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ORIGINAL ARTICLE

From the ground up: holistic management and grassroots rural adaptation to bovine spongiform encephalopathy across western Canada

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Abstract Bovine spongiform encephalopathy (BSE) has been documented in 28 countries and adversely affected farmers and rural communities around the world. Our study examines the impacts of and adaptive responses of producers to BSE in western Canada. Moreover, it explores the role that holistic management (HM), and its combined focus on environmental, social, and economic sustainability, might play in mitigating the effects of BSE. One survey was sent to 835 HM producers and another to 9,740 producers across Manitoba, Saskatchewan, and Alberta. The disease, and concomitant climate change and low commodity prices, had devastating impacts on both groups. Yet, HM producers were much more optimistic about their ability to adapt to BSE and the future of agriculture than their non-HM counterparts. Social networks, namely HM clubs and the larger HM community, enabled these producers to mitigate the impacts of BSE. Agronomic responses, especially those associated with rotational grazing and increases in on-farm biodiversity were also important. That HM has been such an effective adaptive response to BSE indicates the importance of this and other grassroots responses to rural crises, whether they be associated with zoonotic diseases or indeed environmental change as a whole.

Keywords Adaptation · BSE · Global livestock industry · Grassroots · Mad cow disease · Rural decline · Social networks · Sustainability · Vulnerability

1 Introduction

1.1 Background

In May, 2003, the first indigenous case of BSE (bovine spongiform encephalopathy or mad cow disease) was documented in Canada. Over 40 countries immediately imposed import restrictions, which had severe and unanticipated consequences for its livestock industry

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(Leiss and Nicol 2006). The most significant of these was the 18-month closure of the US border to movement of beef products and live cattle from Canada, which then represented the market for 75% of its beef (Rude et al. 2007).

Bovine spongiform encephalopathy put the livestock industry and indeed rural Canada into turmoil. There was an immediate 33% drop in farm cash receipts for cattle and calves (Mitura and Di Piétro 2004), which by 2005 had resulted in costs to the economy that surpassed $7 billion CAD (Leiss and Nicol 2006). The impacts were especially evident in western Canada, as the prairie provinces comprise two-thirds of Canada's beef cattle farms (MacLachlan 2004). To help producers through the resulting crisis, the federal government created the BSE Recovery Program, whereby targeted larger operations, including meat packers, benefited most from the program (LeRoy and Klein 2005), leaving small and mid-size ones more vulnerable (Alam and McLachlan 2007).

1.2 BSE: a global context

Bovine spongiform encephalopathy has had devastating economic impacts around the world, and, in many European countries, has had severe impacts on human health. The global spread of BSE represents one of the most alarming economic and social crises in modern times (Charlebois and Labrecque 2007) and has emerged as one of the highest profile issues in animal health and food safety (Leiss and Nicol 2006). First discovered in 1986 in England, BSE resulted in the eventual infection of more than 185,000 cattle, the slaughter of 18 million cattle, the infection 135 people with its human variant Creutzfeldt-Jacob disease (vCJD), and devastating impacts on the agricultural sector (Hill et al. 1997). The initial denial and subsequent mismanagement of the disease by British authorities enabled the continued transport of contaminated feed and diseased animals throughout Europe, Asia, and the Americas (Gerodimos 2004) and infected cattle have now been documented in 28 countries.

Farm-level impacts on and responses of farmers and rural residents to BSE have yet to be systematically examined in Canada or, for that matter, anywhere in the world. To date, published social research on BSE has been urban-centered and focused on risk perception of consumers (e.g. Weitkunat et al. 2003; Setbon et al. 2005), consumer behavior (e.g. Berg 2004; Sinaceur et al. 2005), and the roles of urban media in risk communication (e.g. Kitzinger and Reilly 1997; Richmond 1997). These studies reflect the heightened concerns regarding human health and consumer reactions as first shaped by the BSE crisis in the UK. In Canada, by contrast, the BSE crisis has primarily been driven by economic concerns rather than those surrounding human health. Recent studies on the Canadian BSE experience have thus focused on risk communication and management (Leiss and Nicol 2006), crisis management and food safety (Charlebois and Labrecque 2007); US/Canada trade relations (O'Neill 2005); post BSE marketing (Rude et al. 2007); and public policy (LeRoy and Klein 2005).

It is important to note that the BSE crisis in Canada has occurred within a larger context of rural decline. Between 1999 and 2001, the number of fulltime farmers in the prairies decreased by 26%, the largest decrease in 35 years (Senate 2002). Decreases in agricultural subsidies and increases in input costs result in increasingly slim profit margins for farms in the prairies, resulting in farm foreclosures and bankruptcies that are accompanied by the elimination of services including schools and banks as well as infrastructure including railways and grain elevators (NFU 2005). And of all of this preceded BSE, which has further exacerbated the challenges facing Canadian farmers and helped create "the worst farm crisis since the 1930s" (Qualman and Wiebe 2002).

1.3 Vulnerability, adaptation, and BSE

Defined as the degree to which environmental change can harm an ecosystem or community, vulnerability consists of the exposure and baseline sensitivity of any system to hazardous conditions and its ability to cope, adapt or recover from those conditions (IPCC 2001). The more exposed or sensitive a system is to a given stimulus, the greater the system vulnerability and, conversely the greater the adaptive response, the lower its vulnerability (Smit and Pilifosova 2003). These adaptive responses occur at all stages of exposure (Reid et al. 2007) and generally operate in a larger social, political, economic and cultural context (Mcleman and Smit 2006).

Much interest has been placed on facilitating appropriate adaptive responses, in part by increasing adaptive capacity that anticipates, plans, or addresses events associated with exposure (Smit and Pilofosova 2003) or by implementing decisions that facilitate further adaptation (Adger et al. 2005). Individuals, social groups, and institutions all play important roles in responding to external stressors that affect livelihoods and well-being, and processes underlying adaptation thus operate at multiple scales of organization (Kelly and Adger 2000). As conventionally defined, rural adaptive potential is largely technical in nature and dependent upon strengths that include access to resources, technology, education, information and skills, and infrastructure (Smit and Skinner 2002).

Agricultural producers operate within a multi-stressor environment and the cumulative effect of these diverse stressors can contribute to vulnerability (Belliveau et al. 2006). Regions vulnerable to climate change are often "double exposed" to other global stressors particularly those subject to poverty and marginalization (O'Brien et al. 2004). Although adaptation, like the stressors themselves, can be multi-fold in nature and operate at many scales of organization, empirical studies often use relatively sensitive 'bottom up' approaches to explore the circumstances that affect the producers and their associated adaptive responses (Smit and Wandel 2006).

Typologies that focus on rural adaptation in North America generally emphasize the importance of individual farms in short-term coping responses and the role of agri-business and governments in fostering and supporting longer-term strategic adaptation (e.g. Smit and Skinner 2002; Kurukulasuriya and Rosenthal 2003; Wall and Smit 2005). With respect to the latter, crisis-specific compensation programs tend to be reactive and relatively short-term in nature whereas longer-term governmental responses are more proactive in approach and include the development of income stabilization programs, implementation of land and water use regulations, and promotion of best management practices (Smit and Skinner 2002).

Although often substantial in size and far-reaching in scope, governmental responses in agriculture can also have unintended outcomes. Governmental subsidization of flood and crop insurance can thus increase susceptibility of people and property to these risks (Mcleman and Smit 2006). Conversely, there is often much dissatisfaction on the part of communities regarding governmental responses to crises such as those associated with hurricane Katrina (Kates et al. 2006), the collapse of the Atlantic fishery (Budreau and McBean 2007) and, indeed, compensation programmes to farmers surrounding BSE (Stozek 2008). Some thus argue that adaptive capacity would more strongly translate into effective responses if they were better informed by inclusive and community-centered processes that focused on those components that were most vulnerable (Budreau and McBean 2007).

Although receiving remarkably little attention in the rural adaptation literature, these community and social groups also play an important role in fostering adaptive responses

(Adger 2003), acting independently or as members of a larger network of actors that can include institutions, government agencies, and industry (Moser et al. 2007). Such initiatives have a long history in western provinces, arguably the part of Canada that has the longest and most deeply established traditions of cooperative social movements that bridge business, community, and political concerns (Rice and Lavoie 2005). Thus, grain co-ops were established in the 1920s to resist the ever concentrated power of railroads, bankers, and grain merchants (MacPherson 1979) whereas cooperative pastures emerged in the 1930s to manage land damaged by drought and ineffective farming practices (Gertler 2001). Holistic management (HM) represents a more recent grassroots adaptive response to environmental and socioeconomic decline in rural landscapes world over, and thus can potentially play an important role in adapting to rural crises including those associated with BSE.

1.4 Holistic management and BSE

Farmers now practice HM on over 30 million acres of agricultural land around the world (HMI 2008). It represents a decision-making framework that emphasizes the interdependence of environmental, economic, and social well being (Savory 1999). A three-part holistic goal is developed with respect to quality of life, forms of production, and the future resource base, this goal thereafter guiding every significant management decision (Savory 1999). An adaptive approach to decision-making is taken whereby outcomes of these decisions are regularly evaluated and modified and a wide diversity of agronomic approaches are used to achieve these ends. In North America, HM is a farmer driven movement and is facilitated by the widespread establishment of management clubs. Substantial economic and environmental benefits such as increases in biodiversity are observed (Stinner et al. 1997; Nerbonne and Lentz 2003) and HM along with organic farming represents a proactive farming practice that provides adequate support for producers (Duram 1997). However, the function of HM as a grassroots adaptive response to rural crises, much less zoonotic diseases, has yet to be explored.

Our goal in this study is to examine the exposure and adaptive responses of western Canadian producers to BSE. Moreover, we will explore the role that HM as a grassroots farmer movement and the role that its combined focus on environmental, social, and economic sustainability might play in mitigating the effects of BSE and future global risks that confront rural communities as a whole.

2 Methods

2.1 Description of study area

Our study area was located in western Canada and included the provinces of Manitoba (MB), Saskatchewan (SK), and Alberta (AB). The sub-humid to semi-arid climate of this region is dominated by cold winters (−9.4°C in Lethbridge, AB and −18.3°C in Winnipeg, MB) and short warm summers (16.1°C in Edmonton, AB and 19.7°C in Winnipeg, MB). Annual precipitation across this region is highly variable, ranging from as low as 250 mm in southeastern Alberta to less than 700 mm in the Lake Manitoba Plains (Environment Canada 2005).

This western region comprises 49.2% of all farms in Canada, and from 2001 to 2006 there was a 10.0% decline in the number of farms across these three provinces (Statistics

Canada 2007). Two-thirds (64.5%) of these farms consist of livestock ranches and mixed farms that produce both livestock and crops. Indeed, this region represents 72.1% of Canada's total number of cattle and calves.

2.2 Data collection techniques and sampling procedure

A mixed methods approach that incorporated both quantitative and qualitative data was used to explore the impacts of and responses to BSE on farmers practicing HM. Individual and group interviews were conducted with HM producers and other stakeholders in the fall of 2005, in part to help better understand HM and to inform the subsequent design of a questionnaire. Themes explored in the questionnaire included the environmental, social and economic implications of practicing HM and the role of HM in adapting to BSE. The survey was pre-tested with eight HM producers in Manitoba and the feedback was used to shorten and to clarify the intent of the final survey instrument. A list of addresses was compiled from mailing lists obtained from all the certified Canadian HM educators. Questionnaires were sent to all farmers who had practiced HM at some point and/or those who had taken an HM course. The study design was approved by the Joint-Faculty Human Research Ethics Board at the University of Manitoba (#J2005:059). On February 13 2006, 792 of the 12-page surveys were sent to HM producers across western Canada followed by follow-up reminder postcards at one and two-week intervals, respectively.

Data from a related 'BSE and Farmers' survey, also conducted through the Environmental Conservation Lab at the University of Manitoba, was used to contrast the concerns of HM and non-HM producers in western Canada. The non-HM survey was designed to assess the socioeconomic and environmental impacts of and adaptive responses to BSE of producers across western Canada. A similar mixed methods approach was used, and individual and group interviews were also conducted with livestock producers, in part to help inform the construction of the survey instrument. A random stratified approach to sampling was taken, these strata being density (i.e. low and high) of cattle production and proximity (i.e. close and far) to the nearest federally inspected slaughterhouse. Low and high cattle production classes were defined as 0–21 cattle km^{-2} and 22–65 cattle km^{-2}, respectively whereas close and far distance classes were defined as <150 km and > 150 km to the slaughterhouses, respectively. All census districts (CDs) from Alberta, Saskatchewan and Manitoba in which at least 30% of the landbase was used for agricultural production were assigned to one of these four strata. Two CDs were randomly selected from each of the four strata in each of the three provinces (n=24). Non-addressed admail service at Canada Post had to be used to access farm households because no rural mailing lists were available for either Manitoba or Saskatchewan. Using Canada Post databases, rural post offices were randomly selected throughout each test CD such that no one post office exceeded 80 farms and that each CD comprised 400–410 test farms (n=9,713). On February 21 2006, 10-page surveys were mailed to all the test farms. At 10-day intervals, a reminder postcard and then a four-page reminder survey consisting of a subset of the questions selected from the larger questionnaire were sent again to all the test farms. One focus group was also conducted in each of the 12 strata, these identified by follow-up phone calls with those that had responded to the survey.

Both HM and non-HM questionnaires were designed using Likert-scaled and open ended questions. The same subset of questions that assessed the impacts of BSE was included in both surveys, allowing us directly compare responses from the two groups of producers. Both surveys took approximately 30–60 min to complete.

2.3 Questionnaire response

In total, 315 completed HM surveys were sent back, representing an absolute response rate of 45.3% and, once undeliverable surveys were accounted for, an overall adjusted response rate of 50.7% was calculated. With respect to the larger non-HM survey 1,470 surveys were returned, resulting in an absolute response rate of 15.3%. Residents in the regions that had been sampled were telephoned, allowing us to assess how many of the questionnaires had actually been received. The resulting adjusted survey response rate was estimated as 33.3%. Although somewhat low, these response rates are typical of large-scale mail surveys conducted in rural areas and reflect a trend of declining mail survey response rates in natural resource-based sectors (Connelly et al. 2003), and the unavoidable use of non-addressed admail in this study. Using 12 questions selected from the original questionnaires that identified potential positive and negative impacts of BSE, a telephone survey was conducted with 20 randomly selected responders and 20 randomly selected non-responders regarding the HM questionnaire (n=40). With respect to the non-HM survey, five responders and five non-responders were contacted in each of the four sample strata in all provinces (n=120). Those that had not responded were also asked to indicate reasons for their refusal. There were no significant differences in response between responders and non-responders for the HM survey (p=0.3946) and the non-HM survey (p=0.5612). In both surveys, lack of time and cynicism about research were cited as the most important reasons for not participating.

2.4 Data analysis

2.4.1 Comparison between HM and non-HM survey respondents

Socio-demographic variables from the HM survey and non-HM survey were summarized and assessed for homogeneity of variance using Levene's test for equality of variance (SAS 2007). Variables included province, farm size, herd size, age, work situation, level of education, and the economic standing of respondents (Table 1). The HM survey approached gender in a unique manner that recognized the whole-family planning philosophy emphasized in holistic management, prohibiting a direct comparison of gender response between the two surveys. If two respondents had completed the survey together, they were each given the opportunity to independently answer the demographic questions and asked to indicate what percentage of the survey each respondent had completed. Any two people completing 30 to 70% of the survey as a team were classified in an intermediate gender category-'both'. The 'both' category included female/male, male/male, and female/female combinations, although 98% of the respondents comprised female/male pairs. For the variables of age, work situation, and level of education, values were calculated by taking the proportion of survey completed by each individual multiplied by the corresponding variable and then adding these values. Means and standard error were calculated for all these variables and compared using t-tests.

The demographics of respondents to the HM and non-HM surveys was contrasted (Table 1). Although HM respondents were comparable in age to non-HM respondents (50.3 vs. 52.9 years), they were more financially stable and had higher levels of formal education. Interestingly, HM producers were also more likely to work off-farm, perhaps reflecting the much higher percentage of female respondents in the HM survey (17.8% vs. 9.1% for the non-HM survey). In contrast, no significant differences were found in geographical location, land base, or number of livestock between HM and non-HM respondents.

Table 1 Comparison of socio-demographic characteristics for Holistic Management (HM) and non-HM surveys

	Mean (standard error)		Significance[a]
	HM survey	BSE survey	
Province	1.70 (0.05)	1.88 (0.02)	<0.0001
Land (ha)	2104.94 (187.26)	2081.06 (113.45)	0.9253
Livestock (head)	359.58 (50.37)	186.32 (9.60)	<0.0001
Age (years)	50.34 (0.65)	52.9 (0.25)	<0.0001
Gender[b]	2.11 (0.04)	1.09 (0.01)	n/a
Work[c]	2.45 (0.10)	1.95 (0.04)	<0.0001
Economic[d]	3.16 (0.07)	2.21 (0.03)	<0.0001
Education[e]	2.92 (0.06)	2.19 (0.03)	<0.0001

[a] Significance for Levene's Test for equal variances ($p<0.001$)

[b] Variable n/a for comparison due to different categorical options for each survey

[c] Scale ranged from "full time farmer/rancher" (0) to "all non-farm/ranch work" (5)

[d] Scale ranged from "family's financial resources are not enough to get by on" (1) to "we have enough money that it is not an issue for our family" (5)

[e] Scale ranges from "less than high school" (1) to "post-graduate" (5)

Twelve socio-demographic, farm, and HM related variables were selected to represent independent variables that could be used for subsequent model building. These included: years since HM course taken, HM management club membership, province, farm size, crop diversity, number of livestock, age, work situation, gender, level of formal education, economic standing, and community mindedness. To determine respondent's level of community mindedness, participants were asked to rank the importance of various character attributes when adapting to BSE, one of which was community support. If respondents ranked community support in their top third of these characteristics, they were identified as community minded and if community support was ranked in the bottom third, they were labeled as individual minded. A Spearman rank correlation matrix was used to assess multicollinearity among these independent variables; as no two variables had r > 0.7, all were retained for analysis.

2.4.2 Factors underlying HM producers concerns toward BSE related issues

Factor analysis (varimax rotation) was used to identify the impacts and responses of HM farmers and rural residents to the BSE crisis (SAS 2007). Any loading on a factor that was at least 0.400 was assigned to a factor. The alpha coefficient was calculated to test the reliability of the Likert scale (Cronbach 1951), any alpha values >0.60 considered satisfactory for internal consistency of a scale and appropriate for variable reduction (SAS 2007). Results of the factor analysis indicated that three factors could be extracted from 17 BSE-related questions, these being Community (factor one), Impacts (factor two), and Farm Management (factor three). Cronbach alpha values for factors one, two, and three were 0.83, 0.70, and 0.65, respectively; the corresponding eigenvalues were 3.06, 1.91, and 1.16, respectively, and accounted for 99.8% of the variance in the data (Tables 2 and 3).

HM surveys with no missing responses ($n=258$) were sorted into low, medium, and high categories using the scores from each factor. A binary response was created by eliminating the middle 33rd percentile for subsequent logistic regression analysis using Akaike's

Table 2 Comparison of mean responses and associated standard error (SE) to BSE related impact questions for HM and BSE survey

Question	HM survey		BSE survey		
	Mean[a]	SE	Mean	SE	p-value
BSE poses extremely low public health risks	6.11	0.08	6.17	0.04	0.5582
Stress and worry increased within my community as a result of BSE	5.65	0.07	6.33	0.03	<0.0001
I have confidence in the future of the Canadian livestock industry	5.51	0.09	5.06	0.05	<0.0001
The effects of BSE will continue to affect rural communities in the future	5.40	0.07	5.68	0.04	<0.0001
BSE had negative impact on our community	5.26	0.08	6.29	0.04	<0.0001
BSE placed my livelihood at risk	4.65	0.11	5.89	0.05	<0.0001
People became more willing to share with others as a result of BSE	4.50	0.08	4.15	0.05	<0.0001
BSE created the worst crisis since the "dirty thirties"	4.36	0.11	5.16	0.05	<0.0001
People relied more on others in the community	4.18	0.08	4.07	0.04	0.2014
Support for local businesses increased because of BSE	4.13	0.09	3.92	0.05	0.0337
In many ways BSE strengthened my community	4.07	0.09	3.56	0.05	<0.0001
Government responses to BSE were adequate	3.32	0.12	2.79	0.05	<0.0001
My family's ability to participate in volunteer activities was reduced as a result of BSE	3.31	0.10	4.38	0.05	<0.0001
BSE is an issue of the past	2.78	0.09	2.49	0.05	0.0040

[a] Scores were derived from a 7-point scale, with 1 indicating 'strongly disagree' and 7 indicating 'strongly agree'

information criterion (AIC). Unlike traditional hypothesis testing involving a null hypothesis, AIC is used to generate and compare multiple working hypotheses (Akaike 1987; Anderson and Burnham 2002). We identified a set of models that consisted of different combinations of independent variables we predicted would affect BSE related challenges that confront producers. These models were generated from *a priori* hypotheses (Burnham and Anderson 2004) garnered from the literature and from our extensive work with rural communities across western Canada.

In order to compare the models, Akaike's information criterion difference with small bias adjustment (ΔAIC) and the Akaike weights (w) were used to evaluate the strength of evidence supporting each model. The ΔAIC is a measure of each model relative to the best model and a substantial level of support for any model occurs when the corresponding $\Delta AIC < 2$ (Burnham and Anderson 2004). We then calculated the cumulative AICc weights for each independent variable thought to influence BSE related risk by summing the AICc model weights of every model containing that variable. Summation of the Akaike weights confirm that variables with the largest AICc weights have the greatest influence on BSE related impacts and responses.

3 Results

3.1 Impacts of BSE

Impacts associated with BSE separated onto factor two. At one extreme, these impacts were associated with stress and worry, were long-standing, and had negative repercussions for the larger community. Indeed, increased stress and worry was ranked highest by HM

Table 3 Variable reduction of HM producers concerns towards BSE related issues using factor analysis

Factor	Variable	Variance[a]	Alpha	Eigenvalues	Factor loadings	Mean scores all producers (SE) (n=258)
Factor 1-Community	People became *more* willing to share with others as a result of BSE	49.83%	0.83	3.06	74	4.50 (0.08)
	People in the community communicated *more* openly with one another				85	4.24 (0.01)
	People relied *more* on others in the community				84	4.18 (0.08)
	Support for local businesses *increased* because of BSE				55	4.13 (0.09)
	In many ways, BSE strengthened my community				46	4.07 (0.09)
Factor 2-Impact	Stress and worry became *much more* prevalent within my community	31.03%	0.70	1.91	45	5.65 (0.07)
	The effects of BSE will continue to affect rural communities in the future				51	5.40 (0.07)
	BSE had a negative impact on our community				48	5.26 (0.08)
	BSE placed my/our livelihood at risk				59	4.65 (0.11)
	BSE created the worst rural crisis since the "dirty thirties"				62	4.36 (0.11)
	My family's ability to participate in volunteer activities was *reduced* due to BSE				44	3.31 (0.10)
Factor 3-Farm Management	I have confidence in the future of the Canadian livestock industry	18.94%	0.65	1.16	47	5.51 (0.09)
	Holistic Management helped reduce the adverse effects of BSE on our farm				72	5.40 (0.10)
	If more people practiced HM, BSE would have much less effect on producers				65	5.00 (0.01)

[a] Variance, alpha values, eigenvalues, factor loadings and mean scores were derived from a 7-point scale, with 1 indicating 'strongly disagree' and 7 indicating 'strongly agree'

producers (Table 2) and many spoke of the financial stress caused by the BSE crisis. One producer from Manitoba indicated 'BSE has had a direct impact on our profit margins and managing post BSE is a daily challenge' (HM, 56) whereas another from Alberta stated "Nothing can prepare you for that (BSE), you just go into survival mode" (HM, 133).

Producers often indicated that these impacts were compounded by coinciding stressors, many of which were associated with changes in climate; one producer from Alberta

indicated 'we were severely hit with drought and grasshoppers before hit with BSE' (HM, 10). The importance of assessing exposure in terms of multiple stressors is increasingly recognized as farmers routinely make decisions amidst various and interacting climatic, environmental, market and economic forces (Reid et al. 2007).

Impacts of BSE were also recognized as long-term in nature, and a majority (83.1%) agreed that its impacts would continue to affect rural communities long into the future. This contrasts strongly with the (urban) media coverage of BSE, which has generally assumed that the crisis ended when the border between the US and Canada reopened in 2005 and indeed for most urban residents (Lemyre et al. 2008). These impacts were severe enough that some respondents were no longer willing to farm. As one producer from Saskatchewan declared: 'Not farming-3 years of drought and especially Mad Cow' (HM, 152) and another from Manitoba indicated: 'When BSE came, we just quit farming completely' (HM, 137). Between 2001 and 2006, the number of beef farms dropped by 10.2%, (Statistics Canada 2007), many declaring bankruptcy or ceasing their operations completely (Charlebois and Lebrecque 2007). On the other hand, impacts of BSE varied widely among respondents, and some actually prospered during the crisis, reflecting the combined roles of circumstance and acumen.

The AIC models that best explained the impacts of BSE included two variables: economic well being and gender, the cumulative AICc value for each variable being 0.99, and 0.57, respectively (Table 4). Respondents that were least economically well off suffered most from BSE, and impacts declined as economic wellbeing increased. With respect to gender, respondents completing surveys together perceived a greater adverse impact than either men or women alone. Little work has been conducted on the role of gender in rural adaptation, much less BSE (Thurston and Amaratunga 2007). Follow-up interviews

Table 4 Rank/cumulative AICc weights (w) for all twelve independent variables hypothesized to influence respondent concern toward the challenges associated with BSE

Variable[a]	Cumulative AICc weight[b]		
	Factor 1 (Community)	Factor 2 (Impact)	Factor 3 (Agronomic)
AGE	*3(0.57)*	3(0.49)	*4(0.47)*
COMM	*1(1.00)*	11(0.49)	11(0.27)
CROPDIV	6(0.31)	5(0.42)	*3(0.74)*
ECONO	8(0.26)	*1(0.99)*	10(0.27)
EDUCATION	8(0.26)	6(0.37)	8(0.34)
GENDER	*2(0.60)*	*2(0.57)*	5(0.40)
LAND	7(0.27)	11(0.28)	*2(0.79)*
LIVE	7(0.27)	7(0.36)	6(0.38)
MGMTCLUB	8(0.26)	9(0.33)	*1(1.00)*
PROV	8(0.26)	10(0.30)	9(0.29)
WORK	*4(0.41)*	4(0.45)	11(0.27)
YRCOURSE	5(0.38)	8(0.34)	7(0.35)

[a] Variables include AGE (Age of respondent as years), COMM (Level of community mindedness), CROPDIV (diversity of crops), ECONO (economic state of being of respondent), EDUCATION (highest level of education), LAND (total ha of land), LIVE (total number of livestock), MGMTCLUB (whether member of a management club), PROV (province of residence), WORK (fulltime producer, part time or retired) YRCOURSE (no. of years since HM course taken)

[b] Cumulative AICc weight of variable = the percent of weight attributed to models containing that particular variable and is calculated by summing AICc model weights of every model containing that variable

suggested that men and women had complementary views of the impacts, reflecting the strong gender roles that characterize farm families in western Canada. Male respondents generally focused on management concerns and women on social changes and the community, which may have resulted in a more comprehensive and, thus, heightened view of the risks when surveys were completed by couples.

3.2 HM vs. non-HM producers

There was some agreement between HM and non-HM producers regarding BSE, both strongly agreeing that BSE posed low public health risks and both strongly disagreeing that BSE was an issue of the past (Table 2). However, substantial differences existed between the two groups regarding both the immediate and long-term impacts of BSE. Interestingly, non-HM respondents were significantly ($p<.0001$) more likely to feel that stress and worry had increased, that the effects of BSE would persist into the future, and that BSE had negative impacts on their communities. Differences in outlook between the two groups arguably reflected the adaptive strength of HM.

The HM producers were also significantly ($p<.0001$) more confident about the future of the Canadian livestock industry (Table 2). As an HM producer from Alberta indicated:

> "HM allowed us to hold back our cattle for 2 years. By 2005 we had doubled our herd and fed more cattle per acre than our non HM neighbors. Without HM we would have had to sell in 2004 and we would have taken a financial beating" (HM, 115).

Interestingly, HM producers were also significantly ($p<0.0001$) more critical of the governmental responses to the crisis. Many highlighted the inadequacy of the support programs, commenting on their poor timing, inadequate level of support, needless complexity, and reflecting a bitterness that those that seemed to benefit most were the feedlots and largest livestock operations. Importantly, many felt that the programs themselves, indeed dependence on the government as a whole, were inherently problematic:

> "Most people will not make a change in their practices as long as there is always a government "safety net" program to rely on…our neighbors made more money with the government-funded BSE relief programs than those proactive people who took initiative to manage their own affairs for the betterment of their land and families" (HM, 61).

This may in part characterize the attitudes of alternative farmers, which as a group are less likely to benefit from compensation programs that target established conventional producers, and which often come to rely on the diversity of their operations and their own support systems to sustain them through crises (Duram 1997).

3.3 Responses

3.3.1 Adaptation as a response to the BSE crisis

The HM producers were generally more optimistic than their non HM counterparts. Although both groups were clearly hurt by BSE, HM respondents were generally more hopeful:

> "We strive to educate ourselves about many issues.—especially BSE and the decimation of our industry. Confidence in the health of our land and livestock and knowledge of the unjustified assault on our livelihood actually helped us remain assured that this can be overcome" (HM, 36).

Farmers routinely make immediate and far less common long term decisions when coping with adversity. The latter tend to extend beyond any given season and include approaches such as HM, organics, and direct marketing to consumers (Anderson and McLachlan 2008). Yet the iterative and reflective nature of HM also facilitated more effective tactical decision-making:

> "Having a written goal and a direction that gets monitored frequently allows us the confidence to challenge previous ideas and make changes and adapt quicker. We now do a lot more acting instead of reacting" (HM, 199).

For some, adapting and confronting the crisis actually made them more resilient: 'I believe we are stronger after BSE than before it' (HM, 274). Others attributed this resilience in their ability to plan ahead:

> "We set our profit that we want to make a year in advance and so far have met or exceeded our profit goals. BSE is no longer a controlling factor in our lives, but rather BSE is only one of many things to consider in our decision making process" (HM, 199).

Some indicated that a stronger financial position associated with HM gave them a longer term view and allowed them to look beyond the BSE crisis into the future. Others further identified that BSE had created opportunities for development and change, describing the role that HM played in their positive outlook:

> "I feel that BSE also created opportunities and HM helped me to find these opportunities. It also helped me to feel confident with decisions I made. HM definitely reduced the amount of stress on the farm" (HM, 22).

3.3.2 Role of community in adapting to BSE

The role of community in adapting to BSE separated out on factor one. At one extreme, producers were largely individualistic in nature, indicating: 'We do our own thing' (HM, 90). Some respondents sought off-farm employment, thus having less time available for their communities. Indeed, those having off-farm work were often less satisfied with their quality of life as they have less time to spend with family and friends.

At the other extreme, many were community-oriented, finding strength and hope within their relationships with family, the larger HM community and/or the surrounding rural communities. As one couple from Saskatchewan reflected, 'We took the BSE situation and turned it into an opportunity to develop/strengthen our team and probably wouldn't have been able to see that opportunity without HM' (HM, 211). Another felt that 'by keeping a positive attitude and having positive friends it was easy to stay focused on the big picture rather than the small blips in time'(HM, 176).

The AIC models that best explained the community-based responses to BSE included four independent variables: community, gender, age, and work; the cumulative AICc value for each variable being 1.00, 0.60, 0.57, and 0.41, respectively (Tables 4 and 5).

As indicated, those that were more community minded were especially able to adapt to the challenges posed by BSE. One HM producer linked family community support with effective decision-making:

> 'HM has reinforced goal setting as an exclusive priority for every decision in our family's everyday life as well as the farm. This is important because we focus on being informed and making sound business decisions with our entire family as well as the community' (HM, 56).

Table 5 Number of model parameters, differences in Akaike information criterion (Δ-AICc), and AICc weights (w) for models developed for respondent community in dealing with the challenges associated with BSE

Model structure	-2Log(L)	k	-AIC_c	AIC_cw
WORK + AGE + GENDER + COMM	215.402	5	0.0	0.405
COMM	222.565	2	1.1	0.228
$COMM^2$ + AGE + GENDER +WORK	214.744	6	1.3	0.206
COMM + AGE + GENDER + WORK + MGMGTCLUB	215.833	6	2.4	0.120
AGE*GENDER + COMM	222.109	4	4.7	0.039
GENDER	233.532	2	12.1	0.001
AGE	234.991	2	13.6	<0.001
COMM*AGE + GENDER + WORK	229.499	5	14.1	<0.001
MGMTCLUB	238.371	2	17.0	<0.001

Many also indicated that their changes in worldview and management associated with HM were, at least initially, viewed with some suspicion by their non-HM counterparts. Some found these changes difficult: 'We may have aroused jealousy in some of our neighbours' (HM, 293). Other studies have also found that HM producers "were considered odd by their immediate neighbours." (Stinner et al 1997) Yet some respondents indicated their HM practices did elicit interest over time, and would even be explored by at least some nearby conventional producers:

> 'We see the neighbours adapting to some of our practices, our family has become closer and more encouraging. We are not experiencing much problem navigating the squeeze on agriculture' (HM, 293).

Despite this suspicion, most indicated they had strong community support in coping with the BSE crisis, a community not so much located in place but reflecting the often new social network that had emerged around HM.

This sense of community arose from meeting others in a larger, often inter-provincial HM community or the generally tight-knit HM clubs they helped create or joined. Indeed, over 60% of the respondents had belonged to a management club at some point in time, usually consisting of half-dozen farm families that met on a monthly basis. These clubs often began focused on HM but as trust developed over time, finances, worries, and other highly personal issues would also often be discussed, a degree of sharing that is very rare indeed in most rural communities. These support systems obviously helped many mitigate the challenges associated with BSE and other stressors. Many explicitly indicated the importance of the club during these times of crisis:

> "We had a group and a network of positive-thinking people who look for solutions to problems rather than dwell on what is going wrong. Through them we found ways to lower our cost of production. The group was also a positive place to be when everyone in the coffee shop wasn't" (HM, 220).

However, many HM producers were not part of management clubs; for some there was no club that was adequately close or they had stopped meeting, whether because of a lack of focus or productivity, personality conflicts, or excessive demands.

Gender also played a strong role in adaptation, and men and women responding alone adapted more readily than those responding as couples. This, in part, might again reflect the

greater adverse impacts perceived by dual-respondents. Those that were highly adaptable tended to be more community minded, especially farm women, who generally play an important role in volunteer networks that extend into their communities (Chiappe and Flora 1998). In contrast, individualists were less adaptable, the proportion of which was largest for men.

Some women further found that HM provided support that helped them cope with non-traditional gender roles: 'HM allowed me, a single woman, to successfully take over and run a farming business on my own' (HM, 85). And others found that HM gave their children a renewed sense of optimism regarding agriculture, this of great importance since youth and young farmers with high debt loads have been especially affected by BSE and because the exiting of youth from agriculture is such a concern to most (Stozek 2008). One woman indicated: 'It is interesting to note that it was the HM course which made our oldest daughter feel that a living in agriculture is possible' (HM, 79).

3.3.3 Management implications of HM for adapting to BSE

Agronomic benefits of HM for mitigating challenges associated with BSE separated out on factor three. Many had confidence in the livestock industry and believed HM played an important role in reducing the impacts of BSE. Thus, most (78.0%) HM producers agreed that HM had helped reduce the adverse impacts of BSE on the farm and, had more people practiced HM, many (68.0%) agreed that BSE would have much less of an impact on producers. Indeed, HM had already substantially reduced the adverse effects of BSE, in part by allowing producers to do with less:

> "We believe we're going in the right direction. BSE didn't change that. We want to stay in the business so HM is used as a tool to make us more efficient. This allowed us to withstand the lower cattle values due to BSE" (HM, 217).

While appreciating the value of HM, others recognized that it was only one part of the solution to challenges associated with BSE: 'This was a crisis beyond comprehension and holistic management was only one small tool in the basket to our success out the other side' (HM, 299).

The model that best described the role of HM farm management in adapting to BSE consisted of four variables: membership in a management club, size of farm, diversity of crop production, and the age of the respondent, the cumulative AICc value for each being 0.99, 0.79, 0.74, and 0.47, respectively (Table 4). Those who had never joined a club were generally less able to adapt to BSE than those who met regularly. Clubs allowed participants to share and discuss new farm management techniques, and to support one another when exploring innovative responses to unforeseen events such as BSE:

> "Our fellow members in the Holistic Management club were helpful and, during this time, regularly shared their observations and thoughts on the BSE crisis as it unfolded. As a result, we did what we could to position ourselves so that we could move forward when it was over" (HM, 305).

Others felt that that clubs better situated members to take advantage of the crisis: 'Our management club was good for support. We looked at BSE as an opportunity to expand because we see a future in grass farming' (HM 154). For many, the clubs were critical in allowing them to adapt and respond to unforeseen events. The formation of these types of farm networks can build resilience as they can facilitate the growth of human relationships and trust among participants. This is especially important when communities are confronted

with rural depopulation and where there are progressively fewer opportunities for rural residents to interact on a casual and place-centered basis.

Although the social and economic benefits of HM were clearly important outcomes of these agronomic responses, most noted that environmental benefits were also substantial, also allowing them to better adapt to any unforeseen circumstances:

> 'We have seen huge change in the diversity of species of plants and animals also in the water cycle. Economically things are getting better due to the land providing more for us with less input which in return frees up more social and family time. If you take care of the land, the land will take care of you' (HM,197).

Many also attributed their ability to adapt to the challenges presented by BSE to the wide diversity of management innovations that arose from HM, especially rotational grazing. Associated short-term environmental benefits including increases in family time and in-field biodiversity, as well as declines in inputs, were incorporated within a longer term strategic plan that emphasized the importance of monitoring and the need to adapt to unanticipated changes in the system on an ongoing basis.

4 Conclusion

Our study is one of the first that focuses on the vulnerability of producers to BSE. These results indicate that the zoonotic has had devastating impacts on producers across western Canada. It also has adverse spill-over effects on the communities as a whole (Stozek 2008) and have been aggravated by other stressors including drought and low commodity prices. Indeed, many producers are still recovering three years after the reopening of the US border (Stozek and McLachlan 2007). Although there is very little hope evident in rural Canada, one exception is the now longstanding optimism surrounding HM.

As rural communities decline in size and infrastructure, residents thus become even more dependent on alternative social networks that in many cases extend beyond the geographical borders of their own longstanding rural communities. HM is unique in that for many it has actively promoted the growth of new networks, largely in the form of local HM clubs that meet regularly and provide ongoing emotional, economic, and technical support in times of stress. These clubs facilitate the exchange of ideas and concerns, ones that are technical and agronomic in nature but also those that relate to financial insecurity, stress and worry. The larger regional and even continental HM community that periodically meets at conferences and workshops also plays an important affirming role for these producers, especially those that are not members of clubs or that are viewed with suspicion by their neighbours. The emphasis that HM places on social priorities contrasts strongly with most approaches to agricultural sustainability that generally focus on economic and environmental priorities.

Although HM continues to grow in popularity and is currently practiced on over 30 million acres of farmland across four continents (HMI 2008), we have yet to find any systematic peer-reviewed study on HM, much less its role in adapting to crises such as BSE. This oversight partially reflects the largely grassroots nature of the phenomenon that has, especially in Canada, received little attention or support from government, industry, academe or, for that matter, consumers. This gap, in turn, likely reflects the difficulties in accommodating a holistic and process-based approach to agriculture that at once emphasizes economic, environmental, and social priorities and that is remarkably diverse in nature. Rather than being restricted to any one technology or set of regulatory standards,

HM producers routinely adopt a wide diversity of agronomic practices to achieve their holistic goals that can include organics, zero till, precision farming, rotational grazing, and direct marketing: many of which are normally seen as mutually incompatible.

Studies like this one that focus on grassroots movements as forms of rural adaption are generally under-represented in the global change literature. Yet, our results show how effective these initiatives can be in both mitigating and adapting to the impacts of rural crises such as those associated with BSE. That these community-driven adaptations continue to thrive with little explicit outside support points to their tremendous potential as adaptive responses in the future. These outcomes complement the typologies of rural adaptations have otherwise focused on individual farm and government level responses (e.g. Smit and Skinner 2002; Kurukulasuriya and Rosenthal 2003). The stability of these grassroots responses and others such as longstanding agricultural cooperatives in the Canadian prairies is in direct contrast, and sometimes opposition, to expert and government subsidized support programs that tend to decline in impact and even collapse in the absence of adequate funding (Stozek 2008). Moreover, they seem to be highly effective, especially for alternative and small scale producers and others in rural communities that are often neglected and sometimes even further marginalized by governmental responses (Adger et al. 2005). Indeed, many in our study noted that they did not want or need to rely on government programs when coping with these changes as their management responses were proactive instead of reactive in nature. Arguably this, in turn, has allowed producers to become more self sufficient and resilient, and, indeed, more optimistic about their futures and the future of agriculture. Although governments and experts should play a meaningful role in facilitating these community-located adaptive strategies in the future, the challenge will then become to find ways of supporting these farmer and community-driven initiatives and to upscale them so they begin to benefit vulnerable populations and entire regions, yet doing so without compromising the autonomy, self reliance, and optimism that they otherwise engender.

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