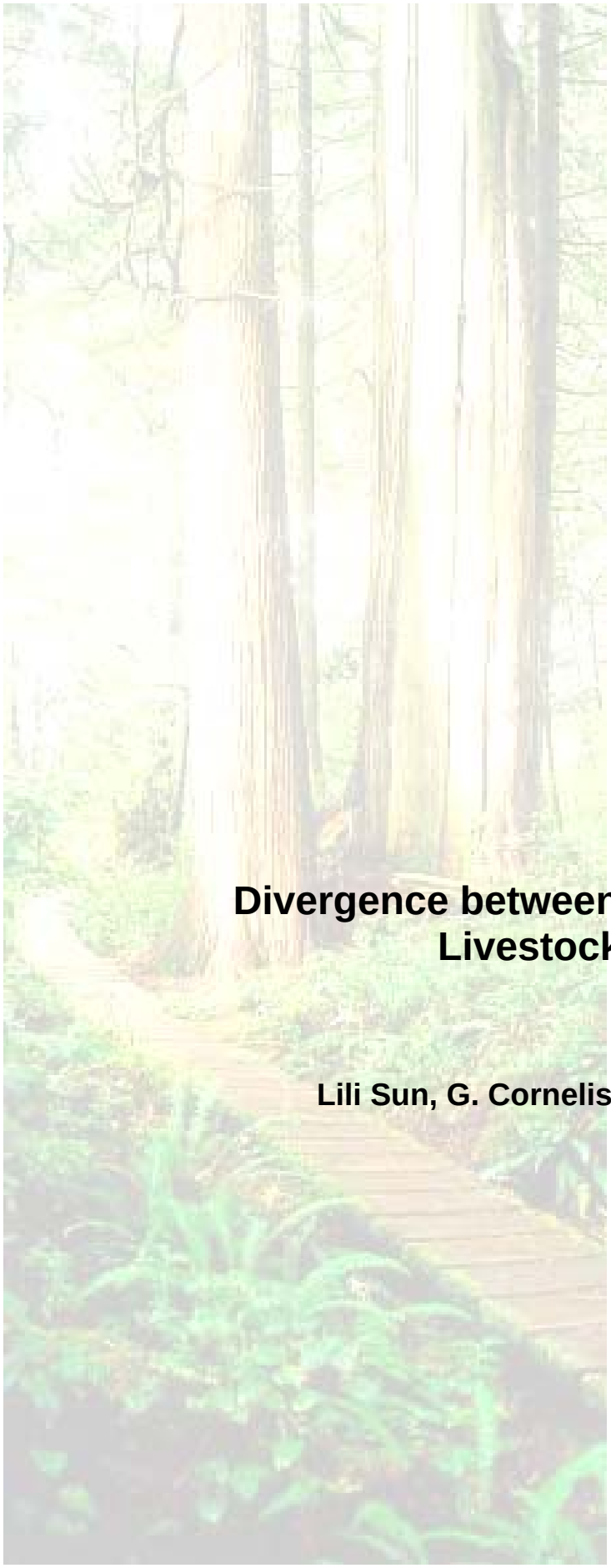

WORKING PAPER
2005-06

Resource
Economics
and Policy Analysis
(REPA)
Research Group

Department of Economics
University of Victoria

Divergence between WTA and WTP Revisited: Livestock Grazing on Public Range

Lili Sun, G. Cornelis van Kooten and Graham M. Voss

July 2005

REPA Working Papers:

2003-01 – Compensation for Wildlife Damage: Habitat Conversion, Species Preservation and Local Welfare (Rondeau & Bulte)
2003-02 – Demand for Wildlife Hunting in British Columbia (Sun, van Kooten, & Voss)
2003-03 – Does Inclusion of Landowners' Non-Market Values Lower Costs of Creating Carbon Forest Sinks? (Shaikh, Suchánek, Sun, and van Kooten)
2003-04 – Smoke and Mirrors: The Kyoto Protocol and Beyond (van Kooten)
2003-05 – Creating Carbon Offsets in Agriculture through No-Till Cultivation: A Meta-Analysis of Costs and Carbon Benefits (Manley, van Kooten, Moeltner, and Johnson)
2003-06 – Climate Change and Forest Ecosystem Sinks: Economic Analysis (van Kooten and Eagle)
2003-07 – Resolving Range Conflict in Nevada? The Potential for Compensation via Monetary Payouts and Grazing Alternatives (Hobby and van Kooten)
2003-08 – Social Dilemmas and Public Range Management: Results from the Nevada Ranch Survey (van Kooten, Thomsen, Hobby, and Eagle)
2004-01 – How Costly are Carbon Offsets? A Meta-Analysis of Forest Carbon Sinks (van Kooten, Eagle, Manley, and Smolak)
2004-02 – Managing Forests for Multiple Tradeoffs: Compromising on Timber, Carbon and Biodiversity Objectives (Krcmar, van Kooten, and Vertinsky)
2004-03 – Tests of the EKC Hypothesis using CO2 Panel Data (Shi)
2004-04 – Are Log Markets Competitive? Empirical Evidence and Implications for Canada-U.S. Trade in Softwood Lumber (Niquidet and van Kooten)
2004-05 – Conservation Payments under Risk: A Stochastic Dominance Approach (Benítez, Kuosmanen, Olschewski and van Kooten)
2004-06 – Modeling Alternative Zoning Strategies in Forest Management (Krcmar, Vertinsky, and van Kooten)
2004-07 – Another Look at the Income Elasticity of Non-Point Source Air Pollutants: A Semiparametric Approach (Roy and van Kooten)
2004-08 – Anthropogenic and Natural Determinants of the Population of a Sensitive Species: Sage Grouse in Nevada (van Kooten, Eagle, and Eiswerth)
2004-09 – Demand for Wildlife Hunting in British Columbia (Sun, van Kooten, and Voss)
2004-10 – Viability of Carbon Offset Generating Projects in Boreal Ontario (Biggs and Laaksonen-Craig)
2004-11 – Economics of Forest and Agricultural Carbon Sinks (van Kooten)
2004-12 – Economic Dynamics of Tree Planting for Carbon Uptake on Marginal Agricultural Lands (van Kooten) (Copy of paper published in the Canadian Journal of Agricultural Economics 48(March): 51-65.)
2004-13 – Decoupling Farm Payments: Experience in the US, Canada, and Europe (Ogg & van Kooten)
2004–14 – Afforestation Generated Kyoto Compliant Carbon Offsets: A Case Study in Northeastern Ontario (Jeff Biggs)
2005–01 – Utility-scale Wind Power: Impacts of Increased Penetration (Pitt, van Kooten, Love and Djilali)
2005–02 – Integrating Wind Power in Electricity Grids: An Economic Analysis (Liu, van

Kooten and Pitt)
2005–03 – Resolving Canada-U.S. Trade Disputes in Agriculture and Forestry: Lessons from Lumber (Biggs, Laaksonen-Craig, Niquidet and van Kooten)
2005–04 – Can Forest Management Strategies Sustain The Development Needs Of The Little Red River Cree First Nation? (Krcmar, Nelson, van Kooten, Vertinsky and Webb)
2005–05 – Economics of Forest and Agricultural Carbon Sinks (van Kooten)
2005–06 – Divergence Between WTA & WTP Revisited: Livestock Grazing on Public Range (Sun, van Kooten and Voss)

For copies of this or other REPA working papers contact:

REPA Research Group
Department of Economics
University of Victoria PO Box 1700 STN CSC Victoria, BC V8W 2Y2 CANADA
Ph: 250.472.4415
Fax: 250.721.6214
http://repa.econ.uvic.ca

Divergence between WTA and WTP Revisited: Livestock Grazing on Public Range

Lili Sun, G. Cornelis van Kooten and Graham M. Voss

Abstract

The research reported here provides further empirical support for the contention that there is a divergence between WTA and WTP. The conclusion is based on results from a 2002 survey of Nevada ranchers that asked about willingness to pay for public forage and WTA compensation to part with grazing rights. WTP and WTA are estimated simultaneously, with the estimators used to demonstrate a statistically significant divergence between WTP and WTA. The simultaneous estimation allows us to identify ranch characteristics that influence the discrepancy in valuations. Ranch size, public grazing allotment, financial distress, and long term commitment to ranching are all significant influences on the disparity. We interpret these results both with respect to general differences in welfare measures and with respect to ranch policy.

JEL Classification Numbers: Q15, Q24, Q51.

Keywords: contingent valuation methods; dichotomous choice surveys; WTA versus WTP; grazing rights and public forage.

1. Introduction

When people are asked to value changes in the availability of a public or environmental good, willingness to accept compensation (hereafter WTA) generally exceeds willingness to pay (WTP), often by a substantial amount. Hanemann [11], building on earlier work by Randall and Stoll [21], demonstrates that divergence between WTA and WTP is to be expected for many environmental goods. Specifically, public goods that have few if any private goods that are ready substitutes, which may often be the case for environmental goods, are likely to have WTA valuations in excess of WTP valuations.[1]

Alternatively, evidence from contingent valuation surveys and experimental markets suggests that individuals become attached to a particular endowment, requiring a higher level of compensation to part with something than they would pay to obtain it (Knetsch [14]). The problem is not on the supply side (availability of substitutes), but lies with preferences. Indifference curves are somehow kinked (and not continuously differentiable) at the endowment. Thus, the observed difference between WTP and WTA remains, even for market goods where there are adequate substitutes, such as mugs and candy bars.[2]

Whatever the explanation, the disparity between the two valuation measures is well established theoretically and empirically, with the empirical evidence nicely summarized in Horowitz and McConnell [12]. The objective of this paper is to examine this disparity in

[1]Divergence in the welfare measures is also positively related to the income elasticity of demand for the good in question, though Hanemann argues the substitution effects are likely to be more important. More generally, the income effect is usually regarded to be insufficient to explain the observed divergences in valuations; see Hanemann [11] and references cited therein.

[2]Empirical support for the endowment effect is presented in Kahneman, Knetsch and Thaler [13] and Knetsch, Tang and Thaler [15]. Shogren et al. [22] and List [16], [17] present evidence against the endowment effect; Shogren et al. use experimental data to demonstrate that, for goods for which substitutes are plentiful, WTP and WTA converge with repeated market participation, but for goods with few substitutes (such as food purchases where health risks are involved) repeated participation did not result in convergence; List finds that the endowment effect is prevalent among inexperienced traders, but not among experienced ones (in his case, trading sport memorabilia). Whether these results convincingly refute endowment effects is the matter of some debate; see Knetsch, Tang and Thaler [15] and Donkers, Gregory and Knetsch [6].

further detail in the context of a recent survey of Nevada ranchers that concerned access to grazing on public lands. The survey elicits both a willingness to pay and a willingness to accept valuation for public forage; in addition it provides a rich set of information about ranch characteristics. The dual nature of the survey, both WTP and WTA, and the extensive information set on ranch characteristics allows us to examine the disparity between welfare measures in a systematic manner. We use a bivariate dichotomous choice framework to model the willingness to pay and accept decisions simultaneously, similar to Poe, Welsh and Champ [20]. This framework allows us to test directly the difference in welfare measures. It also allows us to examine which of the ranch characteristics contribute to the observed differences in welfare measures, providing some information about the importance of close substitutes and endowment effects. To our knowledge, this has not been done previously and is the principal contribution of the paper.

To foreshadow our principal results, we find a significant disparity between willingness to accept and willingness to pay valuations. The discrepancy between valuations is similar to previous studies, with WTA ranging from 2–12 times as large as WTP. We find a number of ranch characteristics associated with this discrepancy: (1) the size of the ranch, which we conjecture may relate to available substitutes for public grazing; (2) the size of allocation of public grazing, which is surprisingly inversely related to the discrepancy in valuations; (3) financial distress; and (4) long term commitment to ranching, either as an occupation or lifestyle. Each of these results bears on public grazing policy, providing insights into ranchers' valuations, as well as some information about the relative importance of substitution effects and endowment effects.

The remainder of the paper is organized as follows. In the next section, we provide a brief background to the issue of livestock grazing on public lands, and we provide a brief description of the 2002 Nevada Ranch Survey. The theoretical model is provided in section

3, while the WTA and WTP estimation results are provided in section 4. We conclude in section 5 with a discussion of policy implications and considerations for further research.

2. Grazing on Public Range and the Nevada Ranch Survey

Although open access grazing ended on some public lands around 1900, it was not until the Taylor Grazing Act of 1934 that it was halted on all public lands in the United States. Over the three decades that followed, administration of grazing on public lands evolved into a system characterized by grazing districts and allotments, limits on herd size (effectively limiting the size of ranches), and fees for public forage using the animal unit month (AUM) measure.[3] While grazing fees differed on U.S. Forest Service and Bureau of Land Management (BLM) lands until 1981, the 1978 Public Rangelands Improvement Act established that all grazing fees would be calculated as a base fee of $1.23 per AUM (established in 1966 using a cost of production approach) that was adjusted using indexes of private grazing values, livestock market prices and rancher operating costs, but with the proviso that the fee not decline below $1.35 per AUM.[4]

The grazing fee reached a high of $2.36 per AUM in 1980 falling to $1.35 in 1985, never again to exceed $2 per AUM; the grazing fee was $1.43 in 2002, falling back to $1.35 in 2003 where it had been for most of the previous decade. This despite the fact that cattle have generally increased in size and private alternatives for grazing averaged $11 per AUM in 1997 (Dietz and Rothenberg [5]). In Oregon, private grazing was valued at an average of $9.23 per AUM in 2004, and an average $8.83 per AUM in the two most southeasterly counties in the State, Malheur ($2.53 per AUM) and Harney ($12.43 per AUM) counties,

[3] An AUM is the amount of forage needed to support one cow and calf, one horse or five sheep for a period of one month.

[4] See Torell et al. [24] and Dietz and Rothenberg [5].

which border Nevada.[5] In 2003, while the BLM grazing fee was set at $1.35, the respective fees charged on state-owned lands in Oregon, Idaho and Washington were $4.16, $5.33 and $7.52 per AUM.[6]

Although rates of return to livestock production average no more than 2 percent while the return to private grazing lands is estimated to average 3.4 percent (Bartlett et al. [1]), grazing permits that give ranchers perpetual rights to graze cattle on public land have positive value.[7] In theory, the value of a grazing permit is equal to the difference between the marginal value of public forage minus the grazing fee appropriately discounted, where the discount rate takes into account the possibility of losing the right to graze livestock at some future time (Gardner [7], [8]). Grazing permits are generally not traded, although they do get capitalized in ranch values, so it is difficult to determine their true value. However, research by Borges and Knetsch [2] does suggest one reason why little trading of grazing permits occurs, namely, that those holding permits value them more highly than those wanting to buy them.

Range economists argue that private and public grazing values are not directly comparable, because operating costs are higher on public lands and private landowners provide services (not available from federal land agencies) that account for at least 30 percent of private value (Bartlett et al. p.429 [1]; Gardner, p.53 [7]). Suppose private grazing sells for $9.23/AUM (the average for Oregon), while the BLM charges $1.35 per AUM. Then the benefit from public forage is $5.11 per AUM ($= 0.7 \times \$9.23 - \$1.35$) and, using the perpetual bond formula (bond value = annual payment $\div$ r, where is r the annual discount rate), a

[5]U.S. Department of Agriculture data for 2004 reported by Barry Adam and viewed 1 June 2004 at www.oregonstatelands.us/rangeland_audit_response.pdf. The disparity between costs of private forage in these counties is surprising. Data for Lake County (the county to the immediate west of Harney) were not available for reasons of confidentiality.

[6]Same source as in previous note.

[7]Grazing permits are considered a privilege and not a right. On May 15, 2000, the U.S. Supreme Court ruled in a unanimous decision that the appeal by the Public Lands Council et al. in opposition to Bruce Babbitt, Secretary of the Interior et al. and the Range Reform Regulations of 1995, has no legal basis. The Court rejected all the arguments that ranchers on public lands have a vested grazing right. See w3.trib.com/∼phxcon/supcourtgraz1.html. Politicians have, however, acted as if the permits are a right.

grazing permit would be worth about $128 per AUM if a discount rate of 4 percent is used ($\approx$ \$5.11/0.04) and \$255 if a rate of 2 percent is used.

Ranchers use of public lands has increasingly come under pressure from environmental groups that see livestock grazing as a contributing factor to the environmental degradation of public lands, and particularly loss of wildlife habitat. The public land agencies have reacted primarily by reducing grazing services. In Nevada, for example, AUMs of grazing have fallen by 32.7 percent (or some 540,000 AUMs) between 1981 and 2002, threatening the viability of some ranchers dependent upon public forage. To address the external impacts of livestock grazing on public lands while making reductions in AUMs politically palatable, Congress has recently begun to consider purchasing ranchers grazing permits. Section 5(a) of the Voluntary Grazing Permit Buyout Act (Bill HR 3324 IH) introduced into the Congress on 16 October 2003 (108th Congress, 1st Session), for example, would have compensated ranchers \$175 per AUM, an amount well within the range calculated above.

Sale of grazing permits implies irrevocable loss of access to the public range and, in most cases, loss of a particular lifestyle. Range economists argue that, because rates of return to livestock production average no more than 2 percent, grazing permits have value only because they provide the owner with a quality of life benefit (Bartlett et al. [1]). That is, there is no evidence that public land ranchers are subsidized and make an inflated rate of return because of low grazing fees (Torell et al., p.6 [24]), so the value of grazing permits is equivalent to the value placed on the ranching lifestyle. Even if this is true, simple neoclassical theory indicates that ranchers should be WTP as much to purchase public forage in a world where available AUMs are declining as they would be WTA to forgo public forage forever — they should be willing to pay as much to keep the lifestyle as they would be willing to accept to forgo it.

To investigate the relationship between these welfare measures, we use the 2002 Nevada

Ranch Survey, which elicited WTA and WTP responses for public grazing. It also included questions dealing with the ranch operation, community activities, experience with fire, investments in range improvements, attitudes toward the public land agencies and the future of public land-based ranching, income, education, and so on. The context of the survey was the reduction in AUMs of public grazing to protect environmental amenities (noted above). Ranchers were asked about their WTP for access to public forage and their WTA compensation for sale of grazing privileges. These questions were embedded in the survey and required a yes/no response to a proposed bid; the questions are provided in the Appendix. There were 244 usable surveys after taking into account non-respondents and those who did not complete some parts of the survey needed for the current analysis. More information on the survey design, response rates and descriptive variables can be found in Thomsen [23] and van Kooten et al. [25].

3. Empirical Model

Ranchers are asked both a willingness to pay and a willingness to accept question in the same survey. As the responses are likely related, we use a systems based approach to estimation, similar to that used by Poe, Welsh and Champ [20] and Cameron and Quiggin [4]. Our objective is to test whether there is a divergence between WTA and WTP and to determine the factors explaining the divergence, if any.

The ith rancher is given randomly determined posted prices for access to grazing rights on public land. In the first instance, the question is structured in terms of willingness to accept a one time payment per AUM for loss of access to public grazing rights. The posted price is denoted p_{1i} and the rancher either indicates they accept the price, $y_{1i} = 1$, or they reject the price, $y_{1i} = 0$. The next posted price is structured in terms of willingness to pay

per AUM for access to public grazing rights.[8] The posted price is denoted p_{2i} and the rancher either indicates they are willing to accept the price, $y_{2i} = 1$, or they reject the price, $y_{2i} = 0$. In addition to the questions concerning willingness to accept and to pay posted offers, the survey asks a number of questions about ranchers' individual characteristics; these covariates are denoted $\mathbf{x}_i$.

Notice that the nature of the questions asked mean that the WTP and WTA quesions are not eliciting immediately comparable information. The WTP is in terms of an annual payment while the WTA is in terms of a current valued one off payment. This requires some adjustment for the different time-value, a point we return to below.

To model individual decisions to our survey, we use the random utility framework for discrete response models discussed in Hanemann [10]. Each rancher i is assumed to have some true unobservable surplus value ν_{ji} for each scenario presented in the survey. Here as above, $j = 1$ refers to the willingness to accept scenario while $j = 2$ refers to the willingness to pay scenario. The surplus in each case is assumed to depend linearly upon a vector of observable attributes $\mathbf{x}_i$, the relevant posted price p_{ji}, and a random component ϵ_{ji}:

$$\nu_{ji} = \beta_j' \mathbf{x}_i + \gamma_j p_{ji} + \epsilon_{ji}.$$

The errors are assumed to be jointly standard normal with covariance (equivalently correlation) ρ; further, the errors are independent of $\mathbf{x}_i$.[9] The covariates are assumed to be common across both surplus measures though we do allow for differing slope coefficients. To fix ideas, we expect that as offers to forgo public grazing increase, p_{1i} rises, the surplus to rancher i will increase, so $\gamma_1 > 0$. Similarly, as suggested payments for public grazing increase, p_{2i}

[8] Although not explicit in the survey question (see appendix), the context is clearly that of an annual payment for one month worth of public forage – a quantity measure.

[9] The assumption of normality for the error terms allows for straightforward estimation; the common alternative, the logistic distribution, is not suitable for these purposes, see Cameron and Quiggin [4]. The unit variance is a simplifying assumption that does not affect our analysis.

rises, the surplus to rancher i will decrease, so $\gamma_2 < 0$.

To estimate the model, we proceed as follows. Denote the bivariate standard normal cumulative density function as $\Phi_2(z_1, z_2;\ \rho)$. Let $z_{ji} = \beta_j' \mathbf{x}_i + \gamma_j p_{ji},\ \text{for } j = 1, 2$. Then the following describes the possible outcomes associated with our model; consider first the case of both the WTP and WTA offered being accepted by individual i:

$$\begin{aligned} \text{Prob}(Y_1 = 1, Y_2 = 1|\ \mathbf{x}_i) &= \text{Prob}(z_{1i} + \epsilon_{1i} \geq 0, z_{2i} + \epsilon_{2i} \geq 0|\ \mathbf{x}_i) \\ &= \text{Prob}(\epsilon_{1i} \leq z_{1i}, \epsilon_{2i} \leq z_{2i}|\ \mathbf{x}_i) \\ &= \Phi_2(z_{1i}, z_{2i};\ \rho) \end{aligned}$$

where the second last line makes use of the symmetry of the bivariate normal distribution. By similar reasoning we get the remaining outcomes:

$$\begin{aligned} \text{Prob}(Y_1 = 1, Y_2 = 0|\ \mathbf{x}_i) &= \Phi_2(z_{1i}, -z_{2i};\ \rho) \\ \text{Prob}(Y_1 = 0, Y_2 = 1|\ \mathbf{x}_i) &= \Phi_2(-z_{1i}, z_{2i};\ \rho) \\ \text{Prob}(Y_1 = 0, Y_2 = 0|\ \mathbf{x}_i) &= \Phi_2(-z_{1i}, -z_{2i};\ \rho) \end{aligned}$$

The log-likelihood for the data is then,

$$\begin{aligned} \ln L = \sum_{i=1}^{N} \Big(&(y_{1i} y_{2i}) \ln \Phi_2(z_{1i}, z_{2i};\ \rho) + (y_{1i})(1 - y_{2i}) \ln \Phi_2(z_{1i}, -z_{2i};\ \rho) + \\ &(1 - y_{1i})(y_{2i}) \ln \Phi_2(-z_{1i}, z_{2i};\ \rho) + (1 - y_{1i})(1 - y_{2i}) \ln \Phi_2(-z_{1i}, -z_{2i};\ \rho) \Big) \end{aligned}$$

The model parameters, including ρ, are estimated using standard maximum likelihood methods, see Greene [9]. We can also test the bivariate model against the simpler set up of two univariate models by testing the null hypothesis of $\rho = 0$. Both the univariate models and the bivariate model provide consistent estimates of the model parameters; however, if $\rho \neq 0$,

then the bivariate model is more efficient, see Poe, Welsh and Champ [20]. In what follows, we report both the univariate and bivariate results as well as a likelihood ratio test of $\rho = 0$.

With the model estimated, we can calculate measures of willingness to pay and to accept and investigate what might explain any observed differences. The linear expression for the surplus value is consistent with an underlying indirect utility function that is linear in the dichotomous variable indicating access to public grazing or not, income, and other covariates. The linear indirect utility function means that the welfare measures of interest are simple linear functions of the estimated model parameters and covariates, see Hanemann [10].

Let WTA_i denote the individual's willingness to accept and WTP_i denote the individual's willingness to pay. Then define $\tilde{p}_{1i}$ as the expectation, conditional on $\mathbf{x}_i$, of the individual's willingness to accept and $\tilde{p}_{2i}$ as the expectation, conditional on $\mathbf{x}_i$, of the individual's willingness to pay. Equivalently in our linear environment these are individual's median willingness to accept or to pay; that is, posted offers at which there is a fifty percent probability the individual rancher will accept the offer. This is easily calculated as the value of p_{ji} that sets the non-random component of the surplus measure to zero:

$$\begin{aligned} \tilde{p}_{1i} &\equiv E(\text{WTA}_i|\mathbf{x}_i) = -\frac{1}{\gamma_1}\beta_1'\mathbf{x}_i \\ \tilde{p}_{2i} &\equiv E(\text{WTP}_i|\mathbf{x}_i) = -\frac{1}{\gamma_2}\beta_2'\mathbf{x}_i \end{aligned}$$

where the expectation is taken over the marginal distribution of ϵ_{1i} in the first equation and ϵ_{2i} in the second equation. Taking expectations over the sample $\mathbf{x}_i$ with respect to the random covariates gives the standard measures of mean WTP and WTA:

$$\begin{aligned} \overline{\text{WTA}} &= -\frac{1}{\gamma_1}\beta_1'\bar{\mathbf{x}} \\ \overline{\text{WTP}} &= -\frac{1}{\gamma_2}\beta_2'\bar{\mathbf{x}} \end{aligned}$$

Estimates of either individual or sample contingent valuations are obtained by substituting the ML parameter estimates, denoted $\hat{\gamma}_j$ and $\hat{\beta}_j$. In this study, we focus on the sample measures.

Estimates of mean WTP and WTA provide information concerning the relationship between these variables and the covariates used in estimation, which is one area of interest. We are primarily interested, however, in the differences between willingness to pay and to accept and how these might be explained by the covariates. To explore this, we need first to make the the two measures comparable, as one is in terms of a flow (willingness to pay) while the other is in terms of a stock (willingness to accept). If we assume that all ranchers have the same discount rate r, then our hypothesis is:

$$\overline{\text{WTP}}/r = \overline{\text{WTA}}$$

where we have interpreted the WTP payment as a perpetual flow. In terms of the model parameters, this is

$$H_0 : \frac{1}{\gamma_1}\beta_1'\bar{\mathbf{x}} - \frac{1}{\gamma_2}\beta_2'\bar{\mathbf{x}}/r = 0$$

where we now let $\bar{\mathbf{x}}$ denote the sample estimate: $\bar{\mathbf{x}} = \frac{1}{N}\sum_i \mathbf{x}_i$. This hypothesis can be tested using a standard Wald test.[10]

The next issue is to consider what factors, that is which of the attributes $\mathbf{x}_i$, systematically contribute to the divergence between our measures of willingness to pay and to accept. For

[10]The Wald test we construct is based upon a delta method approximation, which may not be ideal. An alternative is to use bootstrap methods to estimate the distribution of the individual or across sample valuation measures, as discussed in Poe, Welsh and Champ [20]. We leave this for future work.

any individual i we can again write,

$$\begin{aligned}\tilde{p}_{1i} - r\tilde{p}_{2i} &= -\frac{1}{\gamma_1}\beta_1'\mathbf{x}_i + \frac{1}{\gamma_2}\beta_2'\mathbf{x}_i/r \\ &= (\frac{1}{\gamma_2}\beta_2'/r - \frac{1}{\gamma_1}\beta_1')\mathbf{x}_i\end{aligned}$$

For any covariate k, we can define the contribtion to the difference as,

$$(\frac{\beta_{2k}}{r\gamma_2} - \frac{\beta_{1k}}{\gamma_1})x_{ik}$$

and test the hypothesis, for each k and conditional on r:

$$H_0 : (\frac{\beta_{2k}}{r\gamma_2} - \frac{\beta_{1k}}{\gamma_1}) = 0$$

4. Empirical Results

The Data

A summary of the posted offers and frequencies of discrete responses is provided in Table 1. Of the 244 usable returned surveys, we consider 194 responses that provide a complete set of responses to the conditioning variables of interest (these are discussed further below). As evident from the table, the majority of respondents rejected both the willingness to pay and the willingness to accept posted offers. Just under ten percent accepted one but not the other offer and only one percent accepted both. These results suggest that on balance the survey offers were likely set at too low or too high a level; nonetheless, the results below suggest there is sufficient variation to identify the valuation measures of interest.

The survey asked respondents to provide a wide variety of information beyond their

willingness to pay or accept the posted offer. Due to the nature of the estimation, however, we found it necessary to select a relatively small subset of the possible conditioning variables. We chose those that we thought most likely to have some information concerning the differences in welfare measures; these variables are described in Table 2. For purposes of later discussion, the variables are grouped into (i) financial factors, including income, and education, (ii) lifestyle or quality of life factors, and (iii) attitudes towards environment.

In the first grouping, we have income by category, acres owned by the rancher, acres of public grazing currently used, an indicator of financial stress (Likert scale), and education by category.[11] For the second group, we are looking for variables that suggest a strong attachment to ranching and the local community as indicators of how important the ranching lifestyle is to the respondent. We conjecture that the greater the attachment the greater any endowment effect is likely to be. The variables we select for this are whether the rancher works off the ranch, whether the rancher intends to bequeath the ranch, and whether they are participants in community events such as local sports. Finally, the third grouping consists of an indicator of whether the rancher views grazing as a threat to endangered or threatened wildlife. As the issue of public grazing rights is closely linked to environmental concerns, this is a natural direction to explore.

Based on these variables, a typical ranch owner has a 10000 acre ranch using roughly 6000 AUMs of public forage, earns between $60-75000, considers herself to be under financial stress from the livestock business, has attended or completed college, plans to pass the ranch on to their heir(s), and does not believe that ranching threatens wildlife. Working part time appears not to be an option, with ranchers either working full time on the ranch or full time elsewhere. This latter characteristic suggests that just under half of the respondents are hobby ranchers (that is, 45% of ranchers work full time off the ranch). Finally, a slight

[11] Income is from all sources, not just from ranching.

majority of ranchers do not regularly participate in community events, such as local sporting events.[12]

Probit Models

Empirical estimates of general unrestricted bivariate and univariate probit models are provided in Table 3; Table 4 presents more parsimonious versions of these models. In all cases, the models have as dependent variables the posted offers (p_{ji}, $j = 1, 2$) as well as the covariates, or a subset, discussed above. Note that we also include an interaction term for public grazing and private land ownership to model interdependencies between public and private land uses. Throughout, we restrict the set of covariates to be the same in both the willingness to accept and willingness to pay equations.

Some common features are immediately apparent from the two tables. First, in all cases the posted offers are statistically significant and correctly signed: for willingness to accept, as the offer rises the probability of acceptance increases; for willingness to pay, as the offer rises the probability of acceptance decreases. The magnitude of the coefficients across the two welfare measures differs but this is to be expected given that the willingness to accept question is phrased in terms of a one-off payment (a large current value number) while the willingness to pay is phrased in terms of a stream of smaller annual payments.

Second, in almost all instances the remaining covariates are statistically significant, if at all, only in the willingness to accept equations. The one exception is a variable concerning ranchers' attitudes toward the local environment. This is somewhat of a puzzle; even if there are good reasons to expect the two welfare measures to differ it is not obvious that they should differ in terms of conditioning variables to this extent. As this is not directly

[12]Details about the exact nature of the survey questions are available from the authors. See also van Kooten et al. [25].

relevant to our main focus, we do not pursue this any further leaving it for further research.

Finally, the two estimation methods provide very similar results in terms of what variables are statistically significant and the coefficient magnitudes, suggesting that the results and any conclusions are robust to these different strategies. Since the correlation coefficient between the disturbances is statistically different from zero and relatively large, and because we wish to consider formal hypothesis tests across the two equations, we focus our discussion on the results of the bivariate probit model. This has the additional advantage of being a more efficient estimator given that $\rho \neq 0$.

The general models in Table 3 identify two variables that are statistically insignificant at the ten percent level, education and whether the respondent works off the ranch or not. The parsimonious models in Table 4 drop these two variables and the bivariate version of this model is our preferred specification. Setting aside for the moment the valuations implicit in the model, we fist consider the covariates themselves and how they affect the likelihood of accepting the posted offers. With the exception of the environmental variable, we can confine the discussion to the willingness to accept equation since the other covariates are statistically insignificant in the willingness to pay equation.

Beginning with household income, we see that the higher a rancher's income category the less likely they are to accept an offer to forgo public grazing land. As this relates to income from all sources, it is not possible directly to link this to the success of the ranching operation.[13] One interpretation is that better off households, through a combination of ranch and outside income, are best placed to enjoy the benefits of ranching and hence less willing to give up ranching and the associated use of public grazing.

[13]Fifty-four respondents indicated that at least one spouse worked off-farm part time, while in 51 households one worked full time. For these households, an average 75.6% of income was off farm. For all ranches, one-third of income came from off-farm work. Interestingly, there is essentially zero correlation between household income and extent of financial stress from the livestock business.

A closely related variable is the extent to which ranchers feel themselves to be under financial stress from the livestock business. The results indicate that the greater the financial stress, the less likely the posted offer is accepted. Plausibly, ranchers under financial stress view the public grazing system as a necessary subsidy to continue ranching and consequently are unwilling to forgo the subsidy. This requires that the posted offers are not high enough to compensate for the implicit subsidy, a fact that is indirectly supported by the low number of offers accepted across the sample (see Table 1).

The scale of the ranch measured by acres owned also enters with a negative coefficient, indicating that those with larger ranches are less likely to accept an offer to forgo grazing rights. This suggests that the larger ranches are those more dependent upon public grazing. An implication from this is that private and public grazing lands are not simple substitutes but are somewhat complementary: while ranchers with large private holding are better able to operate without public forage, they also are more likely to have large grazing allotments (a large number of permits).

We next observe that ranchers with larger public grazing utilization are more likely to accept a posted offer, all else equal. That is, of two ranchers that are otherwise equal and offered the same price to forgo entirely public grazing, the one with a greater current utilization of public grazing land is more likely to accept the offer. This is a somewhat confusing result; a simple analysis of ranchers' valuations would suggest that those ranchers with larger allotments, all else equal, would have a larger surplus and so be less likely to accept a posted offer.[14] We offer the following possible explanations. First, it is possible that public grazing is not of uniform quality and that large allotments are systematically associated with lower quality grazing. In this case, it is possible for the surplus value associated with large allotments to be less than those of small allotments. Of course, this does not explain why

[14]Recall that the allotment of public grazing is determined by the public land management agencies and not by the ranchers themselves, so we treat the public grazing allotment as exogenous.

quantity of public grazing does not have similar implications for willingness to pay. Second, a rancher with a large allotment may be more willing to accept a buyout because the payment will be substantial, perhaps making it possible to get out of ranching entirely or to purchase enough private land so they are no longer dependent on public range. Finally, ranchers may believe that large allotments of public grazing are unlikely to persist given the pressures from government and environmental lobbies, while small allotments may be sustainable. In this case, those with large allotments may be more willing to accept an offer of at least a partial buyout as they view the loss of these grazing allotments as inevitable.

The cross-product term of public grazing and private land ownership is also positive and highly statistically significant. This indicates that, as the extent of privately-owned land (allotment of public forage) increases, the eagerness with which a rancher with a larger public grazing allotment (private holdings) accepts the offer of a buyout also increases. Large operators appear readier to be bought out, suggesting that, all else equal, lifestyle is more important than ranching per se. With a significant buyout and a large homestead, a rancher can maintain the ranch lifestyle, living off their private lands without the concerns about potentially losing public forage.

The lifestyle factors we consider are two: whether the ranch is intended to be bequeathed and whether the rancher is an active participant in community events. The former is negative and strongly significant, meaning that those intending to pass the ranch on to their heir(s) are less likely, all else equal, to accept a posted offer, a result we might expect. The community event variable, in contrast, is positive and only weakly significant (ten percent); clearly, it is not picking up a commitment to ranch lifestyle as we might expect.

Finally, we consider ranchers attitude regarding the effect of grazing on the local environment. Recall the question asks whether endangered wildlife species are unaffected by livestock grazing, with strongly disagree equal to one and strongly agree equal to five. The

majority of respondents agreed with this statement, so there is little support from ranchers for these concerns. The regression results indicate that the less concern a rancher has about the environmental effect of livestock grazing, the more likely they are to accept the posted offer and the less likely they are to pay the posted price.

Neither of these results accords with our expectations. Ranchers who do not view grazing as environmentally costly necessarily have a larger surplus than those ranchers who do view grazing as costly, as long as the latter are internalizing these environmental costs. The larger surplus means these ranchers should be less likely to accept a particular offer, all else equal. Similarly, such ranchers should be more likely to agree to pay a posted price than ranchers with greater environmental concerns.

We offer several possible explanations. Suppose people's views on how grazing affects wildlife depends upon how they use their public grazing allotment, more or less intensively. Those using it more intensively are more likely to accept that grazing threatens wildlife than otherwise. Then we might reason that more intensive users of public grazing are those with greater benefits. As a consequence, less intensive users (those with a high value of the threaten species variable) have a smaller surplus and are more likely to accept an offer and less likely to agree to pay a price.

A second possibility is that the result may reflect the context of the survey questions, which motivate reductions in AUMs due to environmental concerns. Those who do not think livestock grazing has an adverse impact on endangered wildlife species may see no reason to pay more for the privilege of grazing cattle, and hence may be less likely to agree to a posted price. Indeed, they may even see livestock grazing as a benefit to wildlife (meaning they should be subsidized even more than currently). Nonetheless, they would be more likely to accept a posted offer to sell grazing permits because, if livestock do increase wildlife numbers, there will be even more pressure in the future to reduce access to public forage as there is

more competition for habitat and forage between wildlife and livestock.

Finally, the result may reflect ranchers' views of the dependence of the future of public grazing on environmental concerns. Ranchers with a negative and pessimistic view of environmental concerns and issues may be more likely to agree that wildlife are not endangered by grazing, primarily as a statement against what they perceive to be growing support for land use policies dominated by environmental concerns. Consequently, these same ranchers may be pessimistic about the future of public grazing and so more willing to be bought out now. At the same time, they may be unwilling to pay more because the payment is considered an environmental payment.

Unfortuantely, it is not possible to discriminate between these and other possible explanations given the data we have from the survey. Our results do suggest, however, that environmental concerns or attitudes may be influential in welfare valuation measures of the sort considered here and that there may well be an element of respondents using surveys for strategic purposes.

Statistical Tests of the Divergence between welfare measures

As discussed in the previous section, we can use the probit models to estimate valuations and to test for differences between the two measures. Table 5 reports mean willingness to accept and to pay for public grazing. To compare these payments, we consider discount rates of 2%, 4%, 7%, and 11%.[15]

[15]The choice of these discount rates is guided by the following. The real rate of return on investments by large U.S. companies over the period 1926-1990 was about seven percent, after taxes. Given a corporate income tax rate of about 35 percent, the pre-tax rate of return is thus about eleven percent. Since individuals in the U.S. pay up to 50 percent in income taxes, the rate of return to individuals as owners of companies is closer to four percent, which can then be considered the rate at which people trade off spending over time. The U.S. Office of Management and Budget requires the use of seven percent for valuing costs and benefits external to the government and 4 percent for internal costs and benefits (Newell and Pizer [19]). Finally, range economists argue an appropriate rate of return to livestock production is two percent.

The estimate of mean willingness to accept is \$262.65 per AUM while the estimate of mean willingness to pay is \$2.21; both are statistically significant. From Table 1, we know that the values of posted offers to accept range between \$5 and \$200, below the estimated mean willingness to accept reported in Table 5, which is consistent with the relatively small number of offers accepted in the sample. Similarly, the estimate of mean willingness to pay of \$2.21 is low relative to the range of posted payment offers (\$1.50 to \$20.62), consistent with the relatively small number of payment offers accepted in the sample. So the model seems to be doing a reasonable job: the predicted valuations are in line with observed behaviour.

It is of some interest to compare the estimated willingness to pay valuation to the current fees for permit holders of public grazing allotments. In 2003, the fee charged was \$1.35 per AUM, below but not statistically significantly different from our estimate of \$2.21 per AUM (p-value of 0.282). If we simply focus on the point estimate, then current permit holders are willing to pay quite a bit more than the current grazing fee. In contrast, our valuation estimate is well below the \$4.90 per AUM that is charged those without permits in Nevada (BLM [3]).

As discussed in the previous section, it is possible to estimate each individual's mean willingness to accept and willingness to pay, $-\frac{1}{\gamma_1}\beta_1'\mathbf{x}_i$ and $-\frac{1}{\gamma_2}\beta_2'\mathbf{x}_i$. As our first indication of how closely related are the willingness to pay and to accept valuations, we can consider the Pearson correlation coefficient; this is 0.60 for our sample, higher than that reported by Borges and Knetsch [2] but below what one would expect if individuals' WTP valuations are closely tied to their WTA valuations.

The last part of Table 5 looks at this issue more formally by testing whether the mean willingness to accept is significantly different from the mean willingness to pay measure adjusted by the discount rates identified above. For all discount rates considered, the willingness to accept valuation exceeds the adjusted willingness to pay valuation by a large

amount and, despite the uncertainty surrounding our estimates, the differences are statistically significant. The differences we observe are consistent with others in the literature. With a discount rate of four percent, the results suggest that willingness to sell a grazing permit exceeds willingness to pay for current access to public forage by a factor of about 5 while for a discount rate of eleven percent the ratio is about 13. These are well within the 'reasonable' range of divergence found by Horowitz and McConnell [12] for public and non-market goods (e.g., hunting permits), health and safety, and even some private goods.

Factors Contributing to the Divergence between WTA and WTP

We now examine divergence in the factors contributing to the difference between the two welfare measures in the manner laid out in the previous section. We continue to focus on the parsimonious bivariate probit model presented in Table 4. The results are presented in Table 6. The numbers can be interpreted as dollar values with positive numbers making a positive contribution to the valuation of interest. In the instance of a dichotomous variable such as the bequest motive, the coefficients have a very simple interpretation: the desire to pass the ranch on to your heir raises the willingness to accept valuation by nearly $100 per AUM.

The following variables make statistically significant contributions to the difference between the two valuations measures; acres owned, public grazing, financial stress, and bequest motive. The other lifestyle factor, participation in community events, and the environmental variable do not make a statistically significant contribution. These conclusions are unchanged across different discount factors.

In the case of acres owned, or size of the ranch, there is a positive contribution to both the willingness to accept valuation and the willingness to pay valuation, but the effect is much larger for the former. Previously, we argued the positive contribution to willingness

to accept might be explained by the dependence of larger ranches on public grazing, so that the two types of grazing are complementary. This is consistent with the positive effect it has on willingness to pay as well (though recall this variable is not statistically significant in the probit model itself). Viewed from this perspective, the fact that the effect is larger for WTA is consistent with the theoretical divergence in the two valuation measures arising from lack of close substitutes for the good being valued, Hanemann [11]. We can provide a rough guide to the magnitude of the contribution as well; the mean value for acres owned is approximately 10, so the contribution to the difference of $207 (using a 4% discount rate) is approximately $130, almost half.

Public grazing has the opposite effect, reducing both valuation measures (again, though, this variable is not statistically significant in the WTP probit equation). The relative magnitude of the two effects, however, is such that it brings the two valuation measures closer together. In general terms, the divergence of the valuation measures for the good (public grazing) is smaller the greater the allocation of the good. If we interpret the discrepancy as arising from an endowment effect, this implies that the effect is stronger for smaller quantities of the good (public grazing), a somewhat surprising result. As indicated previously, however, it may well be that small ranches as opposed to large ones, are all that is needed to maintain the 'ranch lifestyle'. If there is sufficient off-ranch income or a large enough buyout, ranchers appear content to continue on a reduced scale.

Financial stress also makes a significant contribution to the discrepancy between the two valuation measures, raising the willingness to accept and lowering the willingness to pay. Financial stress tends to raise the willingness to accept valuation, as discussed previously, while at the same time reducing the willingness to pay valuation. While the former is somewhat difficult to explain, the latter would seem to be a straightforward prediction. As a general conjecture, it seems that the overall financial situation, including financial constraints, may

bear on the divergence between the welfare measures. Notably, these sorts of issues are very unlikely to arise in standard experimental settings examining welfare measures.

Finally, we see a large contribution from the bequest motive. As noted previously, the desire to pass the ranch on to an heir raises the minimum willingness to accept by nearly $100; similarly, it lowers the maximum (adjusted) willingness to pay by roughly $50 (for a discount factor of four percent). If we view the bequest motive as evidence of a long term commitment to ranching, both as an occupation as well as a lifestyle, then we might conclude that lifestyle — broadly defined — is important for explaining the discrepancy between valuations.

5. Conclusions

The relationship between an individual's maximum willingness to pay and minimum willingness to accept compensation for the same change in a good or service has been the topic of considerable inquiry. The repeated findings from numerous survey-based contingent valuation field studies, which have now been replicated in various experimental and market settings, is that WTA and WTP diverge, with WTA typically much higher than WTP. The persistence of such disparities across numerous settings has defied any single explanation, with researchers having offered a number of competing interpretations. The novelty of this paper is to evaluate the disparities and examine the contributions from different socioeconomic characteristics.

The study uses the results of the 2002 Nevada Ranch Survey, which provides a rich set of information about rancher characteristics as well as responses concerning willingness to pay for access to public grazing and willingness to accept payment for permanently giving up access to public grazing. The joint contingent valuation responses allow us to model the two

valuations simultaneously using a bivariate probit model; this has the added advantage of allowing us to pursue inferences regarding the contribution of different factors to disparities in welfare measures.

The principal conclusions are easily summarized and have implications both for public grazing policies as well as research generally concerned with discrepancies in welfare measures. First, larger ranches are associated with greater discrepancies in valuations. We conjecture this may reflect the lack of viable substitutes for public grazing lands for larger ranches. Second, the size of allocation of public grazing is inversely related to the discrepancy in valuations, a result which we find surprising and which warrants further investigation. Third, financial stress contributes to the discrepancy; it would seem to be of some interest as to whether this result is more general. Finally, long term commitment to ranching, either as an occupation or lifestyle, contributes substantially to the discrepancy.

It is useful to consider these results in terms of land use polices for grazing. Range economists have always argued that the public land agencies should promote trading of grazing rights. Where this has been done, however, trades have been remarkably few. One possible reason for the thin market is the persistence of a difference between WTA and WTP; sellers require greater compensation than buyers are willing to pay. Our results provide support for this explanation of low trading. If successful markets in public grazing rights are desirable, then our results suggest a number of directions worth exploring. First, it might be useful to focus attention on markets tailored to smaller ranches where valuations are more closely aligned. These are likely to be more successful, perhaps providing a starting point for more general markets to develop. Second, in ways that we do not properly understand, existing allocations seem to matter. As this factor is under the direct control of the land use agencies, a better understanding of this result might shed very useful information on improvements to the public grazing system.

A further aspect of our results that may bear on land use polices concerns the evidence of lifestyle factors affecting welfare measures. The results suggest that ranchers with large public AUMs are more willing to be bought out, retreating to their owned acres. This is reinforced by our finding that WTA-WTP divergence is greater for small ranchers. Both are suggestive of lifestyle (and perhaps an endowment effect). While further investigation is needed, it does suggest that surplus is not the driving factor, but lifestyle appears to be the main driver as suggested by ranch economists. If that is the case, the public agencies need to re-think the issuance of large grazing allotments that also provide large subsidies.

Appendix

WTA Question: The Grand Canyon Trust has retired 750,000 acres of public land by providing one-time payments of $75 per AUM to retire grazing leases. Some ranchers have donated grazing leases in exchange for tax deductions to create parks. Environmental groups want the federal government to buyout all permit holders on public lands. Would you be willing to accept a one-time payment of $y per AUM to retire all of your grazing leases? (Circle) Yes No

WTP Question: According to *The Economist* (a global news magazine), grazing represents the last bastion of government-subsidized extraction of commodities from public lands. Suppose that, as a result of such views and environmental lobbying, the costs of grazing on public lands will be increased dramatically. Would you be willing to pay $x per AUM to graze your livestock in the future? (Circle) Yes No

References

[1] E. T. Bartlett, L. A. Torell, N. R. Rimbey, L. W. Van Tassell and D. W. McCollum, Valuing grazing use on public land, J. Range Manage. **55**, 426–438 (2002).

[2] B. F. J. Borges and J. L. Knetsch, Test of market outcomes with asymmetric valuations of gains and losses: smaller gains, fewer trades and less value, J. of Econ. Behav. and Org. **33**, 185–193 (1998).

[3] Bureau of Land Management (BLM), Program Area: 2003 Grazing Fee (2003). Viewed on 18 March 2004. Available at: www.nv.blm.gov/range/Current_Rates.htm.

[4] T.A. Cameron and J. Quiggin, Estimation using contingent valuation data from a 'Dichotomous Choice with Follow-Up' questionnaire, J. Environ. Econ. Manage. **27**, 218–234 (1994).

[5] N. Dietz and L. S. Rothenberg, Foundation of Policy Stability: The Institutional Basis of Non–Market Pricing. Political Science Working Paper Series, WP No. 1, W. Allen Wallis Institute for Political Economy, Rochester Center for Economic Research, University of Rochester (2000). Viewed on 1 June 2004. Available at: www.wallis.rochester.edu/PolsWP/PS_1.pdf.

[6] B. Donkers, R. Gregory and J. L. Knetsch, Discounting future gains and future losses: predictable differences and appropriate measures, presented at the Canadian Resource and Environmental Economics (CREE) Workshop, Calgary, Alberta, (2004).

[7] B. D. Gardner, Transfer restrictions and misallocation in grazing public range, J. of Farm Econ. **44**, 50–64 (1962).

[8] B. D. Gardner, A proposal to reduce misallocation of livestock grazing permits. J. of Farm Econ. **45**, 109–20 (1963).

[9] W. H. Greene, Econometric Analysis, 4th Ed, Prentice-Hall, New Jersey (2002).

[10] W. M. Hanemann, Welfare evaluations in contingent valuation experiments with discrete responses, J. of Amer. Agri. Econ. **66**, 332–341 (1984).

[11] W. M. Hanemann, Willingness to pay and willingness to accept: How much can they differ?, Amer. Econ. Rev. **81**, 635–647 (1991).

[12] J. K. Horowitz and K. E. McConnell, A review of WTA/WTP studies, J. Environ. Econ. Manage. **44**, 426–447 (2002).

[13] D. Kahneman, J. L. Knetsch and R. H. Thaler, Experimental tests of the endowment effect and the Coase Theorem, J. Polit. Economy **98**, 1325–1348 (1990).

[14] J. L. Knetsch, Asymmetric valuation of gains and losses and preference order assumptions, Econ. Inquiry **33**, 134–141 (1995).

[15] J. L. Knetsch, F–F. Tang and R. H. Thaler, The endowment effect and repeated market trials: Is the Vickery auction demand revealing?, Experimental Econ. **4**, 257–269 (2001).

[16] J. A. List, Does market experience eliminate market Anomalies?, Quart. J. Econ. **118**, 41–71 (2003).

[17] J. A. List, Neoclassical theory versus prospect theory: Evidence from the marketplace, Econometrica **72**, 615–625 (2004).

[18] D. L. McFadden, Conditional Logit analysis of qualitative choice analysis, in "Frontiers in Econometrics" (P. Zarembka, Ed.), Academic Press, New York, NY (1974).

[19] R. G. Newell and W. A. Pizer, Discounting the distant future: How much do uncertain rates increase valuations?, J. Environ. Econ. Manage. **46**, 52–71 (2003).

[20] G. L. Poe, M. P. Welsh and P. A. Champ, Measuring the difference in mean willingness to pay when dichotomous choice contingent valuation responses are not independent, Land Econ. **73**, 255–267 (1997).

[21] A. Randall and J. R. Stoll, Consumers surplus in commodity space, Amer. Econ. Rev. **71**, 449–457 (1980).

[22] J. F. Shogren, S. Y. Shin, D. J. Hayes and J. B. Kliebenstein, Resolving differences in willingness to pay and willingness to accept, Amer. Econ. Rev. **84**, 255–270 (1994).

[23] R. Thomsen, The role of social capital in the ranch–public range community of Nevada. MS Thesis, University of Nevada Reno, Reno, NV, 2002.

[24] L. A. Torell, N. L. Rimbey, E. T. Bartlett, L. W. Van Tassell and J. Tanaka, An evaluation of the PRIA grazing fee formula, presented at the Annual Meeting of the Society for Range Management, Hawaii (2001). Viewed on 11 March 2004. Available at: www.publiclandsranching.org/htmlres/pdf/torell_pria_fee_formula.pdf.

[25] G. C. van Kooten, R. Thomsen, T. Hobby and A. J. Eagle, Social dilemmas and range management in Nevada, forthcoming Ecological Economics (2005).

Table 1: Descriptive Statistics: Posted Prices

Variable	Description	Mean	SD	Min	Max
p_{1i}	Posted price, willingness to pay ($/AUM)	$10.37	$4.89	$1.50	$20.62
p_{2i}	Posted price, willingness to accept ($/AUM)	$91.11	$54.55	$5.00	$200.00
Y_1	Discrete response to willingness to pay question $Y_1 = 1$, WTP amount posted	0.11			
Y_2	Discrete response to willingness to accept question $Y_2 = 1$, WTA amount posted	0.08			
	Joint frequencies of discrete responses:				
	$Y_1 = 1$ and $Y_2 = 1$	0.02			
	$Y_1 = 1$ and $Y_2 = 0$	0.09			
	$Y_1 = 0$ and $Y_2 = 0$	0.83			
	$Y_1 = 0$ and $Y_2 = 1$	0.07			
Total number of observations:	194				

SD refers to standard deviation.

Table 2: Descriptive Statistics: Covariates

Variable and Description	Mean	SD/Freq
Financial Factors and Education		
Income	3.974	[0.13, 0.18, 0.11, 0.11, 0.11, 0.36]
Categories 1–6, in $, 000s: [$< 30,\ 30-45,\ 45-60,\ 60-75,\ 75-90,\ > 90$]		
Acres owned, '000s, continuous	10.244	32.185
Public Grazing, '000 AUMs, continuous	5.655	10.336
Under financial stress, Likert scale [1, 5]	3.990	[0.03, 0.08, 0.13, 0.40, 0.36]
Education, Categories 1–8:	3.948	[0.02, 0.19, 0.36, 0.04, 0.23, 0.07, 0.05, 0.05]
1=grade school;		
2=high school;		
3=some college or technical school;		
4=technical training in armed forces;		
5=completed college;		
6=completed college, some grad. classes;		
7=completed Masters degree;		
8=completed PhD.		
Lifestyle or Quality of Life Factors		
Work off ranch, categories 0–2:	0.907	[0.55, 0.00, 0.45]
0 = no;		
1 = yes: part-time;		
2 = yes: full-time.		
Plan to pass ranch on to heir	0.897	
Indicator: yes = 1; no = 0		
Participant in community events	0.479	
Indicator: yes = 1; no = 0		
Attitude towards Environment		
Endangered wildlife are not threatened by grazing	4.036	[0.07, 0.07, 0.10, 0.26, 0.49]
Likert scale [1, 5]		
Total number of observations: 194		

Notes: Likert scale [1, 5] range from 1 to 5 with 1 representing strongly disagree with the statement and 5 representing strongly agree. Frequency is the proportion of each category in the total of 194 observations.

Table 3: Probit Estimation Results for WTP and WTA, General Models

Explanatory Variable	Bivariate Model		Univariate Model	
	WTA	WTP	WTA	WTP
Constant	-2.369**	2.974***	-2.919***	3.156***
	1.094	0.997	1.134	1.017
Posted offer (p_{ji})	0.018***	-0.269***	0.018***	-0.271***
	0.005	0.060	0.005	0.058
Financial Factors and Education				
Income	-0.142*	0.013	-0.144	0.004
	0.085	0.102	0.096	0.099
Acres owned	-0.244***	0.003	-0.218***	0.003
	0.064	0.005	0.059	0.005
Public Grazing AUMs	0.183***	-0.024	0.178***	-0.011
	0.052	0.034	0.054	0.035
Acres owned × AUMs	0.002***	0.000	0.002***	0.000
	0.001	0.000	0.001	0.000
Under financial stress	-0.408**	-0.112	-0.408*	-0.137
	0.188	0.146	0.218	0.148
Education	0.071	-0.070	0.087	-0.092
	0.104	0.077	0.103	0.077
Lifestyle Factors				
Work off ranch	-0.050	0.120	-0.067	0.169
	0.212	0.177	0.221	0.173
Plan to pass ranch on to heir	-1.755***	-0.584	-1.737**	-0.682*
	0.672	0.398	0.725	0.409
Participant in community events	0.542*	-0.365	0.643	-0.450
	0.326	0.341	0.358	0.321
Attitudes towards Environment				
Endangered wildlife	0.432**	-0.261**	0.507*	-0.236*
are not threatened by grazing	0.194	0.124	0.229	0.124
ρ	0.748**		–	–
	0.225			
Log likelihood	-65.625		-29.429	-38.162
Pseudo-R^2	0.459		0.467	0.426

Total number of observation is 194. Numbers are point estimates with heteroskedasticity robust standard errors provided in brackets. A *** denotes statistical significance at the 1% level; ** at the 5% level; * at the 10% level for a two-sided t-test using the standard normal distribution. The psuedo-R^2 is from McFadden [18]. See Tables 1 and 2 for variable definitions.

Table 4: Probit Estimation Results for WTP and WTA, Specific Models

Explanatory Variable	Bivariate Model		Univariate Model	
	WTA	WTP	WTA	WTP
Constant	-2.125**	2.619***	-2.721**	2.749***
	1.001	0.889	1.064	0.903
Posted offer (p_{ji})	0.018***	-0.261***	0.018***	-0.262***
	0.005	0.058	0.005	0.059
Financial Factors				
Income	-0.148*	0.026	-0.149*	0.024
	0.079	0.094	0.087	0.092
Acres owned	-0.240***	0.001	-0.210***	0.001
	0.069	0.004	0.061	0.004
Public Grazing AUMs	0.192***	-0.037	0.186***	-0.025
	0.048	0.032	0.049	0.036
Acres owned × AUMs	0.002**	0.000	0.002**	0.000
	0.001	0.000	0.001	0.000
Under financial stress	-0.408**	-0.085	-0.385*	-0.109
	0.178	0.132	0.207	0.140
Lifestyle Factors				
Plan to pass ranch on to heir	-1.760***	-0.488	-1.693**	-0.583
	0.682	0.383	0.726	0.402
Participant in community events	0.535*	-0.348	0.631*	-0.431
	0.320	0.314	0.346	0.304
Attitudes towards Environment				
Endangered wildlife	0.413**	-0.270**	0.483**	-0.247*
are not threatened by grazing	0.167	0.125	0.216	0.127
ρ	0.823**		–	–
	0.200			
Log likelihood	-66.377		-29.719	-39.043
LR Test (p-value)	0.826		0.415	0.748
Pseudo-R^2	0.453		0.462	0.413

As for Table 3. LR Test reports the p-value for the $\chi^2(q)$ distributed test of the restrictions imposed in these models relative to the general models of Table 3. For the bivariate model, $q = 4$; for the univariate models, $q = 2$.

Table 5: Valuation Measures

Valuations

	Estimate	s.e	p-value
$\overline{\text{WTA}} = -\frac{1}{\hat{\gamma}_1}\hat{\beta}_1'\bar{\mathbf{x}}$	262.65	26.78	0.000
$\overline{\text{WTP}} = -\frac{1}{\hat{\gamma}_2}\hat{\beta}_2'\bar{\mathbf{x}}$	2.21	1.04	0.033

Tests of Divergence

Discount Rate	$\overline{\text{WTA}} - \overline{\text{WTP}}/r$	s.e	p-value	$\overline{\text{WTA}}/(\overline{\text{WTP}}/r)$
2%	152.27	61.03	0.013	2.38
4%	207.46	39.40	0.000	4.75
7%	231.11	32.10	0.000	8.32
11%	242.58	29.43	0.000	13.07

Reported standard errors are based on a first order approximation of the valuation function conditional on the estimated mean, $\bar{x}$. p-values are for a two-sided test of the null-hypothesis that the valuations or functions of the valuations are statistically different from zero.

Table 6: Contributions to Divergence of Valuation Measures

Explanatory Variable	WTA ($-\hat{\beta}_{1k}/\hat{\gamma}_1$)	WTP ($-\hat{\beta}_{2k}/\hat{\gamma}_2 \times 1/r$)			
		Discount Rate (r)			
		2%	4%	7%	11%
Financial Factors					
Income	8.066	5.009	2.504	1.431	0.911
		0.875	0.605	0.361	0.212
Acres owned	13.096	0.204	0.102	0.058	0.037
		0.000	0.000	0.000	0.000
Public Grazing AUMs	-10.482	-7.013	-3.507	-2.003	-1.275
		0.613	0.070	0.002	0.000
Acres owned × AUMs	-0.117	0.062	0.031	0.018	0.011
		0.011	0.006	0.006	0.007
Under financial stress	22.291	-16.400	-8.200	-4.686	-2.982
		0.166	0.054	0.015	0.006
Lifestyle Factors					
Plan to pass ranch on to heir	96.158	-93.589	-46.794	-26.740	-17.016
		0.039	0.012	0.004	0.002
Participant in community events	-29.219	-66.817	-33.408	-19.090	-12.148
		0.597	0.917	0.725	0.482
Attitudes towards Environment					
Endangered wildlife	-22.582	-51.871	- 25.935	-14.820	-9.431
are not threatened by grazing		0.288	0.840	0.541	0.240

Numbers in labelled rows are coefficient ratios; numbers below are marginal significance levels for the hypothesis test that the WTA component and the adjusted WTP component are equal; that is, $-\hat{\beta}_{2k}/\hat{\gamma}_2 = -\hat{\beta}_{1k}/\hat{\gamma}_1 \times 1/r$. Inference is based upon first order approximations.