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Factors influencing farmers' participation in contractual biodiversity conservation: a choice experiment with northern Australian pastoralists

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Private landholders' contributions to biodiversity conservation are critical in landscapes with insufficient formal conservation reserves, as is the case in Australia's tropical savannas. This study reports results from a discrete choice experiment conducted with pastoralists and graziers across northern Australia. The experiment was designed to explore the willingness of pastoralists and graziers to sign up to voluntary biodiversity conservation contracts. Understanding preferences for contractual attributes and preference heterogeneity were additional objectives. Such knowledge can increase effectiveness and efficiency of conservation programs by informing contract design, negotiation and administration. Random parameter logit modelling showed that of contract attributes, conservation requirement, stewardship payment, contract duration and flexibility in contract conditions significantly influenced choices. Land productivity was a significant factor as were attitudes. There was significant heterogeneity of preferences for all contract attributes. Models were run for best–worst scaling responses and the first preferences subset, with the latter model deemed superior. Latent class modelling distinguished four classes of decision-makers and illustrated different decision heuristics. Conservation investment strategies, which offer farmers contract options that meet biodiversity requirements while accommodating heterogeneous attribute preferences, are likely to lead to increased participation rates. Complementary suasion efforts are also required which espouse the benefits that pastoralists derive from biodiversity and participation in voluntary conservation contracts.

Key words: agri-environmental measures, stewardship payments, payments for environmental services, discrete choice model, preference heterogeneity, attribute attendance.

1. Introduction

The tropical savannas of Australia are a vast area of grass-dominated landscapes that stretches across the north of the continent. The major land use is extensive beef cattle grazing on very large farms, which typically measure hundreds of square kilometres in size (Bortolussi *et al.*, 2005). Tropical savannas also support an abundance of endemic plants and animals. The ecological condition and biodiversity value of Australia's tropical savannas has declined since European settlement due to a number of factors

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including grazing, changed fire regimes, and the introduction and spread of exotic plant and animal species (Lewis 2002; Woinarski and Ash 2002; Woinarski *et al.* 2007; Radford *et al.* 2014; Woinarski 2014). Tropical savannas are currently under-represented in the formal conservation estate, prompting calls for farmers – that is, pastoralists and graziers – to be actively engaged in landscape-scale biodiversity conservation (Woinarski *et al.* 2007). This coincides with increasing interest by the north Australian pastoral industry to explore the provision of environmental services as one possible enterprise and income diversification strategy (Puig *et al.* 2011).

To date, participation of north Australian pastoralists and graziers in biodiversity conservation projects has been low (ABS 2011). This is likely due to a combination of paucity of such projects in northern Australia and ineffective targeting and design of past and existing projects (Hajkowicz 2009). Designing incentive programs that are both effective and efficient requires an understanding of, firstly, the financial resources required to incentivise a sufficient number of farmers to participate in on-farm conservation and, secondly, the way in which program and contract design and administrative features influence participation.

Choice experiments are a stated preference method and are ideally suited to help the design of new agricultural markets. A potential emerging market in northern Australia is for private biodiversity conservation services, whereby farmers receive a recurring stewardship payment in return for undertaking actions that support biodiversity. Policies and programs based on the notion of payments for environmental services (PES) have existed in other countries and parts of southern Australia for some time, but are a recent topic in a northern Australia context (Greiner *et al.* 2009a). Choice experiments have been used elsewhere to inform the design of agri-environmental and PES programs (Ruto and Garrod 2009; Espinosa-Goded *et al.* 2010; Christensen *et al.* 2011; Beharry-Borg *et al.* 2013; Broch *et al.* 2013; Kaczan *et al.* 2013). Very few and only locality-specific choice experimental studies with pastoralists and graziers have been conducted in northern Australia to date (Rolfe and Windle 2005; Adams *et al.* 2014) and consequently no comprehensive understanding exists of how the north Australian beef industry may engage with such programs to assist landscape-scale biodiversity conservation efforts. To fill this knowledge gap, a choice experiment was designed and implemented (Greiner *et al.* 2014).

This study focuses on data analysis and presentation of results. In doing so, the paper pursues a number of objectives. It contributes to the body of empirical research using choice experiments to inform conservation policy. In particular, the research results generate the knowledge foundation for the design and tailoring of contractual biodiversity conservation to the distinct landscape and farm operating conditions of Australia's tropical savannas. The paper achieves this by exploring farmers' willingness to participate in contractual on-farm biodiversity conservation, preferences for and trade-offs between contract attributes, and the influence of socio-economic and psychological variables on stated participation. The paper also adds to the methodological discourse on choice experiments by comparing model results derived from the full best–worst scaling data set with results obtained from the first preference subset. The combination of mixed multinomial choice modelling and latent class modelling explores and explains the preference heterogeneity encountered among pastoralists and graziers.

The method section of the paper summarises the rationale for and key design features of the discrete choice experiment and choice modelling techniques employed. It also provides an overview of the study area and explains aspects of survey implementation. The results section provides relevant descriptive survey results and shows and interprets the choice experimental results. The paper concludes by discussing the results in the context of the international literature and offering conclusions as to the policy relevance of the findings.

2. Method

2.1. Design of the discrete choice experiment

Choice experiments are based on the presumption that participants evaluate the alternatives presented to them in a choice task by choosing the alternative (among those presented in the task), which gives the greatest relative utility (Hensher *et al.* 2005). In the given research context, this means that a responding pastoralist will choose conservation contract A over B, if $U(X_A, Z) > U(X_B, Z)$, where U represents his/her indirect utility function, X_A the attributes of alternative A, X_B the attributes of alternative B, and Z the personal (e.g. socio-demographic and attitudinal) and property characteristics (e.g. size, land productivity, farm profitability, ownership structure) that influence the pastoralist's utility. Choice analysis requires the inclusion of a stochastic error term ε in the utility function to reflect the unobservable factors in the respondent's utility function. Thus, a pastoralist will choose alternative A over B, if $V(X_A, Z) + \varepsilon_A > V(X_B, Z) + \varepsilon_B$, where V is the measurable component of utility estimated empirically, and ε_A and ε_B reflect the unobservable factors in the pastoralist's utility function of alternative A and B, respectively.

There are a range of design decisions to be made, in particular relating to the expected make-up of the utility function, statistical properties of the experimental design, likely model to be used for data analysis and number of choice tasks, attributes and attribute levels defining an alternative, number of alternatives defining a choice, and response mechanism (Hoyos 2010; Bliemer and Rose 2011). All design decisions ultimately influence the results of choice experiments and resulting recommendations. A good design is able to explain more of the observed variance and minimises the stochastic element ε. A detailed deliberation of all choice design considerations and decisions relating to the discrete choice experiment (DCE) for this study is given in Greiner *et al.* (2014). Table 1 offers a summary of other key choice design elements.

Table 1 Summary description of the choice experimental design

Design elements	Expression	Explanation
Conceptual construct	Willingness to accept	WTA provided construct validity as farmers have property rights over their land and contracts ask them to give up elements of those rights in return for recurring payments.
Response format	Best-worst scaling	Compared to 'pick one', best-worst scaling delivers a full ranking of all alternatives contained in the choice task. Ranking was achieved through sequential identification of 'best', 'worst' and 'second best' alternatives.
Number of alternatives	Three alternatives plus 'none' option	Three contract alternatives were offered plus a 'none' option to ensure conceptual validity of choice task given that participation in contractual biodiversity conservation was voluntary.
Labelling of alternatives	Unlabelled	Generic contract options were offered to focus respondents' attention on trading off contract attributes.
Types and number of attributes	Five	Attributes were developed in consultation with the pastoral industry and confirmed through pilot testing and pretesting. Attributes defined the hypothetical conservation contracts in terms of the conservation requirement and its impact on cattle production, conservation payment, contract length, flexibility and monitoring arrangements. Attribute details are shown in Table 2.
Number of choice tasks per respondent	Six	The final design included 24 choice tasks, which were blocked into four versions of six choice tasks each. Each survey contained one block, that is each respondent answered six choice tasks. Blocks were assigned randomly. In the pretest, respondents answered two blocks each.
Statistical properties	Bayesian D-efficient	Compared to orthogonal designs, efficient designs lead to smaller standard errors in model estimation at smaller sample sizes. Modified Federov algorithm was used, which does not force attribute-level balance. D-error criterion was used to optimise efficiency of the experimental design. The design was updated following pretest of the survey with priors derived from pretest choice data. The Bayesian D-error for the final design was 0.0716. Design was optimised for choice data analysis with RPL.

Here, only the matters of response mechanism and model to be used for data analysis are revisited in detail as they bear direct relevance to the results.

The response format was multiprofile 'best–worst scaling' (Marley and Flynn 2012). The more commonly used 'pick one' format only reveals the first preference among the alternatives while best–worst scaling is designed to deliver a full ranking of all alternatives contained in a choice set. By offering choice data in addition to the first preference, best–worst scaling offers a means of data augmentation and is particularly useful in situations where the sample size is expected to be low – as was the case here – or in situations where the number of choice tasks needs to be minimised (Potoglou *et al.* 2011; Lancsar *et al.* 2013). Best–worst scaling has also been found to be superior when dealing with qualitative data such as the different conservation requirements and different monitoring arrangements (Flynn *et al.* 2007).

Attributes and attribute levels were determined in a multistage process involving literature review, expert and industry consultation, and pilot testing. The final experiment is summarised in Table 2. The definition of conservation requirements was guided by (i) the idea of a multitenure reserve systems (Fitzsimons and Wescott 2008), which would see land taken out of cattle production and managed, by the pastoralist, exclusively for biodiversity conservation, and (ii) co-existence of grazing and biodiversity, based on the premise that conservation of many species of animals and plants is compatible with grazing, provided grazing land management respects the needs of these species (Woinarski and Ash 2002). Payment levels were guided by historical data about the land productivity of the tropical savannas, in particular the value of cattle sales per hectare during 1992–2011 as derived from farm survey data (ABARES, 2012) and industry comment.

The experiment adopted a Bayesian D-efficient design (Sándor and Wedel 2001; Bliemer *et al.* 2009; Bliemer and Rose 2013). Priors were estimated from results of a pretest of the DCE. The design was optimised for random parameter logit (RPL) modelling of choice data. A final panel design was generated with 24 choice tasks being blocked into four versions of six choice tasks (Greiner *et al.*, 2014). Each choice task consisted of three contract alternatives and a 'none' option to mimic the voluntary nature of conservation contracts. Respondents were asked to pick their preferred option ('1st preference') and subsequently indicate the least preferred then second preferred option in any given choice task. This best–worst scaling format allowed for all contract alternatives and 'none' to be ranked. Figure 1 provides an example of one discrete choice task.

Prior to choice data analysis, protest respondents needed to be identified and removed from the analysis (e.g. Windle and Rolfe 2014). Protest respondents are respondents who had not engaged with the choice experiment, meaning their stated zero WTA was unlikely to be a reflection of their true WTA. A follow-up question was asked of those respondents who answered 'none' as their preferred alternative in all choice tasks to explore the underlying reason. If the reason was insufficient monetary incentive offered

Table 2 Contract attributes, attribute levels and explanation

Attributes	Levels	Definition and other relevant details
Conservation requirement	3 levels: Short spelling Long spelling Total exclusion	The conservation requirement expresses the environmental service to be remunerated. Focus is on broad-scale biodiversity conservation by removing cattle from the contract area either completely for the duration of the contract period or temporarily (i.e. 'spelling' the contract area every year) during times when biodiversity is particularly sensitive to grazing. Defined relative to cattle grazing and associated opportunity cost. SHORT SPELLING: Exclusion of cattle for short periods each year depending on biodiversity need, for example during nesting season of brolga *(Grus rubicunda)*. There is no reduction in cattle production associated with short spelling. Short spelling is the base level for this contract attribute. LONG SPELLING: Prolonged spelling of contract area each year, for example wetlands or riparian areas are spelled during entire dry season, or grassland supporting Gouldian Finches *(Erythrura gouldiae)* is spelled during wet season and until after grasses have seeded. This may result in up to 50% reduction in cattle production from the contract land. TOTAL EXCLUSION: All cattle are removed from the contract area ('locking up country'), resulting in zero cattle production from that land. Fences need to be maintained. Weed and feral animal control need to be conducted. Stray cattle must be removed from contract area every year. A burning regime may have to be implemented to achieve desired biodiversity outcomes.
Annual conservation payment	6 levels: \$1, \$2, \$4, \$8, \$16, \$32; [\$ per ha and year];	The contract stipulates and annual per-hectare conservation payment. The value shown is for year 2013 and the payment is indexed for the duration of the contract period, that is adjusted for inflation. The payment does not cover fixed costs: necessary infrastructure is paid for separately and upfront. Note: To enhance respondents' ability to assess the conservation payment in the context of their cattle enterprise, their business situation was established and an indicative value of per-hectare income from cattle production derived. Respondents were also prompted to consider the cost implications of each of the conservation

Table 2 (*Continued*)

Attributes	Levels	Definition and other relevant details
		requirements – for example, cost savings associated with running a smaller herd or additional costs of feral animal control action – and risk dimensions – for example, accumulated biomass exacerbating fire risk and therefore requiring controlled burning.
Contract length	4 levels: 5, 10, 20, 40 years	No perpetual arrangement or covenants (when conservation requirements are registered on the land title) are considered. If property is sold, the contract transfers to new owner unless he/she chooses to discontinue.
Flexibility	2 levels: Flexibility No flexibility	No flexibility: Standard contract with fixed contract conditions. Penalties may apply if conditions are violated. Base level. Flexibility: Farmer has the right to negotiate a 1-year suspension of the contract in 'exceptional circumstances' and, if suspension is granted, graze the contract area during specified exclusion periods without incurring a penalty. Maximum frequency 1 in 5 years. No conservation payment received during that year.
Monitoring (conducted by)	2 levels: External Self	External monitoring: The administrating agency undertakes regular monitoring or contracts an independent provider for the task. Base level. Self: The pastoralist undertakes the monitoring but random spot-checks are conducted to validate results of self-monitoring. Each year the reports of 25% of program participants are validated.

by any of the alternatives on offer, the respondent was retained in the choice data; if it was disagreement with the conceptual context of the valuation scenario, the respondent was removed from the choice data.

2.2. Survey of north Australian pastoralists and graziers

The objective of the research was to inform landscape-scale biodiversity conservation in Australia's tropical savannas by eliciting information from pastoralists and graziers. It was thus paramount to capture a geographically diverse and sufficiently large sample of properties in the empirical investigation. The research area (Figure 2) included approximately one million sq km of tropical savannas (TS-CRC 2014), intersecting with the 'north live cattle export region' (Gleeson *et al*. 2012). The north live cattle industry is based on *bos indicus* type cattle, which are suitable for tropical conditions and resistant to ticks. Cattle graze on native pastures of low nutrient value, which typically carry between 2 and 10 head of cattle per sq km (PWC 2011).

Block B Choice Situation 2	Option A	Option B	Option C	None
Conservation requirements	Cattle exclusion for proLONGed periods; up to 50% loss of cattle production	TOTAL exclusion of cattle + active management for biodiversity outcomes	TOTAL exclusion of cattle + active management for biodiversity outcomes	
Annual payment ($/ha)	$ 8/ha	$ 32/ha	$ 16/ha	
Contract length (years)	10 years	40 years	5 years	
Flexibility of conditions	Flexibility	No flexibility	No flexibility	
Monitoring conducted by	Self (25% random spot-checks)	Self (25% random spot-checks)	External	
Q1: Which option would you choose?	○	○	○	○
Q2: Which is your least preferred option?	○	○	○	○
Q3: Which is your 2nd preferred option?	○	○	○	○

Figure 1 Illustration of a discrete choice task.

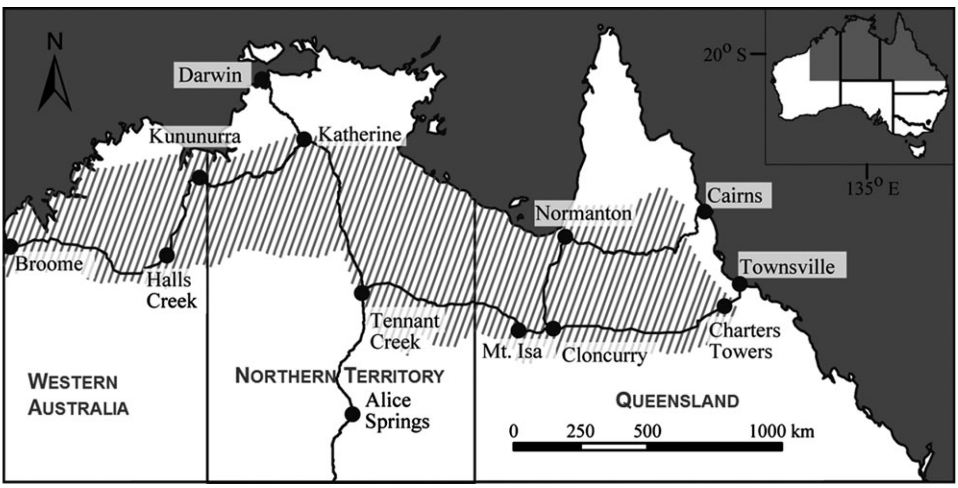

Figure 2 Overview of research area.

The key market of cattle from this region is live export, predominantly to south-east Asia.

The number of potential research participants was estimated to be <700 (Western Australia ≈ 35, Northern Territory ≈ 110, Queensland ≈ 550) due to the generally large size of stations and consolidation of stations into larger pastoral enterprises. A recent survey of pastoral properties in the Northern

Territory reported an average property size of approximately three thousand sq km across the Katherine and Barkly regions (DPIF 2010), which are also covered in this survey. To maximise opportunities for pastoralists to participate in the research and thereby maximise response rate and minimise participation bias of the sample (Wagner 2012), different response formats were offered to accommodate respondents' preferences and to capture decision-makers within business units.[1] A survey containing the choice experiment was conducted during April to July 2013, and 104 valid surveys were completed.

Principally, the survey was administered face-to-face during visits by the lead researcher on pastoral properties or the company's head office. Visits were pre-arranged by telephone and all pastoralists and graziers who were prepared to participate in the survey and were available at a time matching the travel itinerary were interviewed.[2] In addition, research meetings with groups of pastoralists were conducted in association with industry and community events. Facilitation of meetings ensured integrity of the quantitative data in terms of independence of responses. In three instances, respondents completed the survey in their own time and provided the response by mail.

Responses captured approximately 15 per cent of the estimated sample frame with good coverage achieved in all three states/territories and a variety of property sizes and situations represented in the sample (Table 3). Total area coverage was approximately 250,000 km^2, or about one quarter of the research area.

2.3. Choice data analysis

Prior to choice data analysis, four protest respondents (3.8 per cent, all from Queensland) were identified. As each survey contained multiple choice tasks (Greiner *et al*. 2014), panel specification of the choice models was necessary. Panels were unbalanced because some respondents did not complete all six choice tasks and respondents who participated in the pretest and completed 12 choice tasks were included in the full sample. The design of survey and choice data sets are published (Greiner 2014). Data analysis was conducted in ®NLOGIT 5 software (Econometric Software Inc 2012).

The increasing use of random parameter logit (RPL) and latent class (LC) models for the analysis of choice experiments in farming contexts has been underpinned by a recognition of the heterogeneity in farm conditions and farmer preferences, and the desire to make this heterogeneity relevant for

[1] For corporation-owned properties, head office was initially contacted regarding participation in the survey. The CEO or GM decided who was best to complete the survey. In some instances, station managers were subsequently interviewed. In other instances, a relevant person at head office would complete the survey for either the entire property or agglomeration, or part thereof.

[2] The lead researcher drove in excess of 25,000 km to visit pastoralists and conduct research meetings.

Table 3 Overview statistics of survey respondents

Variable (unit)	Measure/Category label	Value
Property size (km^2)	Mean	2411
	Median	775
	Minimum	18
	Maximum	16,116
	Sample total	250,750
Herd size (head)	Mean	15,925
	Median	7000
	Minimum	50
	Maximum	110,000
	Sample total	1,656,200
Stocking rate (head/km^2)	Mean	8.9
	Median	8.1
	Standard deviation	4.9
	Minimum	0.8
	Maximum	22.8
Profit of the beef enterprise in 2011/12 (% of respondents)	Large profit	7%
	Small profit	36%
	Broke even	21%
	Small loss	17%
	Large loss	20%
Respondent's role on the property (% of respondents)	Owner-Manager	62.1%
	Employed manager	26.2%
	Other	11.7%
Gender of primary respondent (% of respondents)	Male	81.6%
Age of primary respondent (% of respondents)	<30 years	5.8%
	30–39 years	24.3%
	40–49 years	26.2%
	50–59 years	25.2%
	60+ years	18.5%
Business structure (% of respondents)	Family-owned	80.8%
	Corporation-owned	19.2%
Length of current property ownership (% of respondents)	<5 years	8.7%
	5–9 years	11.7%
	10–19 years	26.2%
	20–39 years	29.1%
	40+ years	24.3%
Membership of industry/NRM organisation(s) (% of respondents)	Yes	76.7%
Previous participation in a conservation program (% of respondents)	Yes	32.7%

policy formulation (e.g. Jaeck and Lifran 2014; Schulz *et al*. 2014). RPL modelling was adopted as the principal data analytical method to establish the influence of contractual attributes on stated willingness to participate in contractual biodiversity conservation, trade-offs between them, and preference heterogeneity. RPL is a mixed multinomial logit model, which relaxes key assumptions constraining the interpretation of a multinomial logit (MNL) model, namely (i) IID – that is, that unobserved effects are 'extreme value 1' distributed, independent and identically distributed, (ii) independence of observed choices and (iii) homogeneity of preferences (Hensher *et al*.

2005). RPL models take into account heterogeneity of the parameter values among respondents (Train 2000; Hensher *et al.* 2005; Marsh 2012; Mariel *et al.* 2013). Simulations are required in RPL models to provide parameter approximations. Parameters were estimated using 1000 Halton draws. In addition to the attributes, a number of covariates were included in both models as nonrandom parameters. Those found to be not significantly associated with choices in both models were deleted from the final models while significant covariates were retained. Table 4 details the variables contained in the final, parsimonious models.

To further explore heterogeneity of preferences among respondents, LC models were also estimated. LC models assign respondents into behavioural groups or latent classes, thus accounting for taste differences or different types of decision heuristics (Beck *et al.* 2011). Preferences are assumed to be homogenous within each latent class but differ between classes (Colombo *et al.* 2009). There is no common acceptance of the best criteria for determining the correct number of classes (Nylund *et al.* 2007) and parsimony and interpretability are key. Determining the final number of classes was therefore an iterative process, combining quantitative measures of model fit and meaning in a given context (Beck *et al.* 2011).

Table 4 Model Variables

Variables	Details
Attributes	
TOTAL EXCLUSION	Dummy coded 1 = Total exclusion of cattle is required to care for biodiversity
LONG SPELLING	Dummy coded 1 = Cattle have to be removed from the land for long spelling periods every year, which may result in a loss of up to 50% of cattle production from that area
PAY	Conservation payment [$ per ha and year, base year 2013, indexed for contract period]
YEARS	Contract period [years]
FLEXIBILITY	Right to negotiate with funder to suspend contract in 'exceptional circumstances': 1 = yes, 0 = no
MONITORING	Who conducts the monitoring: 1 = self (i.e. grazier but with 25% spot-checks every year), 0 = external
ASC	Alternative specific constant = 1 for status quo alternative
Covariates	
LANDPROD	Land productivity; measured as 3-year average stocking rate [head of cattle per km^2, average across the enterprise] (Table 3).
BIO-ATT	Attitude towards biodiversity; measured in terms of agreement with statement 'Biodiversity is important to me personally' [5-point response scale: 1 = strongly disagree to 5 = strongly agree]
PES-ATT	Attitude towards financial incentives to encourage on-farm conservation; Measured as perceived effectiveness of 'financial incentive schemes such as the one explored in this research to help you undertake (more) conservation activities on your operation' [5-point response scale: 1 = not effective at all to 5 = extremely effective]

RPL and LC models were run on the fully ranked choice data provided by the ‘best–worst’ scaling design. The same models were also run of a subset of the data which contained only the first preference choice made in each choice task. This is referred to as the ‘1st preference’ data set, which mimics a ‘pick one’ choice design. Casewise deletion was used for missing covariate values, meaning that respondents for whom covariate values were not available were eliminated from the analysis. This resulted in 1643 and 598 observations being available in the fully ranked ‘best–worst’ choice data and ‘1st preference’ subset, respectively.

3. Results

3.1. RPL model results

The results for the RPL models for both best–worst data (i.e. full preference specification) and 1st preference data are summarised in Table 5. Both models delivered a good statistical fit as indicated by values of pseudo R^2 of

Table 5 RPL model results for 1st preference and best-worst data

	Best–worst model		1st preference model	
	Coefficients	SE	Coefficients	SE
Random parameter means				
TOTAL EXCLUSION	−1.102***	0.251	−2.866***	0.553
LONG SPELLING	−0.110	0.144	−0.833**	0.342
PAY	0.114***	0.016	0.254***	0.034
YEARS	−0.045***	0.005	−0.110***	0.017
FLEXIBILITY	0.826***	0.150	1.483***	0.308
MONITORING	−0.237**	0.100	−0.324	0.221
Random parameter standard deviations				
TOTAL EXCLUSION	1.164***	0.279	1.781***	0.490
LONG SPELLING	0.941***	0.132	1.726***	0.336
PAY	0.108***	0.015	0.161***	0.030
YEARS	0.031***	0.006	0.074***	0.013
FLEXIBILITY	0.996***	0.262	1.518***	0.358
MONITORING	0.356	0.264	0.908**	0.365
Nonrandom parameters				
LANDPROD	−0.043***	0.014	−0.129***	0.041
BIO-ATT	0.637***	0.147	0.636**	0.286
PES-ATT	0.351***	0.088	0.575***	.1904
ASC	4.051***	0.712	3.800**	1.492
Model statistics				
Observations	1643	–	598	–
Log likelihood	−1521	–	−565	–
AIC/N	1.873	–	1.943	–
McFadden Pseudo R^2	0.332	–	0.319	–
Chi-squared	1514	–	528	–

Note: ***, **, *significance levels at 1%, 5% and 10%, respectively. See Table 4 for definition of variables. ASC, alternative specific constant; SE, Standard error.

0.33 and 0.32, respectively. At a general level, considering coefficient direction and significance, the two models yielded very similar results. The ASC was positive and significant for both models meaning that there were preferences towards the 'none' option, which could not be explained by the variables contained in the model.

Direction of attribute influence was consistent with economic theory. Higher conservation payments (*'Pay'*) significantly increased likelihood of participation in conservation contracts. Longer contract terms (*'Years'*) significantly reduced the likelihood of participation. The need for *Total exclusion* of cattle had a significant negative impact on likely participation, with the coefficient much larger compared to a requirement for a *Long Spelling* period each year. Both conservation levels were defined in terms of opportunity costs relative to short spelling of the contract area each year, which would not affect the cattle production from the contracted land (Table 2). The 1st preference model indicated a significant disutility of *Long Spelling* while the disutility in the best–worst model was not significant. The inclusion of flexibility provisions into contracts, that is the right to negotiate contract suspension in exceptional circumstances, influenced stated uptake of conservation contracts significantly and favourably. External monitoring arrangements were found to be favoured by respondents over self-monitoring, but only the best–worst model found *Monitor* to significantly influence preferences. From an interpretation perspective, the 1st preference model provided a better fit with the narrative that the lead researcher found emerging from the interviews, namely that opportunity costs from changes to grazing regimes mattered most for the 1st preference choice while monitoring arrangements played a minor role in 1st preference choices but were often considered in the subsequent choices of each choice task.

The lesser importance of monitoring compared to other attributes was also evident from stated attribute attendance. After completing the choice tasks, respondents were asked to quantify their attribute attendance: '*When making your choice decisions, how strongly did you consider each of the attributes?'* The rating scale was 1 = never to 5 = always. Attribute attendance for *Monitor* had a mean value of 3.07, with 15 per cent of respondents stating that they 'never' considered it and 23 per cent considering it only 'sometimes'. Mean attribute attendance of other attributes was as follows: *Conservation Requirement* 4.54, *Pay* 4.37, *Years* 4.49, and *Flexibility* 4.18.

Of covariates defining the pastoral business, land productivity *('Landprod'*) was found to negatively and significantly influence participation probability, meaning that pastoralists grazing less productive land were significantly more likely to participate. Of covariates capturing social–psychological dimensions, respondents' intrinsic interest in biodiversity ('*Bio-Att')* and favourable opinion of the concept of payments for environmental services as a policy mechanism ('*Pes-Att')* influenced participation positively and significantly. Covariates that were tested but not included in the parsimonious model because they were not statistically significant included respondent age, respondent education, property size, property ownership (corporate or family owned), previous participation in conservation programs and enterprise profitability.

The WTA estimates for the choice attributes were calculated as the negative of the ratio of each attribute coefficient to the price coefficient. Confidence intervals were estimated using the Krinsky and Robb (1986) procedure based on the unconditional parameter estimates and applying 1000 simulations to calculate the confidence intervals in this procedure. The results of the 1st preference model (Table 6) show that *ceteris paribus*, to get respondents to accept conservation requirements involving total exclusion of cattle from the contract area required an annual payment of approximately \$11 per hectare per year while requiring them to spell land for long periods every year during times when biodiversity was sensitive to cattle grazing required a lower conservation payment of around \$3.50 per hectare per year. Introducing flexibility provisions into the contract reduced the payment that pastoralists required by almost \$6 per hectare per year. The inverse of this ‘discount’ in exchange for some level of contractual flexibility can be interpreted as a risk premium that respondents applied to contracts that they thought might limit the scope for farm-level responses to environmental variability.

3.2. Latent class model

A four-class latent class model supports the existence of preference heterogeneity for contract attributes and illustrates both the different

Table 6 WTA estimates and confidence intervals for the RPL 1st preference model

Attribute	Summary description	Mean WTA (\$/ha)	95% confidence interval (\$/ha)
TOTAL EXCLUSION	Implementing a conservation strategy that requires cattle to be excluded from contract area for the duration of the contract	11.08	(7.45–14.47)
LONG SPELLING	Implementing a conservation strategy whereby the contract area is spelled every year for an extended period of time resulting in up to 50% loss of cattle production from that area	3.45	(0.71–5.95)
YEARS	Adding 1 year to the contract duration	0.41	(0.31–0.53)
FLEXIBILITY	Introducing into contracts the possibility that a grazier can negotiate to suspend the contract in ‘exceptional circumstances’, but no more than 1-in-5 years	−5.90	(−8.54 to −3.47)
MONITORING	Moving from an external monitoring system to monitoring being undertaken by the grazier (with occasional spot-checks)	1.17	(−0.52 to 3.02)

Table 7 Latent class model results for 1st preference data

	Class 1		Class 2		Class 3		Class 4	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Attributes								
TOTAL EXCLUSION	−1.670***	0.531	−3.134**	0.225	−4.915***	0.051	−0.117	0.539
LONG SPELLING	−0.954**	0.456	1.184**	0.508	−2.706***	0.681	0.183	0.443
PAY	0.145***	0.035	0.152***	0.045	0.209***	0.040	0.236***	0.042
YEARS	−0.181***	0.031	−0.072***	0.018	−0.005	0.013	−0.071***	0.016
FLEXIBILITY	1.111***	0.374	2.304***	0.621	1.709***	0.592	0.567*	0.297
MONITORING	−0.705**	0.335	−0.284	0.450	−0.274	0.392	0.153	0.251
Membership probability (%)	0.318***	0.053	0.197***	0.051	0.155***	0.047	0.330***	0.056
Model statistics								
Observations	599	–	–	–	–	–	–	–
Log likelihood	−581	–	–	–	–	–	–	–
AIC	1216	–	–	–	–	–	–	–
McFadden Pseudo R2	0.301	–	–	–	–	–	–	–

Note ***, **, *significance levels at 1%, 5% and 10%, respectively. ASC, alternative specific constant; SE, Standard error.

heuristics that respondents applied in the decision to participate in contractual biodiversity conservation and the diverse preference structures among respondents (Table 7). Common between all four classes was a significant positive influence of P_{AY} at $P < 0.001$, indicating the central role of the level of stewardship payment in respondents' utility function and decision-making. Class 1, with a membership probability of approximately 32 per cent, had distinct preferences across all other contract attributes, which were very similar to the whole-of-sample for total exclusion, long spelling and flexibility, but had a higher time preference (average WTA for an additional contract year was \$1.24/ha/year) and also derived a significant disutility from self-monitoring (WTA \$4.85/ha/year). In contrast, class 4, with a membership probability of 33 per cent, did not distinguish between the different conservation requirements but focussed on the stewardship payment and contract duration. Probability of membership in classes 2 and 3 was <20 per cent each. Class 2 had a positive preference for long spelling arrangements (compared to short spelling), a strong dislike of total exclusion (equivalent to WTA \$20.63/ha/year) but was insensitive to contract length. Class 3 associated a significant and high disutility with total exclusion and long spelling, and with longer contracts (mean marginal WTA of \$0.30/ha/year). Model testing found no relationship between covariates and class membership probability, indicating that class probability was not related to socio-demographic or attitudinal factors.

4. Discussion

The research presented in this paper is based on a sample of 104 north Australian graziers and pastoralists. While the sample may appear small in absolute terms, it is large in relative terms as respondents collectively manage approximately 250,000 square kilometres of land, or approximately one quarter of the study area. The sample also succeeds in capturing the heterogeneity of business and socio-demographic conditions of pastoral enterprises across the tropical savannas. The sample size is sufficiently large to estimate all attribute coefficients at the level of $P < 0.01$ statistical significance because of the D-efficient choice experimental design, which requires a much smaller sample size than a random orthogonal design (Rose and Bliemer 2013). A systematic review of discrete choice experiments based on design features and sample size by Bliemer and Rose (2011) supports the assertion. Limitations associated with small sample size arise, however, because the number of covariates that can be investigated in any given model is constrained because of loss of observations caused by casewise deletion of missing covariate values. This limitation was accepted in preference of imputation of missing values.

RPL models were developed for the best–worst scaling data (i.e. full preference specification) as well as the subset of 1st preference data. The models yielded similar but not identical results and different WTA estimates for a number of attributes. Differences in estimates between the two elicitation methods have been reported in the literature before (Louviere and Islam 2008). In this case, there was virtually no difference for *Years*, but difference for some qualitative variables was up to 73 per cent although the direction of impact remained the same. The likely reason is inconsistency in the attribute trade-offs respondents made between the three choices required in each best–worst scaling task (Giergiczny *et al.* 2013). This assertion is corroborated by the lead researcher's observation that respondents found it increasingly hard to perform successive choices required by each choice task (Figure 1). Consequently, the 1st preference data was deemed to produce more compelling models for an industry-wide analysis, which is the focus of this paper. The augmented choice data, based on full best–worst specification, may prove valuable for more in-depth analytical applications.

The model results about attribute preferences are consistent with expectations based on the literature on farmers' stated participation in environmental services programs elsewhere. Pastoralists and graziers require a greater monetary incentive to sign up to longer contract periods or alternatives causing higher opportunity costs, and they prefer flexibility (Windle and Rolfe 2005; Ruto and Garrod 2009; Espinosa-Goded *et al.* 2010; Christensen *et al.* 2011; Peterson *et al.* 2011; Yu and Belcher 2011; Broch and Vedel 2012; Jaeck and Lifran 2014).

Interestingly, the research does not find any statistically significant influence on the decision to participate in contractual biodiversity conservation contracts based on property size, whether properties are family-operated or corporation-owned, age and education level of pastoralists, and previous experience with conservation programs. This means that likely participation cannot be predicted on the basis of socio-demographic or business descriptors. The principal factors explaining participation choice across the northern pastoral industry are the contract attributes and foremost among them the conservation requirement and level of stewardship payment offered. However, it is important to note that pastoralists have heterogeneous preferences for contract attributes, as demonstrated by the RPL model results and illustrated by the latent class model results.

Across the industry, participation is distinctly positively influenced by favourable attitudes towards biodiversity and towards PES. This finding highlights the importance of complementing new PES-style programs with education and extension. Attitudes can be changed by explaining how PES work and illustrating the social co-benefits that voluntary conservation contracts can deliver to farmers (Greiner and Stanley 2013).

Introducing some level of contract flexibility significantly and positively influences contract adoption. Flexibility –defined in this context as possibly being able to give cattle access in exceptional circumstances to a grass resource that may have been built up through contractual biodiversity conservation – greatly reduces the premium that pastoralists seek for signing up to contractual biodiversity conservation. This finding needs to be seen in the context of the highly risky business environment that north Australian pastoralists operate in (Greiner *et al.* 2009b).

5. Conclusions

The research generates insights that can help enhance the emerging dialogue between the pastoral industry and potential investors in biodiversity conservation, including government, nongovernment conservation organisations and private businesses that wish to off-set their biodiversity impacts or appear conservation-minded.

This research establishes that the pastoral industry operating across Australia's tropical savannas would consider participating in contractual biodiversity conservation if suitable contracts were available. The choice experimental results support a narrative that decisions about participation in contractual biodiversity conservation are to a large extent driven by the financial merit offered by the contract options relative to costs–including opportunity and transaction costs, and costs associated with conservation action. These considerations are independent of property size, type of business ownership and operator age, but with clear consideration to risk aspects including contract duration and contractual flexibility.

Due to the very large size of enterprises, competitive allocation of contracts through mechanisms such as conservation tenders has limited applicability in the tropical savannas. Targeting pastoralists for participation in contractual biodiversity conservation needs to be based on identification of biodiversity assets. To maximise likelihood of participation of targeted pastoralists, a suite of contract options need to be offered. Contract conditions need to ensure that the requirements of target biodiversity are met while attribute options need to consider business-specific cost structures and the significant heterogeneity in preferences across the pastoral industry. Including some flexibility in contracts gives pastoralists more scope in responding to environmental variability and risk, and will increase program participation and reduce the conservation payments. Offering attribute choice, for example for monitoring arrangements, appeals to different personal preferences and thus also fosters participation.

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References

ABARES (2012). AGSURF Data, Australian Government, Department of Agriculture, Fisheries and Forestry. ABARES, Canberra. Available from URL: http://abares.win.hostaway.net.au/ame/agsurf/agsurf.asp [accessed 10 October 2012]

ABS (2011). *Land Management and Farming in Australia 2009–10*. Australian Bureau of Statistics, Canberra.

Adams, V.M., Pressey, R.L. and Stoeckl, N. (2014). Estimating Landholders' Probability of Participating in a Stewardship Program, and the Implications for Spatial Conservation Priorities, *PLoS One* 9, e97941.

Beck, M.J., Rose, J.M. and Hensher, D.A. (2011). Behavioural responses to vehicle emissions charging, *Transportation* 38, 445–463.

Beharry-Borg, N., Smart, J.C.R., Termansen, M. and Hubacek, K. (2013). Evaluating farmers' likely participation in a payment programme for water quality protection in the UK uplands, *Regional Environmental Change* 13, 633–647.

Bliemer, M.C.J. and Rose, J.M. (2011). Experimental design influences on stated choice outputs: an empirical study in air travel choice, *Transportation Research Part A: Policy and Practice* 45, 63–79.

Bliemer, M.C.J. and Rose, J.M. (2013). Confidence intervals of willingness-to-pay for random coefficient logit models, *Transportation Research Part B: Methodological* 58, 199–214.

Bliemer, M.C.J., Rose, J.M. and Hensher, D.A. (2009). Efficient stated choice experiments for estimating nested logit models, *Transportation Research Part B: Methodological* 43, 19–35.

Bortolussi, G., McIvor, J., Hodgkinson, J., Coffey, S. and Holmes, C. (2005). The northern Australian beef industry, a snapshot. 1. Regional enterprise activity and structure, *Australian Journal of Experimental Agriculture*. 45, 1057–1073.

Broch, S.W. and Vedel, S.E. (2012). Using choice experiments to investigate the policy relevance of heterogeneity in farmer agri-environmental contract preferences, *Environmental and Resource Economics* 51, 561–581.

Broch, S.W., Strange, N., Jacobsen, J.B. and Wilson, K.A. (2013). Farmers' willingness to provide ecosystem services and effects of their spatial distribution, *Ecological Economics* 92, 78–86.

Christensen, T., Pedersen, A.B., Nielsen, H.O., Mørkbak, M.R., Hasler, B. and Denver, S. (2011). Determinants of farmers' willingness to participate in subsidy schemes for pesticide-free buffer zones—A choice experiment study, *Ecological Economics* 70, 1558–1564.

Colombo, S., Hanley, N. and Louviere, J. (2009). Modeling preference heterogeneity in stated choice data: an analysis for public goods generated by agriculture, *Agricultural Economics*. 40, 307–322.

DPIF (2010). *2010 Pastoral Industry Survey: Northern Territory Wide*. Northern Territory Government Department of Primary Industries and Fisheries, Darwin.

Econometric Software Inc (2012). NLOGIT. Australia.

Espinosa-Goded, M., Barreiro-Hurlé, J. and Ruto, E. (2010). What do farmers want from agri-environmental scheme design? choice experiment approach, *Journal of Agricultural Economics* 61, 259–273.

Fitzsimons, J.A. and Wescott, G. (2008). The role of multi-tenure reserve networks in improving reserve design and connectivity, *Landscape and Urban Planning* 85, 163–173.

Flynn, T.N., Louviere, J.J., Peters, T.J. and Coast, J. (2007). Best–worst scaling: what it can do for health care research and how to do it, *Journal of Health Economics* 26, 171–189.

Giergiczny, M., Hess, S., Dekker, T. and Chintakayala, P.K. (2013). In *International Choice Modelling Conference Sydney*. Available from URL: http://www.stephanehess.me.uk/papers/Giergiczny_Hess_Dekker_Chintakayala_final.pdf [accessed 31 January 2014].

Gleeson, T., Martin, P. and Mifsud, C. (2012). *North Australian Beef Industry: Assessment of Risks and Opportunities*. Australian Government Department of Agriculture, Fisheries and Forestry; ABARES, Canberra.

Greiner, R. (2014). Survey of north Australian graziers and pastoralists with choice experiment regarding participation in contractual biodiversity conservation: Dataset. CDU eSpace. http://espace.cdu.edu.au/view/cdu:41684

Greiner, R. and Stanley, O. (2013). More than money for conservation: exploring the social co-benefits from PES schemes, *Land Use Policy* 31, 4–10.

Greiner, R., Gordon, I. and Cocklin, C. (2009a). Ecosystem services from tropical savannas: economic opportunities through payments for environmental services, *The Rangeland Journal* 31, 51–59.

Greiner, R., Patterson, L. and Miller, O. (2009b). Motivations, risk perceptions and adoption of conservation practices by farmers, *Agricultural Systems* 99, 86–104.

Greiner, R., Bliemer, M.C.J. and Ballweg, J. (2014). Design considerations of a choice experiment to estimate likely participation by north Australian pastoralists in contractual on-farm biodiversity conservation, *Journal of Choice Modelling* 10, 34–45.

Hajkowicz, S. (2009). The evolution of Australia's natural resource management programs: towards improved targeting and evaluation of investments, *Land Use Policy* 26, 471–478.

Hensher, D.A., Rose, J.M. and Greene, W.H. (2005). *Applied Choice Analysis: A Primer*. Cambridge University Press, Cambridge, UK.

Hoyos, D. (2010). The state of the art of environmental valuation with discrete choice experiments, *Ecological Economics* 69, 1595–1603.

Jaeck, M. and Lifran, R. (2014). Farmers' preferences for production practices: a choice experiment study in the Rhone river delta, *Journal of Agricultural Economics* 65, 112–130.

Kaczan, D., Swallow, B.M. and Adamowicz, W.L.V. (2013). Designing payments for ecosystem services (PES) program to reduce deforestation in Tanzania: an assessment of payment approaches, *Ecological Economics* 95, 20–30.

Krinsky, I. and Robb, A. (1986). On approximating the statistical properties of elasticities, *Review of Economics and Statistics* 68, 715–719.

Lancsar, E., Louviere, J., Donaldson, C., Currie, G. and Burgess, L. (2013). Best worst discrete choice experiments in health: methods and an application, *Social Science and Medicine* 76, 74–82.

Lewis, D. (2002). *Slower Than the Eye Can See: Environmental Change in Northern Australia's Cattle Lands*. Tropical Savannas CRC, Darwin.

Louviere, J.J. and Islam, T. (2008). A comparison of importance weights and willingness-to-pay measures derived from choice-based conjoint, constant sum scales and best–worst scaling, *Journal of Business Research* 61, 903–911.

Mariel, P., De Ayala, A., Hoyos, D. and Abdullah, S. (2013). Selecting random parameters in discrete choice experiment for environmental valuation: a simulation experiment, *Journal of Choice Modelling* 7, 44–57.

Marley, A.J. and Flynn, T. (2012). Best worst scaling: theory and practice, in Hess, S. and Daly, A. (eds), *Handbook of Choice Modelling*. Edward Elgar Publishing, Leeds (UK).

Marsh, D. (2012). Water resource management in New Zealand: jobs or algal blooms?, *Journal of Environmental Management* 109, 33–42.

Nylund, K.L., Asparouhov, T. and Muthén, B.O. (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: a Monte Carlo simulation study, *Structural Equation Modeling* 14, 535–569.

Peterson, J.M., Smith, C.M., Leatherman, J.C., Hendricks, N.P. and Fox, J.A. (2011). *The Role of Contract Attributes in Purchasing Environmental Services from Landowners*. Unpublished report. Kansas State University, Kansas City.

Potoglou, D., Burge, P., Flynn, T., Netten, A., Malley, J., Forder, J. and Brazier, J.E. (2011). Best-worst scaling vs. discrete choice experiments: an empirical comparison using social care data, *Social Science and Medicine* 72, 1717–1727.

Puig, C.J., Greiner, R., Huchery, C., Perkins, I., Bowen, L., Collier, N. and Garnett, S.T. (2011). Beyond cattle: potential futures of the pastoral industry in the Northern Territory, *Rangeland Journal* 33, 181–194.

PWC (2011). The Australian beef industry: the basics. PriceWaterhouseCoopers. Available from URL: http://www.pwc.com.au/industry/agribusiness/assets/Australian-Beef-Industry-Nov11.pdf [accessed 31 January 2014]

Radford, I.J., Dickman, C.R., Start, A.N., Palmer, C., Carnes, K., Everitt, C., Fairman, R., Graham, G., Partridge, T. and Thomson, A. (2014). Mammals of Australia's tropical savannas: a conceptual model of assemblage structure and regulatory factors in the Kimberley region, *PLoS One* 9, e92341.

Rolfe, J. and Windle, J. (2005). Valuing options for reserve water in the Fitzroy Basin, *Australian Journal of Agricultural and Resource Economics* 49, 91–114.

Rose, J.M. and Bliemer, M.C.J. (2013). Sample size requirements for stated choice experiments, *Transportation* 40, 1021–1041.

Ruto, E. and Garrod, G. (2009). Investigating farmers' preferences for the design of agri-environment schemes: a choice experiment approach, *Journal of Environmental Planning and Management* 52, 631–647.

Sándor, Z. and Wedel, M. (2001). Designing conjoint choice experiments using managers' prior beliefs, *Journal of Marketing Research* 38, 430–444.

Schulz, N., Breustedt, G. and Latacz-Lohmann, U. (2014). Assessing farmers' willingness to accept "greening": insights from a discrete choice experiment in Germany, *Journal of Agricultural Economics* 65, 26–48.

Train, K.E. (2000). *Halton Sequences for Mixed Logit. Working Paper No. E00-278*. Department of Economics, University of California, Berkeley.

TS-CRC (2014). Savanna explorer: North Australian information resource, Tropical Savannas CRC, Darwin. Available from URL: http://savanna.org.au/ [accessed 10 April 2014].

Wagner, J. (2012). A comparison of alternative indicators for the risk of nonresponse bias, *Public Opinion Quarterly* 76, 555–575.

Windle, J. and Rolfe, J. (2005). Diversification choices in agriculture: a Choice Modelling case study of sugarcane growers, *Australian Journal of Agricultural and Resource Economics* 49, 63–74.

Windle, J. and Rolfe, J. (2014). Assessing the tradeoffs of increased mining activity in the Surat Basin, Queensland, Preferences of Brisbane residents using non-market valuation techniques, *Australian Journal of Agricultural and Resource Economics* 58, 111–129.

Woinarski, J.C. (2014). The illusion of nature: perception and the reality of natural landscapes, as illustrated by vertebrate fauna in the Northern Territory, Australia, *Ecological Management & Restoration* 15, 30–33.

Woinarski, J.C.Z. and Ash, A.J. (2002). Responses of vertebrates to pastoralism, military land use and landscape position in an Australian tropical savanna, *Austral Ecology* 27, 311–323.

Woinarski, J.C.Z., Mackey, B., Nix, H. and Traill, B. (2007). *The Nature of Northern Australia: Natural Values, Ecological Processes and Future Prospects*. ANU E Press, Canberra.

Yu, J. and Belcher, K. (2011). An economic analysis of landowners' willingness to adopt wetland and riparian conservation management, *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie* 59, 207–222.