different traits in livestock and are these effects comparable between farmers and the public?

The overarching goal is to identify points of convergence in knowledge and attitudes between the public and farmers. This is critical for effective policy design (Skarstad, Terragni, and Torjusen 2007). Additionally, we aim to contribute to the understanding of the role of attitudinal and knowledge factors that directly relate to the environment, in farmer and public decision-making.

Conceptual Framework

User acceptance of technology is influenced by a wide array of factors—attitudes, perceptions, social influences, economic considerations, etc. Given the multiplicity of factors that influence acceptance, researchers have developed different approaches to assess the effects of these factors. A dominant framework in the technology adoption literature is the technology acceptance model (TAM, Davis (1989)) that highlights the role of "perceived usefulness" and "ease of use" of a given technology as important predictors of behavior (Taylor and Todd 1995; Venkatesh and Davis 2000; Hsiao and Tang 2015). Mostly used in the information system (IS) domain, perceived usefulness and ease of use influence actual usage through the intent to use nexus. Applications of the TAM framework have however shown that perceived usefulness is the most important factor that influences the acceptance of technology (Sun and Zhang 2006). This outcome is supported in the few instances the model has been used in an agricultural technology context (Flett et al. 2004). It has also been suggested that accounting for individual, technology, and organizational factors beyond the basic constructs of the TAM model can significantly improve predictive power (Venkatesh, Morris, and Davis 2003; Sun and Zhang 2006). Indeed, extensions of the TAM model have incorporated attitudinal variables, relevance indicators, cognitive instrumental processes, and sociodemographic characteristics (Venkatesh, Morris, and Davis 2003). The user emphasis of the TAM framework makes it adaptable to farmer decision-making (see, for example, Flett et al. 2004). In this study, we centralize perceived usefulness as the main predictor of acceptance of genomics. The implicit assumption here is that *perceived usefulness* influences *intent to use* which in turn determines actual usage. Perceived usefulness is assumed to be influenced by a set of individual and technology-related factors. The latter capture global attitudes toward biotechnology, as these may be directly related to attitudes toward other genetic technologies. Context-specific cognitive process variables such as knowledge about genomics, biodiversity knowledge, and knowledge about environmental problems are likely to have explanatory power. Attitude toward biodiversity is assumed to explain part of the individual variation in the acceptance of genomics in livestock selective breeding. Following Venkatesh and Davis (2000), we include a number of sociodemographic and experience variables in assessing farmer acceptance of genomic selection.

In the public analysis, we include a wider set of individual specific factors that can influence consumer choice decisions. As well as biodiversity attitudes and knowledge, this includes different aspects of trust, views about science, and technology and support for biotechnology (Ishiyama et al. 2012; Matin et al. 2012). In the context of these factors, we can assess how important the biodiversity-related variables might be in the public analysis as compared to the farmer analysis.

Methods

In this study, we examine the effect of public and farmer knowledge and attitude toward biodiversity on their acceptance of new breeding technologies. The analysis is done with survey data collected from representative samples of farmers and the public in Canada. In addition to questions on respondents' sociodemographic characteristics, the survey included questions and attitudinal scales used to measure the variables outlined in the previous section. The assessment of perceived usefulness is undertaken with the personal involvement scale (PII) (Zaichkowsky 1994). The PII scale is a 7-point Likert-type scale multi-item index. Higher levels of involvement are associated with higher perceived relative importance of a given product/activity. Ares et al. (2010) used the PII scale in the assessment of the relationship between involvement and intent to purchase functional milk products. Respondents were asked: The use of genomics for improvements in the relevant trait is? The items in the scale were (Zaichkowsky 1994): "useless–useful"; "worthless–valuable"; "harmful–beneficial"; "foolish–wise"; "awful–nice"; "disagreeable–agreeable"; and "unpleasant–pleasant." The PII scale was common in all the five surveys included in this paper.

Two aspects of biodiversity are considered in this study, i.e., knowledge and attitude. The biodiversity attitude metric was adapted from the UK Department for Environment, Food and Rural Affair's (DEFRA) attitude scale. This scale was reported in "Attitudes and knowledge relating to biodiversity and the natural environment" survey (DEFRA 2011). It comprises four statements (DEFRA 2011):

i. I worry about changes to the countryside, such as the loss of native plants and animals.
ii. There is nothing I can personally do to help stop the losses in the world's biodiversity.
iii. We can afford to lose some of the world's biodiversity.
iv. Biodiversity losses in animals domesticated for food production are less serious than similar losses in wildlife.

These statements measure attitude toward the loss of native species, the respondent's perceived role in reducing losses in biodiversity and perceptions about the extent of losses in biodiversity. Each statement was measured with a 5-point Likert-type scale over the range of 1 ("Strongly disagree") to 5 ("Strongly agree").[1] The attitude scale was common in all the surveys. The biodiversity knowledge scale is composed of three definitions that encompass the three dimensions of biodiversity—genetic, species, and ecosystem. It was adapted from Spash and Hanley (1994):

i. Biodiversity is a measure of the number of different species of plants and animals in a particular area (birds or trees in Ontario, for example).
ii. Biodiversity is a measure of the extent of genetic variation within a species, for example, the number of different types of apple trees, different breeds of cattle.
iii. Biodiversity means the number of different types of ecosystems within a particular region such as wetlands, coastal areas, forest, prairies.

Responses are coded on a scale of 1 ("Strongly disagree") to 5 ("Strongly agree").[2] Each respondent's overall knowledge is a sum of the score for each statement (all statements are true). The knowledge score was included in the beef public and producer surveys and the pork and hog producer surveys. The public surveys also included an open-ended question about respondent's familiarity with the concept of biodiversity which is briefly discussed later in this paper. This question preceded both the attitude and knowledge scales previously discussed.

Survey Instruments

Data from five surveys are reported in this article—three farmer surveys and two public surveys. The public surveys were national online surveys conducted in 2012. The pork survey elicited preferences for pork chops produced by hogs selectively bred for reduced susceptibility to two important diseases using genomic selection. These are porcine reproductive and respiratory syndrome (PRRS) and porcine circovirus associated disease (PCVAD). In the beef survey, preferences for steak from cattle selectively bred with genomics for increased feed efficiency were elicited. The two surveys were conducted within a month of each other, the questions used were exactly the same (with the exception that as appropriate a particular question might have the word pork switched with beef or the genomic application referred to related to disease resistance for pork and feed efficiency for beef) in the same order.

The public surveys were each conducted through the Canadian branch of a multinational market research company, TNS Global at the time (now Kantar TNS). From their maintained panel of respondents, the surveys were opened to a regionally representative sample, by province, and the surveys were targeted to the main household grocery shopper. The respondents had applied to and been accepted as panelists by the company and normally complete somewhere between zero and seven surveys within a 10-day period, given survey and respondent availability. Given the close timing of the two surveys, the surveys were opened to different respondents out of the full panel available. The objective was to have 1,800 completes for each survey. Respondents were compensated through the normal procedures for survey completion in place at the time of the surveys (depending on their selection they could have been compensated with points (cash or prizes)/E-gift cards/non-E-gift cards). Data from 1803 (beef) and 1808 (pork) respondents are included in the present analysis. The data collection process is described below in Table 1.

The farmer surveys focused on the use of genomic information for the selection for different traits. In beef cattle, the trait of choice was feed efficiency. The hog and dairy farmer surveys looked at disease resistance, and productivity and disease traits, respectively. Specifically, the hog survey focused on the use of genomics for selection for increased resistance to two major hog diseases, i.e., porcine reproductive and respiratory syndrome (PRRS) and porcine circovirus associated disease (PCVAD). TNS Global did not have access to a panel of farmer respondents that could generate sufficient responses for our farmer surveys. To that end, we used the resources of IPSOS Agriculture and Animal Health in Guelph Ontario, Canada to recruit farmer respondents for the beef and pork

Table 1. Survey responses public beef and pork surveys.

	Beef	Pork
# of invites sent	12,300	8,387
Completes	1,803	1,808
Break offs—people who start the survey but do not complete it	452	221
Quota fails—people who try to start the survey after the quota has been filled	186	408
Response rate	15%	23%

surveys. The hog and the beef farmers were recruited from a national sample of producers in 2014. The questions, analyzed in this research, were again identical to those included in the public surveys and to each other (cattle and hog), except for some wording changes referring to beef cattle and cattle genomic selection and other related to hogs. IPSOS Agriculture and Animal Health recruited respondents from their databases of farmers who had responded to previous surveys as well as telephoning additional respondents to satisfy the requirements for the regional representation and the sample size required. Although a long period of time elapsed with the hog producer survey (with reminders to complete the survey), it was not found possible to recruit a large enough sample, possibly because the survey related to hog diseases, an unpopular subject or the length of the survey. The results presented here are illustrative only given the small sample size for hog producers. It was found to be much easier to recruit the respondents for the beef cattle survey. Producer respondents were paid $50.00 for their time in completing the survey. Based on the available financial resources for the beef cattle survey, we recruited 250 producers.

The dairy survey focused on the selection for reduced mastitis. Mastitis is a major dairy disease that impacts milk productivity and quality (Heikkilä, Nousiainen, and Pyörälä 2012). In the dairy survey, farmers in the Canadian province of Ontario were sampled and contacted in 2013/2014. The survey was mailed to 2,520 randomly selected dairy farmers in 2013, by the dairy farmers of Ontario (DFO), the provincial producer organization, who also selected the farmers. Following the procedure outlined in Dillman (2007), two reminder notes were sent to producers. In total, 205 surveys were received, representing an 8.1% response rate, while the response rate is relatively low, low response rates are not uncommon in farmer-based surveys (Paudel et al. 2008; Vassalos and Lim 2016; Hailu, Cao, and Yu 2017). Further, as noted by Hailu, Cao, and Yu (2017), the profile of producers in the dairy sample is comparable with that of larger provincial datasets and national surveys.

The problems associated with different sampling modes and the potential for mode bias particularly with respect to questions with elements of social desirability are well documented (Szolnoki and Hoffmann 2013; Hays, Liu, and Kapteyn 2015; Pew Research Center 2015). Two main modes, i.e., internet and mail, were used to elicit responses from survey participants in the surveys in this study. In Table 2, we assess whether there are any differences in responses as a result of the way in which our surveys were administered. Our analysis is constrained by several factors. First, most of our surveys (4 out 5) were internet based, although two of the producer surveys had telephone recruitment to complete the online survey. Second, both sampling modes are impersonal. We assess differences in the frequencies of responses to biodiversity knowledge question was the attitude one not in most of the surveys? and familiarity with genomics selection by mode of survey, i.e., internet versus mail. Following Pew Research (2015), we focus on the highest knowledge and familiarity scores. For the biodiversity knowledge question, we find differences of up to 4.6 percentage points within the internet-based surveys. A similar outcome (up to 4.6%) was found for the familiarity with genomics question. In contrast, a much higher

Table 2. Results of the assessment of mode differences between surveys.

	Internet surveys				Mail survey
Variable	Beef (public)	Pork (public)	Beef (farmer)	Pork (farmer)	Dairy (farmer)
Biodiversity knowledge	20.19% ($n = 332$)	17.02% ($n = 274$)	16.87% ($n = 41$)	15.55% ($n = 7$)	
Familiarity with genomics	1.09% ($n = 18$)	1.31% ($n = 21$)	5.76% ($n = 14$)	2.2% ($n = 1$)	21.46% ($n = 44$)

Table 3. Descriptive statistics for variables used in the logit regression analysis.

			Survey						
				Farmer			Public		
	Variable	Variable description	Beef	Dairy	Hog	CoA[a]	Beef	Pork	Census[b]
Sociodemographic variables	Age	Age of respondent (years)	52	48	46	55	48.99 (12.93)	50.84 (12.37)	46.9[a]
	Education	Years of education (years)	13	12	14		14.06 (1.95)	14.63 (1.92)	
	Income	Household income ($10,000.00)	48.6	84.9	69.8		59.30 (29.39)	68.17 (32.24)	83.4
	Household size	Number of people living in the household[c]					2.41 (1.18)	2.36 (1.13)	2.50
	Female	Female (base is male or other)	13.6	8.2	8.9	27	63.58 (48.14)	70.43 (45.65)	51.7[c]
	Rural	Live in a rural area (base is live in an urban area)					19.45 (39.60)	13.32 (33.99)	19
	French	Completed survey in French (base is English)					22.24 (41.61)	25.24 (43.45)	
Experience variable	Familiarity with genomics	Self-assessed familiarity with genomics (1 = not at all familiar; 4 = very well informed).					1.74 (0.78)	1.75 (0.77)	
Knowledge variables	Biodiversity knowledge	Aggregate biodiversity knowledge score	11.10		11.20		9.20 (3.47)	8.88 (4.84)	
	Knowledge of environmental problems	To what extent do you feel knowledgeable about environmental problems? (1–10 scale)					5.25 (2.14)	5.36 (2.12)	
Other individual specific variables	Biodiversity attitude	Factor scores from four statements					0.06 (0.96)	0.03 (0.98)	
	Biotechnology support	Support for the use of biotechnology (1 = strongly oppose; 4 = strongly support)					2.47 (0.66)	2.94 (0.64)	
	Views about science and technology	All things considered, would you say that the world is better off, or worse off, because of science and technology? 1 means that "the world is a lot worse off," and 10 means that "the world is a lot better off."					6.25 (2.17)	6.51 (2.10)	
	Government trust	Factor score of six statements					0.12 (0.94)	0.08 (0.96)	
	Generalized trust	Generally speaking, would you say that most people can be trusted? 1. Most people can be trusted … 0. Can't be too careful in dealing with people.					0.45 (0.50)	0.50 (0.50)	
	Fair	Would you say that most people would try to take advantage of you if they got the chance or would they try to be fair? 1. Most people would be fair … 0. Most people would try to take advantage of me.					0.65 (0.48)	0.69 (0.46)	
	Helpful	Would you say that most of the time people try to be helpful or that they are mostly looking out for themselves? 1. People mostly try to be helpful … 0. People mostly look out for themselves.					0.51 (0.50)	0.54 (0.50)	
		Sample size (*n*)	$n = 243$	$n = 204$	$n = 45$		$n = 1604$	$n = 1644$	

[a]Average age of people aged at least 15 years.
[b]Census data are from Statistics Canada.
[c]% of people 18 and over; farmer income is % revenue from farming.

difference (up to 20%) in the frequency of responses to the genomic familiarity question exists between the mail administered dairy producer survey and the other internet-based surveys. Part of these differences may be due to dairy farmers being more experienced with the use of genomics, which would be known by the DFO who selected the farmers to send surveys to on our behalf. As well for the mail administered dairy survey, self-selection bias could have resulted in farmers with higher familiarity with genomic selection choosing to complete the survey. Farmers were informed about the focus on breeding technology prior to completing the survey but the public were not signaled that genetic technologies were the focus of the surveys (surveys had broader focus) which may have resulted in self-selection for completion by respondents more knowledgeable about genetic technologies in the farmers' samples.

From Table 3, the mean farmer age 46–52 is lower than the national average of 55 years reported in the Census of Agriculture (CoA) 2011 (Statistics Canada 2012a). About 50% of respondents, the farmer surveys had at least secondary education. This estimate is also comparable with the 51.6% reported in the 2011 Census of Agriculture for all agricultural producers in Canada (Statistics Canada 2012b; Boaitey 2017). The current study, however, has a higher proportion of male farmers (86–90%) as compared to the CoA 2011 (73%) (Boaitey 2017). The average age of respondents in the public surveys (48–50 years) in comparable to national average (46 years) although that of the pork sample is marginally higher (Statistics Canada 2007a, 2007b). The proportion of female respondents tended to be higher 60–70% versus 52% in the census. Mean incomes are higher in the census that those reported in the beef and pork samples. Average household size of approximately 2.5 is like those reported in our surveys.

Analysis

A descriptive analysis of public familiarity with biodiversity, biodiversity attitude, and knowledge is undertaken first. Additionally, a principal component analysis approach is used to aggregate the biodiversity attitude scores into a single score. Second, acceptance of genomics, composed of a multi-item set of qualitative judgments, is aggregated into a single variable which classifies survey respondents as either high or low accepters of genomic selection. Following Ares et al. (2010), a hierarchical clustering approach was used to segment respondents into high and low acceptance categories based the within-group variance in standardized scores. Euclidean distance and Ward's aggregation method are used in clustering. A logit model is used to estimate the effects of selected variates, including biodiversity attitudes and knowledge, on the probability of a respondent being in a higher (lower) genomic acceptance cluster. The factor analysis was done in SPSS (IBM 2016). All the other statistical analyses were performed using the STATA 13 software (StataCorp 2013).

Results

The analysis of the effect of biodiversity attitude and knowledge on acceptance is preceded by a general assessment of the level of familiarity with biodiversity, qualitatively, among the public. Respondents were asked: "In a few words what does the term biodiversity mean to you?" The analysis of responses showed that a large proportion of respondents in the pork and beef surveys was unfamiliar with the concept of biodiversity. Responses such as: *don't* *know; unknown; no idea; unsure; unfamiliar;* and *nothing* occurred 431 times in the beef survey and 525 times in the pork survey, representing 30 and 24% of respondents in the latter and former, respectively. This low level of knowledge about biodiversity is consistent with previous studies (e.g., Spash and Hanley 1994; Hunter and Brehm 2003). Spash and Hanley (1994) reported that 37–46% of the respondents in their biodiversity knowledge study were unfamiliar with the term biodiversity.

Further, when respondents in the farmer and public surveys were presented with the multistatement biodiversity knowledge question. A higher score on the biodiversity knowledge scale meant that respondents are knowledgeable about biodiversity particularly with respect to the different components of biodiversity (i.e., genetic, species, and ecosystem). A lower score implied the opposite. Out of the total score of 15, approximately 20% of respondents in the beef and pork public surveys had a score of 1. In contrast, 30 and 23% of respondents in the hog and beef farmer surveys had a score of 12. The mean score in the hog and beef cattle farmer surveys was ∼11 as compared to 9 in the public surveys.

Further, attitudes toward biodiversity differed between the public and farmers. Even within these categories (e.g., the pork and beef public surveys), biodiversity attitude was not the same. A higher proportion of respondents in beef public survey "strongly disagreed" with each of the four statements as compared to the pork survey (Table 4). In general, concerns about the loss of biodiversity were higher among the public as

Table 4. Comparison of biodiversity knowledge and attitude scale.

	Statements					
Survey	Strongly disagree (%)	Mildly disagree (%)	Neutral (%)	Mildly agree (%)	Strongly agree (%)	Don't know (%)
I worry about changes to the countryside such as the loss of native plants and animals						
Beef public	2	3	11	27	*54*	3
Pork public	2	4	13	28	49	4
Beef producer	3	7	15	40	35	–
Hog producer	0	21	19	33	28	–
Dairy producer	12	12	36	32	7	–
There is nothing I can personally do to help stop the losses in the world's biodiversity						
Beef public	15	29	24	18	6	7
Pork public	13	28	26	17	9	9
Beef producer	19	*39*	22	18	2	–
Hog producer	22	*39*	24	15	0	–
Dairy producer	13	33	38	13	4	–
We can afford to lose some of the world's biodiversity						
Beef public	*40*	23	17	6	5	8
Pork public	37	22	20	7	4	10
Beef producer	25	36	25	12	2	–
Hog producer	27	20	32	18	2	–
Dairy producer	20	31	38	9	2	–
Biodiversity losses in animals domesticated for food production are less serious than similar losses in wildlife						
Beef public	24	21	25	12	4	13
Pork public	23	20	26	13	4	15
Beef producer	21	26	33	18	1	0
Hog producer	23	30	16	25	7	0
Dairy producer	13	23	*47*	13	4	0
Mean biodiversity knowledge scores						
Beef public	9.20					
Pork public	8.88					
Beef producer	11.10					
Hog producer	11.20					

Note: Italics denotes highest % of respondents in each category.

compared to farmers. These concerns were higher for native species. As shown in Table 4, approximately 59 (beef) and 49% (pork) of respondents in the public surveys strongly agreed with the statement on concerns about changes to the countryside as result of losses in native species as compared to 35, 28, and 7% in beef, hog, and dairy farmer surveys, respectively. As comparison, most respondents in the farmer surveys "mildly disagreed" or were neutral when asked about whether biodiversity losses in farm animals were less severe than native species. Similar results were reported by Hunter and Brehm (2003). This notwithstanding both the public "mildly disagreed" with the statement: "There is nothing I can personally do to help stop the losses in the world's biodiversity." A significant proportion of dairy farmers (38%) reported being "neutral." The distribution of responses to the same question in the public and other farmer surveys ranged from 22 to 26%.

As shown in Figure 1, most respondents in the pork and beef public surveys strongly disagreed with the statement, "that we can afford to lose some of the world's biodiversity" (DEFRA 2011). Farmer responses were intermediate with most beef producers "mildly disagreeing" while most dairy and hog producers were "neutral."

Table 5 shows the results of the principal component analysis performed to extract a common factor(s) for the multi-item measure of attitudes toward biodiversity. The analysis yielded one factor in each of the surveys. Most of the variance in the public and producer attitudes toward biodiversity is accounted for by statement 3 (i.e., "We can afford to lose some of the world's biodiversity.")—77–90% of variance. In addition, statement 1 (i.e., "I worry about changes to the countryside such as the loss of native plants and animals.") had the lowest contribution (54–66%) to variance in the biodiversity attitude factor for every group except for hog farmers. The Cronbach alpha (Cronbach 1960) ranged from 0.6 to 0.7. In general, an alpha of at least 0.70 is a preferred indicator of internal consistency, however, estimates of 0.5–0.70 are acceptable (McCrae et al. 2011).

Logit Regression Estimates

The logistic model results reported in Table 7 explore the link between the relevant variables previously discussed and the acceptance of genomic selection. In Table 6, the

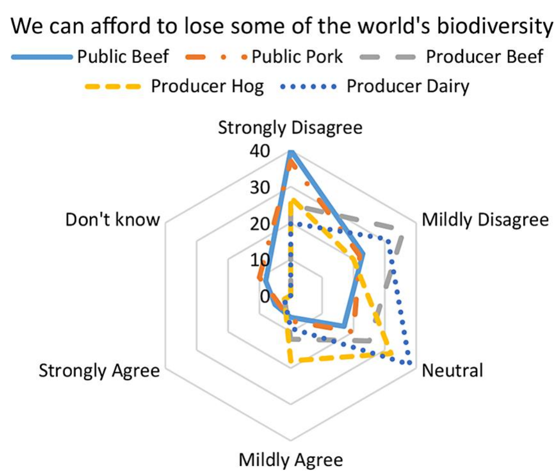

Figure 1. Concerns about the loss of the world's biodiversity by survey.

Table 5. Item loadings on biodiversity attitude factor for the different surveys following principal component factor analysis.

	Public		Farmer		
	Pork	Beef	Beef	Hog	Dairy
Statement	Factor loadings				
I worry about changes to the countryside such as the loss of native plants and animals.	0.62	0.56	0.59	0.66	0.54
There is nothing I can personally do to help stop the losses in the world's biodiversity.	0.66	0.68	0.60	0.87	0.75
We can afford to lose some of the world's biodiversity.	0.79	0.77	0.77	0.90	0.82
Biodiversity losses in animals domesticated for food production are less serious than similar losses in wildlife.	0.74	0.72	0.65	0.39	0.61
Cronbach's alpha	0.66	0.62	0.55	0.65	0.61

Note: The scores for statement 1 were reverse recoded.

mean acceptance scores, and number of clusters derived from the cluster analysis, and the frequency of respondents in each cluster are reported. The hierarchical clustering analysis yielded two clusters in the farmer surveys and three clusters in the public surveys. In the farmer surveys, the average score in the high acceptance cluster was approximately 6, while the average score in the low acceptance cluster was 4. The higher proportion of respondents in the beef survey was in the low acceptance category. The opposite was the case in the hog survey. The distribution of respondents was more even in the dairy survey. The distribution of the public scores showed a higher variance. This is not surprising given that the number of clusters in the public survey was higher. The average score in the high acceptance cluster of approximately five in the public surveys is marginally lower than that of farmers. The lower acceptance cluster had a mean score of about 2. Most of the respondents in both pork and beef public surveys were in the intermediate acceptance category. The mean score in this category was approximately 3.7 (Table 6).

Table 7 shows the results of the logit regression analysis. From the results, older and more educated dairy and beef cattle farmers are more likely to be accepting of the use of genomics in livestock breeding. Female hog farmers are less accepting of genomics in selective breeding. Familiarity with genomics among farmers positively influenced acceptance. This is evident from the dairy and beef farmer results. A similar effect is observed for farmers who are more favorably disposed toward biotechnology. In general, environmental considerations such as knowledge about environmental problems and biodiversity-related variables play a limited role in farmer acceptance of genomics.

In contrast to farmers, these environmentally related variables have a stronger role in public decision-making. Knowledge about biodiversity has a positive effect on the

Table 6. Mean cluster scores and distribution by survey.

	Mean score	Percent	Mean score	Percent	Mean score	Percent
			Farmer survey			
	Beef		Dairy		Hogs	
Low	4.32	70.39 (164)	4	52.60 (91)	4.10	22.50 (39)
High	6.22	29.61 (69)	6	47.40 (82)	6.03	77.50 (9)
			Public survey			
	Beef				Pork	
Low	1.77	15.91 (287)			1.92	36.84 (666)
Intermediate	3.74	59.23 (1068)			3.65	46.02 (832)
High	5.78	24.85 (448)			5.23	17.14 (310)

Note: Sample size in parenthesis.

Table 7. Logit model estimates with acceptance of genomics as the dependent variable.

	Independent variable	Dependent variable (1 = high cluster, 0 = low cluster)			Dependent variable (4 = high cluster, 0 = low cluster)	
		Farmer			Public	
	Context	Beef	Dairy	Hog	Beef	Pork
Sociodemographic variables	Age	0.02 (0.02)	0.03* (0.01)	0.04 (0.06)	0.00 (0.00)	0.00 (0.00)
	Female	−0.36 (0.54)	−0.45 (0.59)	−3.93** (1.86)	0.49*** (0.12)	0.39*** (0.13)
	Education	0.17** (0.09)	0.07* (0.04)	0.27 (0.29)	0.07** (0.03)	0.03 (0.03)
	Income	−0.07 (0.07)	−0.02 (0.01)	0.01 (0.02)	0.01* (0.02)	0.04** (0.02)
	Household size				−0.02 (0.12)	−0.09 (0.06)
	Rural				0.10 (0.14)	0.17 (0.17)
	French				−0.26* (0.14)	−0.19 (0.15)
Experience variable	Familiarity with genomics	0.71*** (0.22)	0.50** (0.25)	0.18 (0.99)	0.98*** (0.09)	0.92*** (0.09)
Knowledge variables	Biodiversity knowledge	0.01 (0.01)		−0.20 (0.28)	0.03* (0.02)	0.04*** (0.01)
	Knowledge of environmental problems				0.12*** (0.03)	0.09*** (0.03)
Other individual specific variables	Biodiversity attitude	−0.46 (0.18)	−0.24 (0.17)	−1.36* (0.75)	−0.11* (0.06)	−0.28*** (0.06)
	Biotechnology support	1.18*** (0.30)		2.17** (1.09)	0.19** (0.10)	0.32*** (0.10)
	Views about science and technology				0.19*** (0.03)	0.11*** (0.03)
	Government trust				0.09 (0.06)	0.11 (0.07)
	Generalized trust				0.07 (0.12)	−0.04 (0.13)
	Fair				0.16 (0.14)	−0.20 (0.15)
	Helpful				−0.22* (0.13)	0.28** (0.13)
Constant		−9.51 (2.00)	−1.95 (1.35)	−9.61 (6.90)	−2.26 (0.63)	−2.08 (0.64)
Log likelihood		−113.35	−105.38	−13.42	−1124.52	−1098.68
Pseudo R^2		0.18	0.09	0.36	0.17	0.15

***, **, * Significance at 1, 5, and 10%, respectively.

acceptance of genomics in the pork and beef analysis while attitudes toward biodiversity have the opposite effect in both instances. Like the farmer analysis, the link between support for biotechnology in general and familiarity with genomics and acceptance of genomic selection is positive. Respondents with positive views about science and technology tended to be more accepting of genomics used in selective livestock breeding. While aspects of trust such as generalized trust and trust in government play a limited role, other dimensions of trust such as the degree to which a respondent thinks others are helpful play an important role. With respect to the effects of socioeconomic factors, female and more highly educated respondents are more accepting of genomics used in selective breeding. The latter effect is only observed in the beef survey. The link between income and acceptance is also positive for higher income households in the two public surveys. French respondents in the beef survey tended to be less accepting of genomics.

Discussion

This article examines the effect of biodiversity attitudes and knowledge on farmer and public acceptance of genomic selection. With respect to our first research objective, knowledge about biodiversity is relatively lower among the public as compared to producers. In contrast, concerns about the losses of biodiversity are much higher in the public. These concerns tend to be higher for native species as compared to domesticated animals. The low levels of familiarity with biodiversity and seeming higher concern for biodiversity losses in native species as compared with farmed animals are consistent with previous studies (Spash and Hanley 1994; Hunter and Brehm 2003; Hunter and Rinner 2004; Christie et al. 2006; Buijs et al. 2008). Further, farmers and the public do not seem to assume individual responsibility for losses in biodiversity. This gap in engagement with biodiversity may be a corollary of the limited concern for biodiversity losses in farm animals and lack of familiarity with the concept of biodiversity. Our results also show that acceptance of genomic selection by the public is slightly lower than that of farmers. One would have expected the difference in acceptance to be much wider considering that the technology is production based. However, given that genomics has applications in other contexts such as health, for example, part of the public acceptance may be explained by familiarity with these other applications of genomics, considered to be nonthreatening.

With respect to the second research question, our results show evidence of context specificity in the effect of key predictors of acceptance of genomics selection. While the biodiversity-related variables seem to play a limited role among farmers in general, attitude toward biodiversity negatively impacted the acceptance of genomics among hog farmers. We find a more robust role for factors such as experience with technology, attitudes toward biotechnology, and sociodemographic characteristics such as education among farmers. This study is by no means a validation of the TAM framework. However, it seems that a number of the constructs outlined in the extended TAM model are reasonably robust (Venkatesh and Davis 2000; Venkatesh, Morris, and Davis 2003). In contrast to farmers, knowledge about biodiversity and biodiversity attitude play a significant but opposing role in public decision-making. What this result suggests is that while concerns about biodiversity reduces acceptance, increased knowledge about biodiversity can dampen the effect of higher concerns on acceptance. The size of the effect of biodiversity attitude on acceptance is higher in the beef and pork public survey analysis as compared to biodiversity knowledge. The estimated marginal effects are −0.028 (attitude) versus 0.007 (knowledge) in beef and −0.036 (attitude) versus 0.006 (knowledge) in pork.

Conclusion and Implications

Overall, the key implication of the results of this article is that the link between biodiversity knowledge and attitudes, on the one hand, and the acceptance of breeding technologies that can impact genetic diversity in farm animals, on the other hand, is not straightforward. We find evidence of convergence in the role of higher concerns about biodiversity losses on acceptance between the public and farmers when these concerns are relevant. At the production end, this result has significant implications for livestock production systems. This is because unlike crop production where breeding is often managed by plant breeders, livestock breeding is managed by a large number of individual producers and the link between concerns about biodiversity and breeding decision-making might reduce the potential risk to genetic diversity from over-selection for certain traits in domesticated species. The context specificity of this outcome among farmers suggests that they may be more tolerant toward potential loss of genetic diversity as it relates to, for example, feed efficiency as against disease resistance. This is because the linkage between disease resilience and biodiversity losses may be more clearly identified by farmers dealing with breeding animals regularly. At the consumer end, the effect of biodiversity concerns is mitigated by increased knowledge. At the very least, this suggests that the potential demand side effects that stem out of concerns about biodiversity may dampened by greater awareness about biodiversity. Increasing public awareness about biodiversity is therefore mutually beneficially to both farmers and consumers. To an extent, this conclusion supports a key strategy of the International Strategic Plan for Biodiversity 2011–2020 which in part requires that (Agard et al. 2005, p.136):

> “Knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.”

Our results must however be interpreted within the context of the fact that in general, both farmers and public seem to care more about the loss of biodiversity in native species as compared to domesticated species. Whether or not concerns about genetic diversity losses in domestic animals are sufficiently high enough to instigate action remains an open empirical question. Our analysis also only focused on acceptance or perceived usefulness and not on actual behavior. This notwithstanding, the results of this study indicate that there are enormous opportunities for the science community to engage the public and farmers about natural processes and the potential impact of biotechnology-based production methods on these processes. For the livestock sector, this is critical as pressures to increase meat production through breeding innovations continue to increase.

A unique feature of our study is the incorporation of data of different sample sizes from multiple farmer and public surveys to examine an issue of relevance to these two key stakeholders. This notwithstanding, the problems associated with low response rates such as nonresponse bias and representativeness of the data (Campbell and Waters 1990; Clendenning, Field, and Jensen 2004) may be present in the smaller samples, i.e., dairy and hog data. These results should therefore be treated with these caveats in mind. Our goal in this article was exploratory and a more rigorous analysis is required to identify the exact pathways of the knowledge and attitude effects identified. There are three facets of biodiversity (i.e., species, ecosystem, and genetic) and it is plausible that attitudes toward each of these facets may not necessarily be identical. Also, a narrower focus on genetic diversity as opposed to biodiversity would have been more consistent with the decision-making context faced by farmers. Future studies can also consider using an identical set of covariates to enhance comparability. These represent fruitful areas of future research and useful extensions to the present work.

Notes

1. The public survey included a 6th option coded "I don't know".
2. "Don't knows" are coded as zeros.

Acknowledgments

We thank Livestock Gentec for their technical support and two anonymous reviewers for their helpful comments.

Funding

This work was supported by the Genome Canada [Grant Number RES0011900], and Genome Alberta [Grant Number RES0013126].

ORCID

Albert Boaitey http://orcid.org/0000-0002-2054-609X
Ellen Goddard http://orcid.org/0000-0002-5638-0562
Getu Hailu http://orcid.org/0000-0003-1257-5939

References

Agard, J., S.H.M. Butchart, J. Carino, W.W.L. Cheung, B. Collen, L. G. Firbank, S. Hales, M. Hockings, R. Hoft, J. Kitzes, M. A. McGeoch, C. Prip, T. E.E. Oldfield, K. H. Redford and H. Toivonen. 2005. Biodiversity. *In Global environmental outlook*, ed. A. M. Rosser and M. J. Walpole, 133–166. Nariobi: United Nations Environment Program.

Ares, G., M. Besio, A. Giménez, and R. Deliza. 2010. Relationship between involvement and functional milk desserts intention to purchase. Influence on attitude towards packaging characteristics. *Appetite* 55:298–304. doi:10.1016/j.appet.2010.06.016.

Boaitey, A. 2016. Biodiversity and livestock producer acceptance of genomics: Evidence from three producer surveys in Canada. Paper presented at the University of Cambridge, Cambridge, UK, 30 June.

Boaitey, A. 2017. *Three essays in beef genomics: Economic and environmental impacts*. PhD diss., University of Alberta.

Brotherstone, S., and M. Goddard. 2005. Artificial selection and maintenance of genetic variance in the global dairy cow population. *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 360:1479–88. doi:10.1098/rstb.2005.1668.

Buijs, A. E., A. Fischer, D. Rink, and J. C. Young. 2008. Looking beyond superficial knowledge gaps: Understanding public representations of biodiversity. *The International Journal of Biodiversity Science and Management* 4:65–80. doi:10.3843/Biodiv.4.2:1.

Campbell, M. J., and W. E. Waters. 1990. Does anonymity increase response rate in postal questionnaire surveys about sensitive subjects? A randomised trial. *Journal of Epidemiology and Community Health* 44:75–76. doi:10.1136/jech.44.1.75.

Christie, M., N. Hanley, J. Warren, and T. Hyde. 2006. Valuing the diversity of biodiversity. *Ecological Economics* 58:304–17. doi:10.1016/j.ecolecon.2005.07.034.

Clendenning, G., D. R. Field, and D. Jensen. 2004. A survey of seasonal and permanent landowners in Wisconsin's northwoods: Following Dillman and then some. *Society and Natural Resources* 17:431–42. doi:10.1080/08941920490430223.

Cronbach, L. J. 1960. *Essentials of psychological testing*. New York: Harper and Row.

Davis, F. D. 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly* 13:319–40. doi:10.2307/249008.

Department for Environment, Food and Rural Affairs. 2011. *Attitudes and knowledge relating to biodiversity and the natural environment, 2007–2011*. London: Department for Environment, Food and Rural Affairs.

Dillman, D. 2007. *Mail and internet surveys: The tailored design method*. 2nd ed. Hoboken, NJ: John Wiley and Sons.

Farmer-Bowers, Q., and R. Lane. 2009. Understanding farmers' strategic decision-making processes and the implications for biodiversity conservation policy. *Journal of Environmental Management* 90:1135–44. doi:10.1016/j.jenvman.2008.05.002.

Flett, R., F. Alpass, S. Humphries, C. Massey, S. Morris, and N. Long. 2004. The technology acceptance model and use of technology in New Zealand dairy farming. *Agricultural Systems* 80:199–211. doi:10.1016/j.agsy.2003.08.002.

Foley, J. A., N. Ramankutty, K. A. Brauman, E. S. Cassidy, J. S. Gerber, M. Johnston, and C. Balzer. 2011. Solutions for a cultivated planet. *Nature* 478:337–42. doi:10.1038/nature10452.

Food and Agriculture Organization. 1999. The global strategy for the management of farm animal genetic resources: Executive brief. Accessed May 5, 2016. http://www.skogoglandskap.no/filearchive/global_strategy_for_the_management_of_fangr_pd.pdf

Food and Agriculture Organization. 2015. The second report on the state of the world's animal genetic resources for the food and agriculture. Accessed May 6, 2016. http://www.fao.org/3/a-i4787e.pdf

Goddard, M. E., and B. J. Hayes. 2007. Genomic selection. *Journal of Animal breeding and Genetics* 124:323–30. doi:10.1111/j.1439-0388.2007.00702.x.

Hailu, G., Y. Cao, and X. Yu. 2017. Risk attitudes, social interactions, and the willingness to pay for genotyping in dairy production. *Canadian Journal of Agricultural Economics* 65:317–41. doi:10.1111/cjag.12123.

Haile-Mariam, M., P. J. Bowman, and M. E. Goddard. 2004. Genetic parameters of fertility traits and their correlation with production, type, workability, liveweight, survival index, and cell count. *Crop and Pasture Science* 55:77–87. doi:10.1071/AR03059.

Hays, R. D., H. Liu, and A. Kapteyn. 2015. Use of internet panels to conduct surveys. *Behavior Research Methods* 47:685–90. doi:10.3758/s13428-015-0617-9.

Heikkilä, A. M., J. I. Nousiainen, and S. Pyörälä. 2012. Costs of clinical mastitis with special reference to premature culling. *Journal of Dairy Science* 95:139–50. doi:10.3168/jds.2011-4321.

Hsiao, C. H., and K. Y. Tang. 2015. Investigating factors affecting the acceptance of self-service technology in libraries: The moderating effect of gender. *Library Hi Tech* 33:114–33. doi:10.1108/LHT-09-2014-0087.

Hunter, L. M., and J. Brehm. 2003. Brief comment: Qualitative insight into public knowledge of, and concern with, biodiversity. *Human Ecology* 31:309–20.

Hunter, L. M., and L. Rinner. 2004. The association between environmental perspective and knowledge and concern with species diversity. *Society and Natural Resources* 17:517–32. doi:10.1080/08941920490452454.

IBM. 2016. *SPSS statistics for windows (version 24.0)*. Armonk, NY: IBM.

Ishiyama, I., T. Tanzawa, M. Watanabe, T. Maeda, K. Muto, A. Tamakoshi, and Z. Yamagata. 2012. Public attitudes to the promotion of genomic crop studies in Japan: Correlations between genomic literacy, trust, and favourable attitude. *Public Understanding of Science* 21:495–512. doi:10.1177/0963662511420909.

Matin, A. H., E. Goddard, F. Vandermoere, S. Blanchemanche, A. Bieberstein, S. Marette, and Roosen, J. 2012. Do environmental attitudes and food technology neophobia affect perceptions of the benefits of nanotechnology? *International Journal of Consumer Studies* 36:149–57. doi:10.1111/j.1470-6431.2011.01090.x.

McCrae, R. R., J. E. Kurtz, S. Yamagata, and A. Terracciano. 2011. Internal consistency, retest reliability, and their implications for personality scale validity. *Personality and Social Psychology Review* XX:1–23. doi:10.1177/1088868310366253.

Paudel, K. P., W. M. Gauthier, J. V. Westra, and L. M. Hall. 2008. Factors influencing and steps leading to the adoption of best management practices by Louisiana dairy farmers. *Journal of Agricultural and Applied Economics* 40:203–22. doi:10.1017/s1074070800028066.

Pew Research Center. 2015. From telephone to the web: The challenge of mode of interview effects in public opinion polls. Accessed February 2, 2018. http://www.pewresearch.org/2015/05/13/from-telephone-to-the-web-the-challenge-of-mode-of-interview-effects-in-public-opinion-polls/

Skarstad, G. Å., L. Terragni, and H. Torjusen. 2007. Animal welfare according to Norwegian consumers and producers: Definitions and implications. *International Journal of Sociology of Food and Agriculture* 15:74–90.

Spash, C. L., and N. Hanley. 1994. Preferences, information and biodiversity preservation. MPRA Paper No. 38351,Economics Department, University of Stirling, Stirling.

StataCorp. 2013. *Stata* (Release 13). College Station, TX: StataCorp LP.

Statistics Canada. 2007a. 2006 Census. Catalogue Number 97–551-XCB2006010. Accessed May 6, 2016. http://www12.statcan.gc.ca/census-recensement/2006/dp-pd/tbt/Rp-eng.cfm?LANG=E&APATH=3&DETAIL=0&DIM=0&FL=A&FREE=0&GC=0&GID=0&GK=0&GRP=1πD=88988&PRID=0&PTYPE=88971,97154&S=0&SHOWALL=0&SUB=0&Temporal=2006&THEME=66&VID=0&VNAMEE=&VNAMEF=.

Statistics Canada. 2007b. Population and dwelling counts, for Canada, provinces and territories, 2006 and 2001 censuses population and dwelling count highlight tables. 2006 census. Statistics Canada Catalogue no. 97–550-XWE2006002. Ottawa.

Statistics Canada. 2012a. Distribution of farms by age of the oldest operator and farm type, Canada 2011. Accessed May 6, 2016. http://www.statcan.gc.ca/pub/96–325-x/2014001/article/11905/c-g/desc/desc04-eng.htm.

Statistics Canada. 2012b. Socioeconomic overview of the farm population, 2011. Accessed May 6, 2016. http://www.statcan.gc.ca/daily-quotidien/131127/dq131127b-eng.htm.

Steinfeld, H., P. Gerber, T. Wassenaar, V. Castel, M. Rosales, and C. de Haan. 2006. *Livestock's long shadow: Environmental issues and options*, Chapter 5. Rome: Food and Agricultural Organization.

Sun, H., and P. Zhang. 2006. The role of moderating factors in user technology acceptance. *International Journal of Human-Computer Studies* 64(2):53–78. doi:10.1016/j.ijhcs.2005.04.013.

Szolnoki, G., and D. Hoffmann. 2013. Online, face-to-face and telephone surveys-Comparing different sampling methods in wine consumer research. *Wine Economics and Policy* 2:57–66. doi:10.1016/j.wep.2013.10.001.

Taylor, S., and P. A. Todd. 1995. Understanding information technology usage: A test of competing models. Information systems research 6(2):144–176.

Tittensor, D. P., M. Walpole, S. L. Hill, D. G. Boyce, G. L. Britten, N. D. Burgess, S. H. M. Butchart, P. W. Leadley, E. C. Regan, R. Alkemade, et al. 2014. A mid-term analysis of progress toward international biodiversity targets. *Science* 346:241–44. doi:10.1126/science.1257484.

Vassalos, M., and K. O. Lim. 2016. Farmers' willingness to pay for various features of electronic food marketing platforms. *International Food and Agribusiness Management Review* 19:131–49.

Venkatesh, V., and F. D. Davis. 2000. A theoretical extension of the technology acceptance model: Four longitudinal field studies. Reviewed work. *Management Science* 46:186–204. doi:10.1287/mnsc.46.2.186.11926.

Venkatesh, V., M. G. Morris, and F. D. Davis. 2003. User acceptance of information technology: Toward a unified view. *MIS Quarterly* 27:425–78. doi:10.2307/30036540.

Zaichkowsky, J. L. 1994. The Personal Involvement Inventory: Reduction, revision, and application to advertising. *Journal of Advertising* 23:59–70. doi:10.1080/00913367.1943.10673459.