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Rotational grazing adoption in cattle production under a cost-share agreement: does uncertainty have a role in conservation technology adoption?

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Rotational grazing has been promoted as a best management practice with environmental benefits and associated higher revenue. Its adoption rate has been relatively low. This study investigates the role of uncertainty in the adoption of rotational grazing with a cost-share by cattle producers. Mail survey results indicate that 63–71 per cent of cattle producers are uncertain about adoption with a government cost-share. The study suggests that the possibility of uncertainty should be considered in cases where willingness-to-pay is elicited in the context of adoption of technology.

Key words: best management practices, ex-ante technology adoption, rotational grazing.

1. Introduction

When faced with technology that involves substantial cost, management, and social impacts, farmers may be uncertain about whether to adopt if these factors are in conflict.[1] Farmers deciding whether to adopt capital and management-intensive best management practices (BMP) with environmental benefits and sometimes uncertain profitability are likely to encounter conflicting goals. On one hand, they appreciate the conservation benefits of BMPs, which have both public good (environmental) and private good (land preservation) attributes. On the other hand, some BMPs require significant adoption costs, yet may not result in noticeable short or intermediate-run benefits from a private good perspective.

BMP are voluntary practices whose adoption is encouraged via cost-share incentives under the Environmental Quality Incentives Program (EQIP).

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[1] We discuss the role of conflicting goals as leading to uncertainty. Others such as Ready *et al*. (1995), have used the term ‘ambivalence’ to describe this uncertainty; others have used both terms (Svedsater 2007). Ambivalence is defined as, ‘in psychoanalysis, the simultaneous operation of two conflicting wishes’ (Allee 1997). We use the term uncertainty in our paper, though a case could be made for terming this as ambivalence.

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Established in the 1996 Farm Bill, EQIP provides farmers with up to a 75 per cent cost-share of the BMP adoption cost.[2] For some BMPs, cattle producers may experience uncertainty toward adoption, whether or not a cost-share is offered. Uncertainty may be particularly high in the adoption of rotational grazing because of its extensive associated management commitment. Rotational grazing is one of 16 beef production BMPs recommended in Louisiana. To operate effectively, 5–10 paddocks are recommended. Self-filled metal troughs are generally installed in each paddock and electric fencing is used to keep animals in intended paddocks. The key to successful rotational grazing is allowing forages in some pastures to rest and regrow while grazing another pasture. Advantages include increased carrying capacity, better pasture persistence and productivity, improved utilisation of more forage species, less forage wasted by trampling, and soil erosion prevention. Disadvantages include significant initial investment cost and increased management. (Ball *et al.* 1999). Profitability is likely to vary by region and forage type.[3]

Policymakers have an interest in the cost-share level that would entice BMP adoption. Initially, it seems that this could be determined using a straightforward contingent valuation (CV) method—ask farmers whether they would adopt if given a specific cost-share amount. However, in designing this study, it became clear from discussions with farmers that uncertainty was present in their decision-making processes regarding rotational grazing adoption. For a generic technology, this could be due to (i) lack of full information about the technology, (ii) substantial initial capital investment required to adopt, (iii) associated commitment made to alter management practices to fully realise the benefits associated with adopting (significant on-going transaction costs associated with adoption), and (iv) as discussed by Opaluch and Segerson (1989), the pursuit of often conflicting goals such as profit maximisation and conservation. Such decisions in the CV context are likely to result in greater uncertainty than the more common application dealing with respondents' willingness to contribute a one-time sum to preserve an environmental amenity. Gillespie *et al.* (2008) lend insight into initial capital investment vs. on-going adoption costs. Comparing similar stocking rate continuous vs. rotational grazing with eight paddocks in Louisiana, they show continuous vs. rotational grazing fixed expenses per acre (depreciation + interest) and direct (variable) expenses per acre are, respectively, \$23.41 and \$65.40 greater for rotational grazing. Thus, start-up costs spread over the life of the investment are significantly lower than on-going expenses associated with adoption.

This study examines the expected adoption rate of rotational grazing at different cost-share rates. Both dichotomous choice (DC) and polychotomous

[2] The EQIP provides beginning or limited resource farmers with up to a 90 per cent cost-share. Since the 2002 Farm Bill, ≥ 60 per cent of EQIP funds are targeted to livestock operations (USDA-Economic Research Service 2002).

[3] Gillespie *et al.* (2008) found in a Louisiana trial that rotational grazing was less profitable than continuous grazing at similar stocking rates.

choice (PC) CV elicitation formats are utilised. A PC format explicitly recognises uncertainty by allowing respondents to choose their levels of certainty in response by presenting more choices than simply 'yes' and 'no' to the adoption question. The DC format used in this study includes follow-up questions to determine respondents' levels of certainty. The authors are unaware of previous studies using these methods to examine technology adoption responses. The study objectives are to determine: (i) the importance of uncertainty in farmers' technology adoption decisions and (ii) whether there are differences in BMP adoption and uncertainty in farmer responses under DC and PC formats.

2. Previous studies

Arrow *et al*. (1993) suggest incorporating 'do not know' choices in DC CV questions to allow for respondent uncertainty. Uncertainty and ambivalence with the DC method have been incorporated in a variety of ways (Li and Mattson 1995; Ready *et al*. 1995; Champ *et al*. 1997; Wang 1997; Blamey *et al*. 1999; Ready *et al*. 2001; van Kooten *et al*. 2001; Groothuis and Whitehead 2002; Alberini *et al*. 2003; Caudill and Groothuis 2005; Svedsater 2007). Though none of these studies has dealt with technology adoption, two are particularly relevant for this study. Ready *et al*. (2001) included follow-up questions in a CV study with five levels of certainty. Ready *et al*. (1995) compared responses of PC questions with those of DC questions. PC questions elicited respondents' certainty of willingness to pay (WTP) to preserve an amenity, with six potential responses. They found rather wide ambivalence regions, slightly higher response rates with PC questions, more 'yes' responses with PC questions, and PC respondents were 'less influenced by the scenario being presented'. The DC format elicited a 'strict conservatism' strategy: respondents replied 'yes' only if the bid offer was outside of the ambivalence region.

A number of studies have used CV to analyse farmers' ex-ante adoption of technology, though none have addressed response uncertainty (Kenkel and Norris 1995; Hubbell *et al*. 2000; Hudson and Hite 2003; Qiam and de Janvry 2003). Cooper and Keim (1996) analysed the government cost-share payment farmers would be willing to accept to adopt BMPs that protect water quality, followed by analysis of adoption intensity. Cooper (2003) evaluated farmers' willingness to accept a cost-share payment to adopt BMPs. Finally, Cooper and Osborn (1998) analysed farmers' willingness to re-enroll in the Conservation Reserve Program, including 'donot know' as a response option.

3. Conceptual model

Lusk and Hudson (2004) provide a conceptual model showing producer WTP for new technologies as a profit maximisation model. Though profit is likely among the most important attributes determining the adoption of rotational grazing, Basarir and Gillespie (2006) found Louisiana beef producers to rate the goal, 'maintain and conserve land' as more important than 'maximise profit' in farm decision-making. Thus, we model the decision of a cattle farmer faced with whether to adopt rotational grazing with a cost-share payment according to the following random utility model, extending Cooper and Keim (1996). The farmer will adopt if the utility associated with adoption exceeds the utility associated with nonadoption:

$$U(0, y_0 - C_0, m_0, E_0, x) \leq U(1, y_1 - C_1 + \mathrm{CS}, m_1, E_1, x) \tag{1}$$

where $U(\cdot)$ is the utility operator; 0 and 1 represent the base and adoption states, respectively; y represents income; C represents costs of production; CS is the cost-share provided to the farmer to adopt the technology; m represents management requirements associated with the technology; E represents environmental impacts of the technology; and x represents farmer characteristics.

The farmer's utility $U(i, y_i - C_i, m_i, E_i, x)$ is unobservable, but what is estimable, similar to Cooper and Keim (1996), is $V(i, y_i - C_i, m_i, E_i, x)$. Thus, the decision to adopt technology with a cost-share is expressed as:

$$V(0, y_0 - C_0, m_0, E_0, x) + e_0 \leq V(1, y_1 - C_1 + \mathrm{CS}, m_1, E_1, x) + e_1 \tag{2}$$

where V is estimable utility and e_i the error term. This implies that adoption depends on a cost-share, management considerations, environmental concerns, and a set of individual characteristics influencing utility.

While $y_0 - C_0$ and $y_1 - C_1$ are stochastic, there is often little basis to quantify differences in variances of net returns when one distribution represents a technology for which there is little history. Given there is little basis to compare distributions for rotational vs. conventional grazing, this model does not examine differences in expected utility between practices, but rather how factors affect willingness to adopt technology and accordingly alter management practices with an economic incentive. With a government cost-share, farmers' WTP their cost-share portion is presented in Equation (3), which results from Equation (2):

$$\mathrm{WTP(Yes/No)} = \mathrm{WTP}(\mathrm{CS}, y, x, m, E) \tag{3}$$

Values of x, y, CS, m, and E are likely to influence adoption.

4. Methods

4.1 The survey

In May 2003, after having cattle producers review the questionnaire at an annual convention of the Louisiana Cattlemen's Association, a pretest survey with 200 cow–calf farmers was conducted. To determine farmers' WTP for rotational grazing, an iterative bidding process in a DC CV with follow-up certainty question was used. WTP rather than willingness to accept questions were chosen to prevent overestimation of the cost-share payment, as suggested by Arrow *et al*. (1993). With prior knowledge about cost-share rates based on current EQIP payments, producer reviews and the pretest were designed to test respondents' understanding of the questionnaire rather than to determine the range of cost-shares. Resulting questionnaire changes for WTP incorporated uncertainty due to respondents' reluctance to answer iterative format DC questions. A split sample was developed with half of the individuals receiving questionnaires with single-bounded DC with follow-up questions and the other half PC with six Likert-scale options regarding whether they would adopt rotational grazing with a specific cost-share.

With both questionnaire versions, a half-page introductory message was provided including information about the EQIP and rotational grazing. Following this, respondents were asked, 'Suppose that the total cost of establishing a rotational grazing system is \$50 per cow, including self-filled troughs, electric fencing, pipeline and labour charges for this installation. Suppose the federal government were to agree to pay X per cent (\$Y per cow) of the cost. Would you be willing to pay the remainder (\$Z per cow) to adopt it?' Chosen cost-shares (X) were varied among 60, 70, 80, 90 and 100 per cent, with 20 per cent of respondents receiving the 60 per cent version, 20 per cent receiving the 70 per cent version, and so forth. The \$Y and \$$Z$-values were calculated and presented accordingly.

In similar fashion to Ready *et al*. (1995) and Svedsater (2007), PC responses included, 'I definitely would adopt it', 'I probably would adopt it', 'I would slightly lean towards adopting it', 'I would slightly lean towards not adopting it', 'I probably would not adopt it', and 'I definitely would not adopt it'. Similar to Ready *et al*. (2001), one of two follow-up questions to the DC format was to be answered, depending upon the response. Those who responded 'yes' ('no') were to respond, 'How sure are you that you would (not) adopt a rotational grazing system given the federal government would cost-share X per cent of the adoption expenses?' Four choices were offered: 'I definitely would (not) adopt it', 'I probably would (not) adopt it', 'I would slightly lean towards (not) adopting it', and 'I would slightly lean towards not (delete "not") adopting it'. Respondents were not provided with 'probably' and 'definitely' options that contradicted their original responses; Ready *et al*. (2001) found few respondents whose follow-up responses contradicted their initial responses at the extreme levels.

Respondents to CV questions were farmers who had either not adopted rotational grazing or previously responded that they were using it, but with fewer than five paddocks (and were, thus, nonadopters of the technology of interest). According to Ball *et al*. (1999), 5–10 paddocks are recommended for a rotational grazing system. The adoption cost used in the question assumed current market prices of materials necessary to establish a rotational grazing system.

A mail survey of 1500 Louisiana cattle farmers was conducted by the authors in Summer 2003. Three contacts were made: the initial questionnaire with a cover letter and return envelope; a postcard reminder; and finally a new cover letter, return envelope and replacement questionnaire. A hand-written note on the replacement questionnaire stated, 'I would appreciate your response. Thanks!', signed by the principal investigator. Dillman's (2000) tailored design was used. Cover letters were personally addressed and signed. A stratified sample was drawn from the USDA-National Agricultural Statistics Service by herd size. Size categories were 1–19, 20–49, 50–99 and ≥ 100 animals in the herd. These size categories constituted 26.7, 23.3, 23.3 and 26.7 per cent of the sample, respectively.

4.2 Econometric models

Equation (3) is estimated using logit models to determine: (i) farmers' WTP to adopt rotational grazing, (ii) the role of uncertainty, (iii) the influence of risk preference on response, and (iv) the influence of farm, farmer, financial, managerial and attitudinal factors on willingness to adopt. Estimates are used to determine the probability of adoption given specific values of independent variables (Greene 2000, p. 815). The impact of an independent variable on the dependent variable is measured by the marginal effect, holding all other variables constant, as in Greene (2000, p. 816). Marginal effects for dummy variables are estimated as in Greene (2000, p. 817). Appropriate weighting adjusts for the stratified sample.

Six logit models were estimated, assuming different levels of certainty as 'yes' responses, shown in Table 1. Models 1–3 do not consider the DC follow-up question response while Models 4–6 adjust the DC response according to the follow-up response. Sample selection was tested using Heckman's bivariate probit selection model for each of the models, with the first stage indicating

Table 1 Dependent variable coding of estimated models

Models	Responses treated as 'yes'
Model 1	DC: 'yes' PC: 'I definitely would adopt it,' 'I probably would adopt it,' or 'I would slightly lean towards adopting it.'
Model 2	DC: 'yes' PC: 'I definitely would adopt it,' or 'I probably would adopt it.'
Model 3	DC: 'yes' PC: 'I definitely would adopt it.'
Model 4	DC with follow-up: 'I definitely would adopt it,' 'I probably would adopt it,' or 'I would slightly lean towards adopting it' PC: 'I definitely would adopt it,' 'I probably would adopt it,' or 'I would slightly lean towards adopting it.'
Model 5	DC with follow-up: 'I definitely would adopt it,' or 'I probably would adopt it' PC: 'I definitely would adopt it,' or 'I probably would adopt it.'
Model 6	DC with follow-up: 'I definitely would adopt it' PC: 'I definitely would adopt it.'

whether farmers had previously adopted rotational grazing with at least five paddocks. In none of the models was ρ significant at the 0.10 level. Thus, the sample selection model was not used.

Table 2 shows independent variables and descriptive statistics. The price variable is Farmer CS, a variable from 0 to 40 in increments of 10 that indicates percentage farmer cost-share if adopted. (Farmer cost-share depended upon the questionnaire version received.) DC Format is a dummy variable indicating the farmer received a DC as opposed to a PC format questionnaire. The pooled regression approach with both DC and PC responses is consistent with Whitehead *et al.* (1998). It is expected that, as Farmer CS increases, farmers would become less willing to adopt rotational grazing, assuming downward sloping demand. It is expected that, using the DC format, farmers using a strict conservatism decision rule would be less likely to respond positively to adoption, as in Ready *et al.* (2001).

The following independent variables are farmer management considerations, *m*. Number of acres in the beef operation (Beef Acres) indicates enterprise size. Larger farmers are expected to more likely adopt; they can spread the fixed investment over greater output (Feder *et al.* 1985). *Stocker* indicates the farmer is involved in the stocker segment, grazing weaned calves on ryegrass through the winter to be sold in the Spring. *Diverse* indicates the number of enterprises other than cattle on the farm. Diversification is expected to limit technology adoption due to limited span of control, as found by others (Fernandez-Cornejo *et al.* 1994; Gillespie *et al.* 2004). The percentage of income from the beef operation (per cent Importance) measures the financial importance of the enterprise to the household. Those with higher percentages are expected to place greater managerial resources into the enterprise, more likely adopting. Finally, previous adoption of Rotational Grazing with less than five paddocks allows for determination of whether limited experience influences adoption.

Having a stream running through the farm (Stream Through) accounts for potential increased regulatory oversight and associated management difficulties. Owned Land is the ratio of owned to total land acres in the cattle operation. Those owning greater percentages of land are expected to more likely adopt, as found by Lambert *et al.* (2006).

Attitudinal variables are included to assess the impacts of farmers' views on willingness to adopt. Laws Needed is the farmer's reaction to the statement, 'Laws regulating excess soil erosion are badly needed,' coded from 5, strongly agree, to 1, strongly disagree. This proxies the farmer's environmental attitude. Government's Role is the reaction to the statement, 'Government involvement has helped farmers,' coded similarly to the previous variable. These statements were used by Duffy and Molnar (1989). Farmers with more favourable attitudes toward government involvement are expected to more likely adopt rotational grazing with a government cost-share.

A proxy for risk attitude was the response to a question used by Fausti and Gillespie (2006): 'Relative to other investors, how would you characterise yourself?' Possible responses were, 'I tend to take on substantial levels of risk

Table 2 Definitions and summary statistics of explanatory variables

Variable	Definition	Mean, Entire Sample	Standard Deviation	DC Mean	PC Mean
Price and format					
Farmer CS	Willingness to pay amount, %	19.705	13.582	20.707	18.703
DC format	Dummy, dichotomous choice format	0.501	0.501	1.000	0.000
Managerial variables					
Beef acres	Number of acres devoted to beef cattle, divided by 100	2.657	7.466	2.424	2.890
Stocker	Dummy, stocker operation	0.055	0.228	0.055	0.055
Diverse	Number of crops or livestock enterprises other than beef on the farm	1.022	1.040	1.109	0.935
% Importance	Percentage of income coming from beef, coded 1, 2, 3, 4, 5 for 20% increments	1.119	0.925	1.043	1.197
Stream through	Dummy, a stream or a river runs through the farm	0.426	0.495	0.451	0.402
Owned land	Ratio of owned to total land in beef operation	0.669	0.382	0.663	0.675
Rotational grazing	Previous adoption of any type of rotational grazing	0.483	0.500	0.494	0.472
Attitudinal variables					
Laws needed	Farmer response to, 'Laws regulating excess soil erosion are badly needed' (5 = strongly agree, 1 = strongly disagree)	2.395	1.112	2.285	2.506
Government's role	Farmer response to, 'Government involvement in agriculture has helped farmers' (5 = strongly agree, 1 = strongly disagree)	2.044	1.025	2.050	2.038
Risk averse	Dummy, risk averse farmer	0.710	0.454	0.711	0.708
Financial variables					
Household income	Household net income, coded 1, 2, 3, 4, 5 for $30 000 increments	2.372	1.220	2.400	2.343
Debt asset ratio	Debt : Asset ratio, coded 1, 2, 3, 4, 5 for 20% increments	1.228	0.635	1.272	1.219
Farmer characteristics					
Age	Respondent age divided by 10	5.835	1.296	5.702	5.964
College	Dummy, college bachelor's degree	0.299	0.458	0.328	0.272
Family take over	Dummy, having a family member to take over the farm	0.296	0.456	0.330	0.262

in my investment decisions', 'I neither seek nor avoid risk in my investment decisions', and 'I tend to avoid risk when possible in my investment decisions'. Risk Averse is a dummy variable indicating the farmer marked the third option. Risk averse farmers are expected to be less willing to adopt if there is uncertainty about the economic benefits of adoption.

The impacts of financial situation are explored, as adoption requires significant initial capital investment. Those with greater Household Income and lower Debt : Asset Ratio (greater solvency) are expected to be more likely to adopt.

Farmer characteristics are expected to influence adoption. *Age* is expected to negatively influence adoption, as found by Soule *et al.* (2000) and Rahelizatovo and Gillespie (2004). Holding a college bachelor's degree (College) is expected to increase adoption, as more educated producers have been found to be the greater BMP or other technology adopters (Feder *et al.* 1985; Wu and Babcock 1998). Anticipating a family member will take over the farm upon the farmer's retirement (Family Take Over) is expected to positively influence adoption if maintaining interfamily social capital is of importance.

4.3 WTP and motivations for responses

WTP values were calculated as in Bishop and Heberlein (1979) and modified by Hanemann (1984, 1989). Independent variable means (except for the bid offer variable) were used. The coefficient associated with *Farmer CS* was used to calculate the mean WTP. Median values were obtained as suggested by Haab and McConnell (1997).

Follow-up questions were used to determine why respondents responded positively or negatively to adoption questions, including discernment of whether respondents responded with hypothetical or strategic bias, as discussed by Garrod and Willis (1999, p. 182).

5. Results and discussion

5.1 Comparing responses by question format

With 504 responses, the response rate was 41 per cent after deducting 270 who indicated via note, e-mail, or telephone that they were no longer in the cattle business. A total of 369 producers answered the rotational grazing CV question. Of these, 185 DC and 184 PC responses were received. Nearly equal numbers do not suggest a difference in response rate.

Table 3 shows percentages of responses coded as 'yes', depending upon how a 'yes' response was defined. Using traditional DC coding (no follow-up question), 47 per cent indicated they would adopt rotational grazing with a cost-share. This percentage differs at the 0.05 level from (i) the DC format where only respondents answering 'definitely yes' in the follow-up question were considered as 'yes'; (ii) the PC format where only respondents

Table 3 Percentages of producers willing to adopt rotational grazing, different measures of 'yes' answers

Definition of 'yes'	Percentage of 'yes' responses
DC	
a. No Follow-up question	46.86^{b,e,g}
b. DC with follow-up answer of definitely yes	14.86^{a,c,d,f,g}
c. DC with follow-up answer of definitely plus probably yes	39.43^{b,c,e,g}
d. DC with follow-up answer of definitely plus probably plus slightly yes	54.29^{b,c,e}
PC	
e. Definitely yes	19.05^{a,c,d,f,g}
f. Definitely plus probably yes	48.30^{b,e,g}
g. Definitely plus probably plus slightly yes	59.86^{a,b,c,e,f}

Note: Superscripts indicate response percentages differing from the listed percentage at the 0.05 level.

answering 'definitely yes' were considered as 'yes'; and (iii) PC questions where the top three 'definitely', 'probably', and 'slightly yes' were coded as 'yes'. The range in 'yes' responses was 15–60 per cent, depending upon whether the DC or PC format was used and whether uncertain responses were included. Clearly, allowance for uncertain responses greatly influences expected adoption rate. However, when DC and PC were coded consistently, they never differed at the 0.05 level. Thus, degree of uncertainty assumed had greater influence on whether a 'yes' response was obtained than question format.

Figure 1 illustrates the uncertainty region. Most (64 per cent) of the DC respondents responded other than 'definitely yes' or 'definitely no' to the follow-up question regarding their certainty of response. Seventy-one per cent of PC respondents answered other than 'definitely yes' or 'definitely no' to the question. This differs from the ambivalence range found by Ready *et al.* (2001) in a study valuing the health impacts of air pollution: 80 per cent of respondents to a DC follow-up question were 95 per cent certain of their responses. Differences between Ready *et al.* (2001) and this study would be expected due to greater uncertainty associated with (i) adoption of a practice with significant adoption costs, (ii) management strategies needed to be carried out over a number of years to realise the benefit of the investment (transaction costs), and (iii) the generally established impact of air pollution on human health, as opposed to rotational grazing's impact. In addition, Ready *et al.*'s (2001) follow-up '95 per cent sure' response allowed for 'slight' uncertainty, while the 'definitely yes' response in the present study does not. Finally, the complexity involved in CV questioning regarding technology adoption vs. a simple contribution could result in greater response uncertainty, a worthwhile subject for future studies.

While uncertainty regions differed numerically between the DC and PC levels, they did not differ at the 0.05 level. Thus, the authors cannot conclude that PC uncertainty regions were greater than DC with follow-up regions.

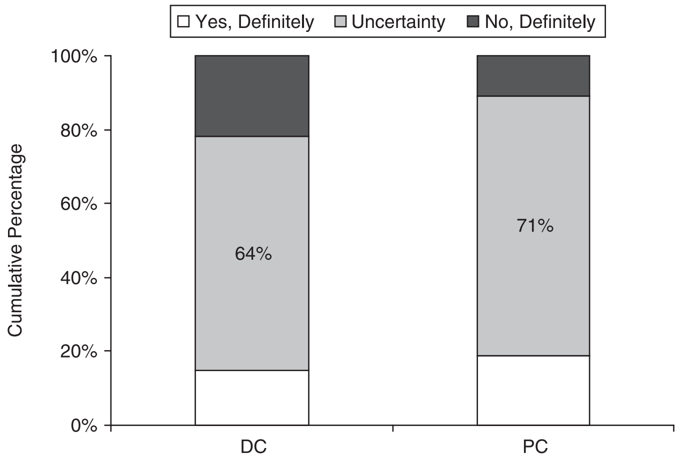

Figure 1 Percentages of definitive vs. uncertain responses, PC and DC formats.

However, using the CATMOD procedure in SAS to contrast the distributions, analysis of the PC and DC distributions across all six responses showed the two distributions differing significantly at the 0.05 level.

5.2 Factors affecting willingness to adopt

Correlation coefficients, variance inflation factors, and condition indices do not indicate that multicollinearity was problematic in the models. Table 4 shows marginal effects for six logit models. Missing values for explanatory variables reduced the sample size to 261 for Models 1–3 and to 256 for Models 4–6. (Five DC respondents did not answer the follow-up certainty question.) Farmer CS was significant with the expected sign at the 0.05 level or higher in five of the six models. A 1 per cent increase in farmer cost-share decreased the probability of adoption by up to 0.0085, depending upon how a 'yes' response was defined.

The DC Format resulted in a lower adoption rate than the PC format when the top three PC responses were coded as 'Yes', consistent with 'strict conservatism' of DC responses found by Ready *et al.* (2001). On the other hand, the DC Format resulted in a higher adoption rate than when only the 'Yes, Definitely' PC responses were coded as 'Yes'. This suggests DC respondents (without a follow-up response) are more closely aligned with the 'Top 2 PC' responses than either 'Top 3 PC' or 'Top 1 PC' responses. Significant differences did not exist when DC responses were adjusted according to follow-up questions.

Previous adoption of rotational grazing with less than five paddocks increased adoption in all models. Greater numbers of acres in beef production increased adoption in Model 4. Stocker operations were more likely to adopt rotational grazing with Model 6, and more diverse operations were less likely to adopt in Models 3 and 6, as expected. Having a stream running

Table 4 Marginal effects from logit rotational grazing adoption analyses

Variables	Model 1 DC (yes) and Top 3 PC	Model 2 DC (yes) and Top 2 PC	Model 3 DC (yes) and Top 1 PC	Model 4 Top 3 DC and PC	Model 5 Top 2 DC and PC	Model 6 Top 1 DC and PC
Farmer CS	−0.0085***	−0.00731**	−0.0049**	−0.00786***	−0.0056**	−0.0012
	(0.00288)	(0.00288)	(0.00234)	(0.00285)	(0.00276)	(0.00159)
DC format	−0.2153***	−0.01669	0.280014***	−0.05885	−0.10835	−0.06643
	(0.07535)	(0.07857)	(0.06086)	(0.07688)	(0.07377)	(0.04352)
Rotational grazing	0.154338**	0.219523***	0.183185***	0.156052**	0.180392**	0.089171**
	(0.0788)	(0.07376)	(0.06761)	(0.07379)	(0.07162)	(0.04552)
Beef acres	−0.00546	−0.00497	−0.00341	−0.00802*	−0.00561	−0.00352
	(0.00461)	(0.0045)	(0.00377)	(0.00429)	(0.00454)	(0.00266)
Stocker	0.20086	0.155561	0.068524	0.041612	0.123431	0.432427*
	(0.19547)	(0.2573)	(0.19948)	(0.2314)	(0.26295)	(0.23891)
Diverse	−0.04403	−0.03373	−0.07988*	−0.02812	−0.01941	−0.06859**
	(0.03917)	(0.04089)	(0.04304)	(0.03874)	(0.0397)	(0.03382)
Importance (%)	−0.0137	0.000111	0.003347	0.056578	0.02524	−0.00295
	(0.0548)	(0.06065)	(0.06128)	(0.05661)	(0.06424)	(0.03935)
Stream through	−0.07789	−0.06629	−0.1133*	−0.01366	−0.02859	−0.01488
	(0.08184)	(0.07858)	(0.06716)	(0.07807)	(0.07566)	(0.04556)
Owned land	−0.05962	−0.0149	−0.00578	−0.0539	−0.09269	−0.0338
	(0.11664)	(0.11735)	(0.10038)	(0.10891)	(0.10967)	(0.05911)
Laws needed	0.071118*	0.086702**	0.051435*	0.079237*	0.062231*	0.025387
	(0.03717)	(0.03645)	(0.03052)	(0.03534)	(0.03547)	(0.01951)
Government's role	0.039461	0.078642**	0.07817**	0.063181	0.091242**	0.041803*
	(0.04119)	(0.03915)	(0.0368)	(0.03924)	(0.03928)	(0.02459)
Risk averse	−0.13491	−0.12276	−0.18257**	−0.03646	−0.13783*	−0.04719
	(0.08579)	(0.08494)	(0.08369)	(0.08499)	(0.08342)	(0.05385)
Household income	0.00201	−0.00757	0.001015	−0.01212	−0.01052	−0.025
	(0.0353)	(0.03353)	(0.02953)	(0.03348)	(0.03149)	(0.01961)
Debt-asset ratio	0.12415**	0.13693***	0.100872**	0.14554***	0.117335**	0.032171
	(0.05017)	(0.05102)	(0.04147)	(0.05092)	(0.04828)	(0.02232)

Table 4 *Continued*

Variables	Model 1 DC (yes) and Top 3 PC	Model 2 DC (yes) and Top 2 PC	Model 3 DC (yes) and Top 1 PC	Model 4 Top 3 DC and PC	Model 5 Top 2 DC and PC	Model 6 Top 1 DC and PC
Age	–0.1059***	–0.10743***	–0.07103***	–0.09253***	–0.08404***	–0.00313
	(0.03349)	(0.03447)	(0.02757)	(0.03164)	(0.0327)	(0.01712)
College	0.13259	0.146806*	0.068915	0.123078	0.156094*	0.090991
	(0.09194)	(0.08738)	(0.08119)	(0.08205)	(0.08736)	(0.06656)
Family take over	0.163533*	0.238403***	0.168077**	0.122319	0.140285*	0.059756
	(0.08461)	(0.08244)	(0.08158)	(0.07938)	(0.08004)	(0.05368)
Observations	261	261	261	256	256	256
Log-likelihood	–145.35	–141.94	–123.54	–144.54	–141.53	–99.09
Pseudo-R^2	0.20	0.21	0.25	0.17	0.18	0.14

Note: ***, **, and * indicate that the values are significant at 1%, 5% and 10% levels, respectively.

through the farm reduced adoption in Model 3. Thus, managerial considerations significantly influenced adoption.

Laws Needed was positively significant in five models, suggesting that environmental concerns influenced response. Government's Role was significant in four models: those with positive feelings about the government's role in agriculture were more likely to respond positively. Risk Averse producers were less likely to adopt rotational grazing than risk neutral or risk prone individuals two models. Perhaps producers see rotational grazing as having uncertain benefits and need further education on the economics of rotational grazing to adopt.

Debt : Asset Ratio was significant in five models, suggesting that high-debt farmers would be particularly favourable to adoption with a cost-share, a result not initially expected but plausible if high-debt farmers have resisted adoption due to financial constraints. Of the farmer characteristics, older farmers were consistently less likely to adopt, college educated farmers were more likely to adopt in two models, and those with family expected to take over the farm upon retirement were consistently more likely to adopt.

Mean farmer WTP was highest in Model 4, 27 per cent, where all positive responses were considered as 'yes' in both formats (Table 5). Mean WTP declined when positive but uncertain responses were not included as 'yes' responses. Mean WTP fell to a low of 6 per cent under no uncertainty in either format. Mean WTP was lower under Models 5 and 6 than Models 2 and 3, respectively, reflecting the influence of uncertainty on WTP for DC questions. Median percentages of WTP were lower in all cases than were means, suggesting farmer WTP was negatively skewed.

Figure 2 shows estimated probabilities of rotational grazing adoption. As farmer cost-share decreased, adoption increased in all but Model 6. When PC and DC responses were treated consistently, what constituted a 'yes' response greatly influenced adoption. When only certain responses constituted a 'yes' response, the probability of adoption was consistently < 0.05, while with the top three responses constituting a 'yes' response, the probability ranged from 0.25 to 0.57. Sensitivity to cost-share percentage may be considered somewhat low for most of the models. Given the greater direct (variable) costs associated with adoption relative to the up-front costs, this is not surprising. Perhaps of greater interest is the effect of uncertainty on expected adoption rate.

Table 5 Mean and median farmer percentage willingness to pay to adopt rotational grazing

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	DC (yes) and Top 3 PC	DC (yes) and Top 2 PC	DC (yes) and Top 1 PC	Top 3 DC and PC	Top 2 DC and PC	Top 1 DC and PC
Mean	24.00	19.45	10.48	26.59	17.28	5.67
Median	20.30	14.73	6.58	20.80	12.79	5.02

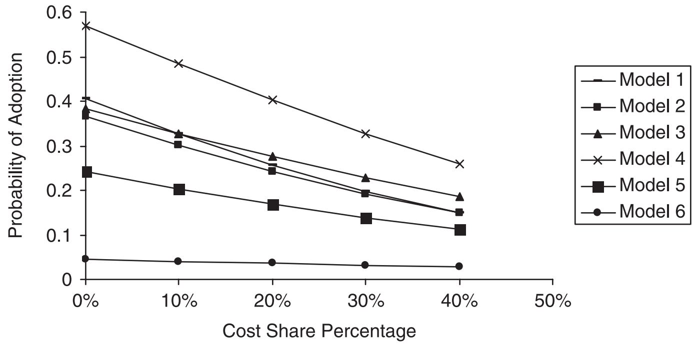

Figure 2 Rotational grazing adoption by farmer cost share rate.

Responses to questions dealing with why farmers were or were not willing to adopt rotational grazing with a cost-share provide additional insight. It is expected that those who believed they had too few animals to practically use the system (41 per cent) or preferred not to deal with the additional management and labour required (29 per cent) would unlikely be swayed much by cost-share increases. This partially explains the relatively low price sensitivity in the model and respondents who were unwilling to adopt with a 100 per cent government cost share. Only 9 per cent of those responding negatively did so because they needed more information, suggesting the high uncertainty was due less to lack of information than to other factors such as increased management.

Respondents answering that they would adopt typically responded positively due to their belief that soil and water conservation was very important, that rotational grazing was a better way of managing land, or that rotational grazing was profitable under these circumstances, as expected from the conceptual model. Relatively little hypothetical or strategic bias was detected from follow-up questions including ‘I am very concerned about this issue, but I am not sure I could afford to pay this much’ (11 per cent), and ‘I wanted to show support for the government’s funding of EQIP’ (11 per cent), though individuals responding positively to these questions would be candidates for uncertain responses.

6. Conclusions

Uncertainty is found to be important in this CV technology adoption study, and therefore potentially important in other similar studies. Uncertainty regions are likely to be quite wide, leading to discrepancies in WTP to adopt. This is particularly important since a number of studies have used DC methods to elicit WTP in the context of technology adoption. Uncertainty regions in the case of rotational grazing adoption under a cost-share payment are wider than regions found by Ready *et al.* (2001) in a study of the health effects of air pollution. Like any alternative technology or management practice, uncertainty exists with respect to the benefits and costs of rotational grazing. Rotational grazing has been, however, promoted for a number of years, and the authors' experience working with cattle producers suggests most are aware of its managerial requirements. Larger uncertainty regions would be expected in cases where technology is new and the respondent has little prior information about it.

When responses were treated consistently by format, significant differences were not found in percentages responding that they would adopt, though numerically, the PC format resulted in slightly higher adoption. When PC questions were compared with DC questions ignoring the follow-up, DC responses most closely resembled responses of the PC with 'definitely' and 'probably yes' responses, which shows some tendency toward strict conservatism with the DC method.

Management associated with rotational grazing is important in producers' adoption decisions. Management indicators Rotational Grazing, Beef Acres, Stocker Operation, Diverse and Stream Through influenced adoption decisions differently depending upon how uncertain responses were treated. College, a proxy for managerial ability, was also significant in one run. More striking is that 29 per cent of nonadopters indicated they would not adopt due to the additional management and labour requirements. Likewise, environmental attitude influenced adoption decisions differently depending upon how uncertain responses were coded. Like the management factor, response to a follow-up question regarding environmental attitude was striking: a substantial portion would adopt due to soil and water conservation being very important.

How important is cost-share rate in getting cattle farmers to adopt rotational grazing? In all but one model, results show that increasing the government cost-share would increase adoption. Large increases in adoption among cow-calf farmers should not, however, be expected if the cost-share rate is increased, as initial adoption cost issues may be overshadowed by additional management requirements. While maximising profit is a consideration for these farmers, other goals that contribute to uncertainty are also likely to play a significant role in their adoption decisions.

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