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A Contingent Valuation Estimate of the Benefits of Wolves in Minnesota

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ABSTRACT

In this paper we estimate the willingness to pay for a wolf management plan and a wolf damage plan in Minnesota using the contingent valuation method. The theoretical definition of willingness to pay for wolf protection is composed of use and non-use values. We incorporate a don't know response option in the dichotomous choice valuation questions. A large number of respondents answered don't know. The multinomial logit model is used to differentiate between don't know and no responses. Non-use motives are important factors that explain willingness to pay. We use these benefit estimates in combination with two alternative cost estimates to consider the efficiency of the wolf management and damage plans. Both plans have estimated benefits greater than costs.

INTRODUCTION

Throughout most of history, economic development was pursued without concern for its impact on the biological world. Forests were leveled; species were lost. Eventually, policy makers and their constituents became concerned with this damage to the environment. Recent estimates suggest that, worldwide, 40–100 species are lost to extinction each day. In order to reduce the loss of species in the U.S., the Endangered Species Act was passed in 1973. As of 2001, there were 514 animals (and 740 plants) listed as threatened or endangered, up from 370 (and 302 plants) in 1991. The preservation of these animals requires protection of the individual species and also conservation of the habitats in which they live. The costs of such conservation to society can generally be easily measured. In order to determine the economic efficiency of specific protection programs, however, it is necessary to compare these costs to some estimate of the economic benefits of preservation. Worldwide, wildlife managers are recognizing the importance of estimating such benefits as environmental preservation programs come under scrutiny. One case in point is the preservation of the gray wolf (*canis lupus*) in Minnesota. The problems faced by wildlife managers in Minnesota are similar to those of their counterparts throughout the world.

When the Endangered Species Act (ESA) was passed, the gray wolf was one of the first animals listed. The goal of the act is to protect endangered and threatened animals and plants so that their populations can recover to a point where they are sustainable without further intervention. At this point, the species can be removed from the list. To achieve this goal, a national recovery plan for the gray wolf was approved in 1978 and revised in 1987. This recovery plan includes population criteria for delisting: 1250 wolves in Minnesota and 100 in Michigan and northern Wisconsin. The Minnesota population reached recovery goals in 1978, but populations in the rest of the upper Midwest did not meet the criterion until the early 1990s. Current populations are estimated at 2445 in Minnesota and 370 to 400 in Michigan and Wisconsin.

If the gray wolf is removed from the endangered species list, management of the population will revert to the states and tribal authorities. As part of the delisting process, the U.S. Department of Fish and Wildlife, in cooperation with the states, is required to implement a system of monitoring the recovered species for at least five years and to "*. . .* prevent a significant risk to the well being of any such recovered species" (Endangered Species Act, section 1533, p. 7). In 1998, the state of Minnesota created a round table panel made up of representatives from several groups likely to be affected if the gray wolf is delisted (e.g., farmers, hunters, environmentalists) and a professional moderator. This panel presented its recommendations to the Minnesota Department of Natural Resources, which then made recommendations to the state legislature. In April 2000, the legislature passed a bill that included regulations concerning how wolves may be legally taken in Minnesota and required the development of a wolf management plan. The bill was signed by Minnesota Governor Ventura in May, 2000. In March, 2001, the Minnesota Department of Natural Resources sent a detailed wolf management plan to the U.S. Fish and Wildlife Service. This plan includes wolf population and health monitoring, habitat protection, depredation control as well as budget needs and delineation of legal responsibility and authority over wolf management. If the plan is accepted by the U.S. Fish and Wildlife Service, wolves are expected to be fully

removed from the endangered and threatened species lists in fiscal year 2003. The state of Minnesota's roundtable discussions attempted to include the views of as many interested parties as possible. As is often the case, the discussions focused largely on the costs imposed by wolves, in terms of livestock and pet depredation and possibly the reduction of the deer population. Loomis and White (1996) maintain that economic analysis of the costs of protecting species often focuses on short term costs, which have significant "shock value" (p. 198). However, throughout the process of developing a wolf management plan, Minnesota officials attempted to determine and consider public opinion. Kellert (1999), in conjunction with the International Wolf Center in Ely, Minnesota, conducted a phone survey to gauge public opinion. The survey indicated that there is widespread nonconsumptive use value for wolves in Minnesota.

Conservationists in Minnesota, as they have elsewhere, relied on emotional appeals to protect wolves and imprecise suggestions that the presence of wolves and the International Wolf Center increase tourism and therefore revenue in northeast Minnesota. Missing from both the Kellert study and the roundtable discussions is the use of a more comprehensive, theoretically appropriate measure of the economic benefits of wolves, such as willingness to pay. The purpose of this paper is to provide an estimate of the willingness to pay for wolf management and for a fund to reimburse those who suffer damages from wolves. In our review of the species valuation literature, we identify several issues related to the measurement of willingness to pay for wolves, which we address in the empirical application.

LITERATURE REVIEW

Like most environmental amenities and natural resources, the preservation of endangered and threatened species is not traded in the open market. Therefore, one faces the usual difficulties when attempting to measure the demand for such goods. We rely on the contingent valuation method (CVM) to generate a willingness to pay estimate (Mitchell and Carson 1989). This methodology has been used extensively to determine the value of threatened and endangered species. Loomis and White (1996) reviewed 20 CVM studies measuring the value of rare, threatened or endangered species, including the gray wolf. The authors then conduct an empirical meta-analysis. They find that willingness to pay is explained by the species population change, whether the payment is a one-time or annual payment (respondents were willing to make a significantly larger payment when it was a one time payment rather than an annual payment), whether the respondent is a non-user and the type of species.

Although less publicized nationally, the delisting of the gray wolf in Minnesota has aroused controversy similar to that which has surrounded the reintroduction of wolves in Yellowstone National Park. Using both regional and national samples, Duffield and Neher (1996) conducted a telephone CVM survey to measure the value of reintroduced wolves in Yellowstone National Park and the surrounding national forests. Because the reintroduction was controversial, they also surveyed those opposed in order to measure the willingness to pay to prevent reintroduction. They found that in both the Montana, Wyoming, Idaho region and in the nation as a whole there were positive net economic benefits to reintroduction. Those who supported reintroduction were willing to pay more to support the program than the

opposition was to prevent it. Also, in both samples, they found that the population of supporters was larger than the population opposed (although the margin was small in the regional sample). They then compared these benefits to the costs of managing the wolf population as measured by the loss of benefits to hunters, livestock losses and administrative costs. Total net benefits of Yellowstone wolf introduction are between $6 and $8.9 million (1993 dollars) annually.

Since Loomis and White, several additional endangered species valuation studies have appeared. Loomis and Ekstrand (1998) emphasize that survey respondents may be uncertain about their values for threatened and endangered species. In an application to the Mexican spotted owl, they compare recent approaches to including uncertainty in willingness to pay estimates. They employ a follow up question asking how certain respondents are about their yes and no answers. They first multiply the yes responses by the subjective probability that the respondent would actually pay. Then they scale both the yes and no responses by the follow up probability. Incorporating uncertainty tends to lower willingness to pay estimates. These adjustments do not improve the efficiency of the willingness to pay estimates.

Kotchen and Reiling (2000) focus on the attitudes and motives (e.g., bequest, altruism) underlying the non-use value of species preservation, using the peregrine falcon and the shortnose sturgeon as a case study. Respondents were asked to complete the New Environmental Paradigm (NEP) to assess environmental attitudes. The NEP is a multi-item index of environmental attitudes consisting of fifteen questions. These questions can be grouped into five areas of environmental concern: reality of the limits of growth, anti-anthropocentrism, the fragility of the balance of nature, rejection of the idea that humans are exempt from the constraints of nature, and the perceived possibility of an ecological catastrophe. Using a dichotomous choice willingness to pay question, respondents are then asked if they would be willing to pay a given amount in order to preserve either the shortnosed sturgeon or the peregrine falcon (each respondent was asked to value only one species). Kotchen and Reiling find that environmental attitudes are related in expected ways to non-use values. Those identified by the NEP as having strong pro-environmental views were significantly more likely to answer “yes” to the willingness to pay question. Finally, respondents were asked to indicate the importance of various motives for their willingness to pay for species protection. These motives include option value, bequest value, altruism, existence value and a belief that endangered species have a right to exist. Those with strong pro-environment views were more likely to rate each of these motives as “very important” than those with moderate or weak environmental views. However, the empirical relationship between motives and non-use values is not estimated. One possible interpretation of their approach is that attitudes are an intervening variable in the relationship between motives and non-use value.

Because the Yellowstone situation is not directly comparable to that in Minnesota due to the nature and history of the Minnesota wolf populations, we are interested in finding a measure of the economic benefits of wolves in northeastern Minnesota. Similar to Duffield and Neher (1996), we compare the values of locals and non-local residents. Like Kotchen and Reiling (2000), we are interested in the influence of non-use value motives on willingness to pay. In contrast to their study,

however, we include responses to questions concerning motivation in our empirical model.

Following recommendations by NOAA (Arrow et al. 1993), we employ dichotomous choice willingness to pay questions and consider respondent uncertainty by including a “don’t know” option in addition to the “yes/no” dichotomous choice response categories. There is currently debate about whether the don’t know response is a middle response (e.g., indicating uncertainty) or an alternative response category (e.g., indicating a protest of the contingent valuation question). Wang (1997) argues that “don’t know” responses are middle responses and develops an empirical model to account for the uncertainty. Carson et al. (1998) use the multinomial logit model and find that don’t know responses are statistically indistinguishable from no responses. In contrast, Haener and Adamowicz (1998) find that don’t know responses are different from either yes or no responses. Groothuis and Whitehead (2002) compare an ordered logit model similar to Wang (1997) with the multinomial logit model. In two applications they reject the ordered logit model. Using the mulitinomial logit, they find that the don’t know response is similar to the no response in one application, similar to Carson et al. (1998), and a separate response category in another, similar to Haener and Adamowicz (1998). We use the multinomial logit model and consider two issues: whether don’t know responses are statistically equivalent to “no” responses and the effect of discarding “don’t know” responses. The next section provides some economic theory to guide the methodological and empirical application.

THEORY

We begin with a utility function in which households gain satisfaction from the wolf stock in three ways: consumption through recreation trips related to wolves (e.g., wolf howls, monitoring radio tracking), the existence of wolf stocks, and the utility of others who enjoy wolves, whether these others are current or future generations. The utility function is

$$u = u(x(q), q, z, \tilde{u}(x(q), q)) \quad (1)$$

where $u(\cdot)$ is the utility function, $x(q)$ is wolf trips, q is the wolf stock, z is a composite commodity of all other goods and $\tilde{u}(\bullet)$ is the utility function of others who enjoy wolves. We assume that utility is non-decreasing in trips, $u_x \geq 0$, which implies that the marginal utility of wolf trips may be zero. Trips are an increasing function of the wolf stock, $x_q > 0$.

Utility is non-decreasing in the wolf stock, $u_q \geq 0$, and $u_{qq} \leq 0$. This implies two things about the effect of the wolf stock on utility. The first is that the marginal utility of the wolf stock may be, in fact, equal to zero. In this case (and assuming the value of wolf trips is also zero) the household is a pure altruist. The second is that the existence of a threshold wolf stock (e.g., a viable stock where wolves are taken off the threatened species list) may yield the maximum utility of wolves. Increases in the wolf stock beyond this threshold may yield zero or even negative marginal utility.

The altruistic portion of the utility function follows McConnell's (1997) paternalistic altruism case. Households only value the utility provided to others through the use or existence value of wolves. In other words, only the benefits of wolves to others are considered, and the household does not consider non-wolf sources of utility to others. The costs of wolves to others are not a factor in the household utility function.
The budget constraint is $y = px + z$, where y is income, p is the travel cost associated with the wolf-related recreation trips, and the price of the composite commodity is normalized at one. Solving the utility maximization problem yields the indirect utility function

$$v = v(p, q', y, \tilde{u}(x(q), q)). \quad (2)$$

The willingness to pay for an increase in the wolf stock is defined by comparing indirect utility functions

$$v(p, q', y, \tilde{u}(q')) = v(p, q'', y - WTP, \tilde{u}(q'')) \quad (3)$$

where $q'' > q'$ and WTP is the total willingness to pay.

The total willingness to pay may be composed of use value, existence value, altruistic or bequest value. A household may enjoy any or all of these types of value from wolf stock. We elicit the total willingness to pay from survey respondents. Since it is clear from theory that motives play a potentially important role in the measurement of total willingness to pay in the empirical model we consider the contributions of each portion of value to total willingness to pay, although we are not able to explicitly estimate the individual components.

SURVEY

A contingent valuation survey was designed to measure the willingness to pay for two wolf management policies. The survey began by asking questions regarding the recipients knowledge about wolves. These include two questions: "Have you ever seen or heard a wolf in the wild?" and "Do you remember ever reading a magazine, reading a newspaper or watching a television program about the status of wolves in Minnesota?" Two questions measure past and future use of wolves: "Have you ever seen or heard a wolf in its natural habitat in Minnesota?" and "During the next 12 months, do you plan to take a trip to northeastern Minnesota for the primary purpose of attempting to observe, photograph, see signs of, or listen to wolves in their natural habitat?"

Next, we asked a series of four questions similar to those asked by Kotchen and Reiling (2000), designed to determine motives for preservation of wolves. To determine whether the respondent has a paternalistic altruistic motive, we asked if it is very important, important, somewhat important or not important to know that other people are able to enjoy wolves in Minnesota. The bequest motive is measured by asking how important it is to know that future generations will be able to enjoy wolves in Minnesota. Existence value is determined by asking how important it is to know that wolves exist in Minnesota even if no one ever sees

them. Finally, ethical opinions are measured by asking how important it is to allow all endangered species in Minnesota to exist. This final question is indicative of a more general environmental ethic, not necessarily related to wolves, which may not be related to the utility-theoretic definition of willingness to pay.

We then described two hypothetical, state funded management programs.1 The first is a Wolf Management Plan (WMP), which would include monitoring the population and health of wolves and preserving their habitat and that of their primary prey. The respondents are informed that if the plan is passed, a stable wolf population goal of 1600 would be sustained and wolves would not be returned to the threatened and endangered species list in the near future. Respondents were asked if they would be willing to pay a one-time tax increase ($A) to fund this plan:

> These management activities are expensive. New state money would be needed to fund the management plan. Suppose that a *one-time* tax increase of $A would be required from each Minnesota household to support and fund the wolf management plan. Would you be willing to pay the one-time tax increase of $A to fund the Wolf Management Plan?

The values of this tax increase were varied across surveys. Some respondents were asked if they would be willing to pay $5, others $25, $50, $75 or $100. The question was followed by three answer categories: yes, no, and don't know. We chose these values based on the study by Loomis and White (1996). For gray wolves, the reported willingness to pay values ranged from $16 to $118, with an average of $67. Use of the one-time tax payment, relative to annual payments, tends to yield larger estimates of willingness to pay (Loomis and White 1996).

The second state funded program depends on the success of the wolf management plan. It concerns the development of a Wolf Damage Plan (WDP) to compensate owners for lost livestock or pets and for the veterinary costs associated with hurt animals. This plan would increase compensation for livestock losses and initiate compensation for lost pets and veterinary costs resulting from injured livestock or pets. Again, respondents were asked if they would pay a one-time tax increase ($B) to fund this damage plan:

> Suppose that a one-time tax increase of $B would be required from each Minnesota household to support and fund the Wolf Damage Plan. Would you be willing to pay the one-time tax increase of $B?

Each respondent received one of the following tax increases: $1, $10, $15, $25, $35, $50, or $75. The question was followed by three answer categories: yes, no, and don't know.

DATA

We randomly selected 400 individuals from the Ely, Minnesota phone book and 400 individuals from the St. Cloud, Minnesota phone book to receive mail surveys. Ely is in the northeast corner of Minnesota, in the heart of the wolf habitat. These residents represent the "locals." St. Cloud is near the center of the state, outside of

the area designated by the U.S. Fish and Wildlife Service as primary wolf habitat. These residents represent the “non-locals.” Following Dillman (1978), surveys were sent first to the entire sample of 800 randomly chosen individuals. Those that were returned as undeliverable were dropped from the sample. This left a sample of 318 survey recipients in Ely and 357 in St. Cloud. After two weeks, a reminder postcard was sent to those who had not responded. A second survey was sent two weeks after the postcard to those who still had not responded. The response rates were 58.8% for Ely and 53.8% for St. Cloud, for an overall response rate of 56.1%.

Table I. Data summary

Variable	Description	Ely		St. Cloud	
		Mean	Stan. dev.	Mean	Stan. dev.
INCOME	Household income (in thousands)	39.77	14.45	40.00	14.93
EDUC	Education in years	15.04	2.33	14.86	2.04
AGE	Age in years	55.68	15.26	44.18	16.77
GENDER	1 = male, 0 = female	0.68	0.47	0.58	0.50
CHILD	Number of children	0.40	0.75	0.66	1.11
ALTRUISM	1 if very important or important, 0 otherwise	0.50	0.50	0.62	0.49
BEQUEST	1 if very important or important, 0 otherwise	0.56	0.50	0.72	0.45
EXISTENCE	1 if very important or important, 0 otherwise	0.53	0.50	0.74	0.44
ETHICAL	1 if very important or important, 0 otherwise	0.72	0.45	0.85	0.36
KNOW	Prior knowledge: 1 = yes, 0 = no	0.88	0.32	0.78	0.41
READ	Read or watched: 1 = yes, 0 = no	0.90	0.31	0.74	0.44
SEEN	Seen or heard: 1 = yes, 0 = no or dk	0.95	0.22	0.48	0.50
PLANTRIP	Plan a trip? 0 if no definitely, 1 otherwise	0.35	0.48	0.46	0.50
WMP Price	Wolf Management Plan (WMP) price	$48.20	34.36	$47.89	34.09
WDP Price	Wolf Damage Plan (WDP) price	$28.36	23.13	$27.49	22.94
Cases		172		180	

Table I reports means and standard deviations for the variables included in the analysis. Overall, 27 surveys were dropped because respondents either failed to answer one of the willingness to pay questions or did not answer demographic questions. This left us with 352 cases, 173 for Ely and 180 for St. Cloud. For 37 of those cases, the respondent did not answer the question relating to income. For these, income was imputed using the other available demographic information. The average household income in the St. Cloud sample is $40 thousand and almost that in the Ely sample. The St. Cloud sample is 58% male, with mean education of almost 15 years, mean age of 44 and mean number of children of 0.66. The Ely sample is 68% male, with mean education of 15 years, mean age of 56 and an average of 0.4 children.

We operationalize the motives for nonuse value by creating dummy variables for the Likert scale categories equal to 1 if the respondent considered the motive important or very important (hereafter, important) and 0 otherwise. 50% of the Ely sample and 62% of the St. Cloud sample indicate an altruistic motive, stating that it is important to know that other people are able to enjoy wolves in Minnesota. 56% of the Ely sample and 72% of the St. Cloud sample have a bequest motive, stating that it is important to know that future generations will be able to enjoy wolves in Minnesota. 53% in Ely and 74% in St. Cloud have an existence motive, stating that it is important to know that wolves exist in Minnesota even if no one ever sees them. 72% of the Ely sample and 85% of the St. Cloud sample have a general ethical motive, stating that it is important to allow all endangered species in Minnesota to exist. The correlation coefficients among the altruistic, bequest and existence motives range from 0.71 to 0.76. The correlation coefficients between the general ethical motive and the specific motives are less than 0.50.

The sample is well-informed about wolves. 88% of the Ely sample and 78% of the St. Cloud sample had prior knowledge of wolves in Minnesota; 90% in Ely and 74% in St. Cloud have read something or watched a program about wolves. The sample also contains a significant number of users of wolves, those which we interpret to have use values. 95% of the Ely sample and 48% of the St. Cloud sample have seen or heard wolves in their natural habitat and 36% of the Ely sample and 46% of the St. Cloud sample do not rule out planning a wolf-related recreation trip during the next 12 months.

In Table II we report the responses to the willingness to pay questions. The majority of Ely respondents do not support either the wolf management or wolf damage plans. 23% of Ely respondents said that they would be willing to pay the requested increase in taxes in order to fund the Wolf Management Plan, 10% answered don’t know and 67% said they would not. Upon success of the Wolf Management Plan, 30% of Ely respondents would be willing to pay the tax amount to fund the subsequent Wolf Damage Plan, 14% do not know and 56% would not. A larger number of St. Cloud respondents support both the wolf management and wolf damage plans. 33% of St. Cloud respondents said that they would be willing to pay the requested increase in taxes in order to fund theWolfManagement Plan, 23% answered don’t know and 44% said they would not. 42% of St. Cloud respondents would be willing to pay the tax amount to fund the Wolf Damage Plan, 18% do not know and 40% would not. These results suggest that there is low support for wolf management in Ely relative to St. Cloud. Also, the frequency of don’t know responses suggests that there is some uncertainty about willingness to pay for the management options.

Table II. Willingness to pay responses

	WMP		WDP	
	Number	Percent	Number	Percent
Ely				
Yes	40	23	52	30
Don't know	17	10	24	14
No	115	67	96	56
St. Cloud				
Yes	60	33	75	42
Don't know	41	23	32	18
No	79	44	73	40

EMPIRICAL MODEL

The empirical form of the indirect utility function acknowledges that the utility function observed by the researcher contains deterministic and random components

$$\hat{v} = v(p, q, y, \tilde{u}(x, q)) + \epsilon, \quad (4)$$

where _, is a mean zero error term. When respondents are faced with the tax price (T) (T = A for the wolf management plan and T = B for the wolf damage plan), it creates the choice problem
v(p, q

$$\begin{aligned} & v(p, q', y, \tilde{u}(q')) + \varepsilon' \gtreqless v(p, q'', y - T, \tilde{u}(q'')) + \varepsilon'' \\ & 0 \gtreqless v(p, q'', y - T, \tilde{u}(q'')) - v(p, q', y, \tilde{u}(q')) + \varepsilon'' - \varepsilon' \\ & 0 \gtreqless \Delta v + \mu \end{aligned} \quad (5)$$

where $\Delta v = v(q'') - v(q')$ and $\mu = \epsilon'' - \epsilon'$. If $\Delta v + \mu$ is greater (less) than zero, the optimal response is yes (no). The probability of a yes response is

$$\prod(yes) = \prod(\Delta v + \mu) \geq 0. \quad (6)$$

This formulation of the choice problem suggests that respondents know their willingness to pay value with certainty and will provide either a yes or no response to the valuation questions. However, when faced with the choice problem above, some respondents will answer that they don't know. The source of a don't know response could be uncertainty, a lack of familiarity about the case study, utility theoretic indifference, or ambivalence about environmental and dollar tradeoffs.
A don't know response could also be indicative of a respondent who does not care enough to put serious thought into the question or one who does not have

enough information. Regardless of the source, the don't know response category is provided in order to account for these preferences. The empirical question involves how to analyze the trichotomous choice data.

After preliminary analysis rejected the ordered logit model, the probability of each response is estimated with the multinomial logit model

$$\prod_j = \frac{e^{\alpha_j \log(T) + B_j' x}}{\sum_{k=1}^{3} e^{\alpha_k \log(T) + \beta_k' x}} \quad (7)$$

where α is the coefficient on the tax variable, log(T) is the natural log of the tax amount (T = A, B), β is a vector of regression coefficients, X is a vector of independent variables (including a constant), and j ε k. The k = 3 choices are: k is equal to 1 if yes, 2 if don't know, and 3 if no. The coefficients for the base case yes (β_1), are normalized to 0. The multinomial logit model produces coefficient vectors for both the don't know (β_2) and no (β_3) responses (Greene 1997). The null hypothesis for the test for whether don't know and no responses are statistically equal is *Ho*: $\beta_2 = \beta_3$.

Following Cameron (1988) and Carson et al. (1998), the median willingness to pay estimates are calculated from the logit coefficients when the don't know and no response vectors are constrained to be equal

$$WTP = e^{(\beta_*' x / \alpha_*)} \quad (8)$$

where $\beta^* = \beta_2 = \beta_3$ and $\alpha^* = \alpha_2 = \alpha_3$. Standard errors for the median willingness to pay estimates are constructed using the delta method (Cameron 1991; Greene 1997).

RESULTS

The multinomial logit results for the Wolf Management Plan and Wolf Damage Plan are presented in Tables III and IV. Each of the variables in Table I are included as independent variables except for KNOW, READ, and SEEN. In general, the models estimate the factors that make a respondent more (or less) likely to answer no or don't know to the willingness to pay questions rather than yes. The first coefficient vector (β_2) distinguishes between those that answered yes and those that answered don't know to the valuation question. The second coefficient vector (β_3) distinguishes between yes and no answers. The second coefficient vector is equivalent to a logit model in which don't know responses are discarded. We also estimate a restricted model which constrains the coefficients on no and don't know answers to be equal. This model is used to test whether don't know responses are statistically equivalent to no responses.

The results of the models for the Wolf Management Plan are reported in Table III. The likelihood ratio specification test for the equivalence of don't know and no responses indicates that the unconstrained model is preferred for both Ely and St.

Cloud samples. This means that don't know and no responses are fundamentally different responses. The likelihood ratio test for pooling the Ely and St. Cloud samples indicates that the split sample models are appropriate.

Table III. Multinomial logit model: Wolf management plan

	Ely				St. Cloud			
	Don't know		No		Don't know		No	
	Coeff.	*t*-ratio	Coeff.	*t*-ratio	Coeff.	*t*-ratio	Coeff.	*t*-ratio
ONE	1.19	0.35	2.42	0.92	3.23	1.45	0.29	0.14
Log(PRICE)	1.18	2.85	0.89	3.13	0.36	1.60	1.41	5.01
INCOME	−0.01	−0.40	−0.05	−2.41	−0.03	−1.64	−0.01	−0.55
PLANTRP	−1.16	−1.59	−1.93	−3.32	0.59	1.17	−0.33	−0.70
ALTRUISM	−0.16	−0.14	−0.43	−0.49	1.03	1.17	−0.37	−0.55
BEQUEST	−0.39	−0.23	−1.52	−1.45	−1.20	−1.19	−1.10	−1.26
EXIST	−0.12	−0.07	−1.98	−1.74	−1.23	−1.35	−1.31	−1.66
ETHICAL	−0.70	−0.56	−0.36	−0.38	−0.58	−0.46	−2.06	−1.92
EDUC	−0.22	−1.30	0.00	0.00	−0.21	−1.70	−0.14	−1.17
AGE	−0.03	−1.23	0.01	0.63	0.02	1.59	0.02	1.29
GENDER	1.76	2.24	1.44	2.40	−0.69	−1.51	0.93	1.98
CHILD	0.24	0.46	0.54	1.29	0.34	1.53	0.23	1.12
LL function	−90.01				−140.77			
Beginning LL	−143.98				−191.63			
Model χ^2	107.94				101.72			
χ^2 (DK = NO)	111.46				63.40			
χ^2 (pooled samples)	48.44							
Cases	172				180			

As expected for both the Ely and St. Cloud samples, the coefficient on the tax amount is positive and statistically significant in both the don't know and no coefficient vectors. Those respondents that were asked to pay more for the management plan were more likely to answer don't know or no relative to a yes response. Increases in income have a positive effect on the probability of answering yes although this effect is only significant when comparing yes to no responses for Ely respondents and when comparing yes to don't know responses for St. Cloud respondents. Ely respondents who said that they might plan a trip for the primary purpose of viewing or hearing wolves were significantly less likely to answer no. This indicates that wolf preservation potentially provides nonconsumptive use value.

The coefficients on the non-use value motives are not significant in distinguishing yes answers from the don't know responses in either the Ely or the St. Cloud models. The existence value motive makes it less likely that Ely respondents

will answer no to the wolf management plan. The existence value and ethical motives make it less likely that St. Cloud respondents will answer no to the wolf management plan. As education increases, St. Cloud respondents are less likely to answer don't know. The coefficient on the gender variable is positive and significant for each coefficient vector in the Ely model and in the no coefficient vector in the St. Cloud model, indicating that males were more likely to answer no to the elicitation question.

Table IV. Multinomial logit model: wolf damage plan

	Ely				St. Cloud			
	Don't know		No		Don't know		No	
	Coeff.	*t*-ratio	Coeff.	*t*-ratio	Coeff.	*t*-ratio	Coeff.	*t*-ratio
ONE	−1.14	−0.43	1.01	0.50	−2.04	−0.97	−0.01	−0.01
Log(PRICE)	0.57	2.60	0.41	2.83	0.52	2.72	0.73	4.44
INCOME	−0.04	−1.87	−0.02	−1.34	−0.03	−1.65	0.01	0.37
PLANTRP	−1.41	−2.23	−0.82	−1.79	1.67	2.81	−0.49	−1.12
ALTRUISM	1.94	1.85	0.60	0.84	1.54	1.51	−0.20	−0.33
BEQUEST	−1.56	−1.37	−1.43	−1.90	−0.67	−0.59	−0.67	−0.90
EXIST	−1.48	−1.24	−1.51	−1.83	−2.41	−2.41	−0.87	−1.32
ETHICAL	0.82	0.88	0.07	0.11	−0.94	−0.87	−1.16	−1.53
EDUC	0.11	0.80	0.06	0.55	0.06	0.48	−0.06	−0.60
AGE	−0.02	−1.15	−0.01	−0.35	0.02	1.42	0.02	1.28
GENDER	1.02	1.66	0.97	2.14	0.11	0.22	0.67	1.63
CHILD	0.46	1.09	0.31	0.92	0.47	2.09	0.17	0.89
LL function	−132.04				−145.50			
Beginning LL	−165.45				−186.81			
Model χ^2	66.83				82.63			
χ^2 (DK = NO)	60.73				50.81			
χ^2 (pooled samples)	28.89							
Cases	172				180			

Table IV presents the results of the multinomial logit models for the Wolf Damage Plan. The likelihood ratio specification test indicates that the unconstrained (i.e., separate don't know and no coefficient vectors) and split sample models are preferred. In both the Ely and St. Cloud models the coefficients on the tax amount variables are positive and statistically significant indicating that increasing the tax amount makes it more likely that respondents will not answer in the affirmative.

The income coefficient in the don't know vector is negative and statistically significant in both the Ely and St. Cloud samples. Ely respondents who plan to take a wolf-related trip are less likely to answer don't know and no (i.e., more

likely to support the wolf damage plan), indicating positive nonconsumptive use value. Curiously, St. Cloud respondents who plan to take a wolf-related trip are more likely to answer don't know relative to yes. For Ely respondents the altruistic motive coefficient is positive and statistically significant in the don't know vector and the bequest and existence motive coefficients are negative and statistically significant in the no vector. These results indicate that bequest and existence value motives are important contributors to willingness to pay. For St. Cloud respondents the existence value motive coefficient is negative and statistically significant in the don't know vector indicating that existence value motives are important determinants of willingness to pay. Males are significantly more likely to answer no relative to yes in both the Ely and St. Cloud samples. Males are significantly more likely to answer don't know relative to yes in the Ely sample.

Table V. Willingness to pay estimates

	WMP	*t*-statistic	WDP	*t*-statistic
Ely	$4.77	1.89	$4.43	1.78
St. Cloud	$21.49	3.89	$20.16	3.41

As shown in equation (8), the coefficients from these logit models can be used to calculate median willingness to pay.We calculate willingness to pay for theWolf Management Plan and Wolf Damage Plan for both the Ely and St. Cloud samples. The results of these calculations are reported in Table V. For Ely residents, the median willingness to pay value is $5 for the Wolf Management Plan. The median willingness to pay estimate for the St. Cloud sample is $21. The willingness to pay estimate for the St. Cloud sample is statistically greater, at the 0.05 level, than the corresponding estimate for the Ely sample. Similar differences in the estimates of willingness to pay arise when we consider theWolf Damage Plan. For Ely residents the median willingness to pay is $4. For St. Cloud, median willingness to pay value is $20. The median willingness to pay estimate for the St. Cloud sample is statistically greater, at the 0.10 level, than the corresponding estimate for the Ely sample.

BENEFITS AND COSTS

These values are estimates of the median willingness to pay for each household in the sample. In order to estimate the total willingness to pay for each plan, we must aggregate these values. The simplest way to do this would be to multiply the willingness to pay per household from our sample by the number of households in Minnesota. However, because there are differences between Ely and St. Cloud residents, this may be inappropriate. Instead, we assume that the Ely residents are representative of Minnesotans living in proximity to wolves and St. Cloud residents are representative of the rest of the state.

The 1992 federal wolf recovery plan proposed dividing the state of Minnesota into five zones, based on the density of the wolf population. Zones 1–4 have

wolf population goals varying from one wolf per 10–15 square miles to one wolf per 50 square miles. For zone five, the goal population is zero. We have labeled the counties in zones 1–4 as the “wolf zone” and assume that the residents of these counties have willingness to pay similar to Ely residents. Zone five, which includes the city of St. Cloud, is a “no wolf zone” and we assume its residents have willingness to pay similar to St. Cloud residents.

We multiply the willingness to pay for Ely residents by the approximate number of households in the wolf zone. Similarly, we multiply willingness to pay of St. Cloud residents by the approximate number of households in the no wolf zone. Using this method of aggregation, we find that residents of the wolf zone are willing to pay a lump sum of $655,131 for the Wolf Management Plan and residents of the no wolf zone are willing to pay a lump sum of $26,791,754. For the state of Minnesota, the aggregate willingness to pay for the wildlife management plan is a lump sum of $27,446,885. Upon success of the wolf management plan, residents of the wolf zone are willing to pay an additional lump sum of $608,434 and residents of the no wolf zone are willing to pay an additional lump sum of $25,133,633 for the Wolf Damage Plan. The total lump sum willingness to pay for the damage fund is $25,742,067 for the state of Minnesota. 90% confidence intervals for these aggregate estimates indicate that residents of the wolf zone are willing to pay between $84,924 and $1,225,337 for the Wolf Management Plan and between $46,145 and $1,170,723 for the Wolf Damage Plan. For the residents of the rest of the state, these confidence intervals are $15,462,080 to $38,121428 for the Wolf Management Plan and $13,009,051 to $37,258,215 for the Wolf Damage Plan.

With these aggregate estimates, it is possible to compare the costs and benefits of maintaining the wolf population in Minnesota. Mech (1999) estimates that for a wolf population of 3,150 animals, control costs would be $342,830 annually for the period 2001-2005. Given wolf depredation patterns and the current level of compensation for lost pets and livestock, compensation costs for this period would be $116,953 annually. Note that these cost estimates apply to a wolf population that is greater than that associated with the population goal used in this paper. Another cost estimate is from the Minnesota Department of Natural Resources Wolf Management Plan. This plan includes a budget of $95,000 for fiscal year 2002, $785,000 for fiscal year 2003 and $695,000 for fiscal year 2004. These funds would be used to hire additional professional staff, fund depredation programs, provide enforcement of the plan and continue education and public participation in order to improve the probability of success of the plan. In addition, the Minnesota Department of Agriculture recommended appropriations for compensation for wolf depredation of $158,000 in each of these fiscal years. If the state were able to collect revenue equal to our aggregate willingness to pay estimates and placed this revenue in a trust fund, assuming 5.5% interest (the rate for a 30 year T-bond at the time the survey was completed), this fund would generate annual interest income of $1,509,579 for the Wolf Management Fund and $1,415,814 for the Wolf Damage Fund. If we further assume that this 5.5% is the social discount rate, these values also represent the annualized aggregate willingness to pay for the management plan and the damage plan. Annual benefits exceed annual costs indicating that the wolf population management and damage plans are efficient government policies.

CONCLUSIONS

In this paper we have estimated the benefits of wolves in Minnesota using the contingent valuation method. We illustrated theoretically that willingness to pay is composed of use and non-use values. Non-use values are composed of existence, altruistic, and bequest values. In the empirical application, use and non-use motives are important factors that explain willingness to pay. Future applications of the contingent valuation method to threatened and endangered species should consider both use and non-use motives in the measurement of willingness to pay.
A large number of respondents answered don't know to the valuation question. In both of the empirical models, we find that no and don't know responses do not provide the same valuation information. Considering the amount of uncertainty related to species-based policy decisions, future applications of the contingent valuation method to species valuation should allow for respondent uncertainty in the measurement of willingness to pay.

We use these benefit estimates, in combination with the cost estimates of Mech (1999) and those from the Minnesota Department of Natural Resources, to consider the efficiency of the wolf management and damage plans. Both plans are economically efficient with benefits significantly greater than costs. One limitation of this comparison is our focus on the Ely and St. Cloud populations. We assume that residents in these cities are representative of the wolf and no wolf regions of the state. In contrast, Loomis (2000) shows that political boundaries (e.g., cities and states) are not the same as the market boundaries for willingness to pay for species. In other words, while willingness to pay declines with distance from the species habitat, positive willingness to pay may exist over a geographic area larger than the state in which the habitat is located. In fact, some endangered species have national market boundaries. Future research should incorporate a more representative and geographically disperse sample.

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NOTE

1. The exact wording of the program descriptions and willingness to pay elicitation questions can be found in the appendix.

APPENDIX: DESCRIPTION OF PROGRAMS AND WTP QUESTIONS AS THEY APPEARED IN SURVEYS

A WOLF MANAGEMENT PLAN IN MINNESOTA

The gray wolf is currently listed as a threatened species in Minnesota under the federal Endangered Species Act. Because of the change in public attitudes and the U.S. Endangered Species Act, the wolf population in Minnesota has recovered to such an extent that it will soon be removed from the threatened species list altogether. Management of the wolf population will then revert to the State of Minnesota. Wolves are an endangered species in the rest of the Midwest.

In recent efforts to pass a plan, the Minnesota Department of Natural Resources (DNR), proposed to continue some current wolf management activities, and to enhance or add others. The goal of this management plan was to ensure the long-term survival of wolves in Minnesota. With the management plan, it was expected that the gray wolf would remain stable and not be placed on the endangered species list in the near future. These management activities are expensive. New state money may be needed to fund the management plan.

The Wolf Management Plan proposed by the MN DNR included:

Population Monitoring

- assess wolf population numbers across the state
- encourage and conduct more intensive monitoring of wolves in selected areas
- monitor aspects of wolf health and diseases

Population Management

- wolf populations in Minnesota would expand, with a minimum population goal of 1,600
- no general hunting of wolves would be proposed for the first 5 years of the plan

Habitat management

- Preserve wolf habitat
- Preserve wolf prey (deer and moose) and the vegetation and other environmental variables they depend upon

A WOLF DAMAGE PLAN

If the Wolf Management Plan is successful, wolf populations in Minnesota would have a minimum population goal of 1,600.With this population size, a Wolf Damage Plan would be necessary. The goal of the Wolf Damage Plan would be to manage the problems that happen when wolves and people live in the same place.

The Wolf Damage Plan would include:

- increasing compensation for livestock losses
- initiating compensation for losses of dogs
- initiating compensation for veterinary costs resulting from injuries to livestock and dogs

A POPULATION MANAGEMENT PLAN

The Wolf Management Plan previously proposed by the DNR does not include any hunting. If the Wolf Management Plan is successful, wolf populations in Minnesota would be maintained at a minimum population goal of 1,600. With this population size, some people believe that a Wolf Hunting Season may be necessary to manage the wolf population.

The Population Management Plan may include:

- a two week wolf hunting season
- a legal limit of one wolf per hunter per season

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