Reintroduction of the Mexican wolf (*Canis lupus baileyi*) to the Southwestern United States: An economic perspective

Timm Kroeger, [a, b] *Frank Casey,* [a] *and Chris Haney* [a]

[a] Defenders and Wildlife, 1130 17th St. NW, Washington DC 20036
[b] State University of New York, College of Environmental Science and Forestry, 1 Forestry Dr., Syracuse, NY 13210

Paper presented at the 18th Annual North American Wolf Conference, Chico Hot Springs, MT, Apr. 4-6, 2006

Abstract

In 1998 the Mexican gray wolf (*Canis lupus baileyi*) was reintroduced to the Blue Range Wolf Recovery Area (BRWRA), located in east-central Arizona and west-central New Mexico, as a result of efforts to reestablish a wild population of Mexican gray wolves in the species' former home range. Because the gray wolf is a large predator and a species that elicits interest nationwide, its reintroduction to an area used by humans is bound to generate economic impacts ranging from direct use to indirect use and non-use values, and comprising both market and non-market impacts. Although several studies have provided more or less comprehensive estimates of the economic impacts of the reintroduction or conservation of gray wolves in other regions in the U.S., to date no comprehensive study has been carried out for the southwestern U.S. The purpose of this paper is to remedy this shortcoming. We apply different economic valuation approaches in order to generate a comprehensive assessment of the impacts caused by the reintroduction of Mexican wolves to the BRWRA. These approaches rely both on individuals' observed and stated willingness-to-pay for wolf reintroduction. We estimate observed willingness-to-pay based on the results of a market experiment in "wolf-friendly" beef that was conducted in New Mexico in 1998. Stated willingness-to-pay is estimated in two ways: first, we apply a single-point benefit transfer to the WTP for wolf reintroduction reported in the study whose context most resembles that of the BRWRA; in addition, we conduct a meta-analysis of the available studies that provide WTP estimates for gray wolf reintroduction, and apply the estimated WTP regression function to derive WTP estimates for reintroduction of wolves to the BRWRA. Our results suggest that reintroduction of Mexican wolves to the Southwest has generated substantial benefits as well as costs. It further indicates that benefits outweigh costs by a large margin, at both the regional and the national levels of analysis.

Introduction

The Mexican gray wolf (*Canis lupus baileyi*), native to the southwestern United States and Mexico, is the southernmost subspecies of the gray wolf (*Canis lupus*). Mexican gray wolves are assumed to have become extirpated in the wild from the southwestern United States by 1970 as a result of bounties offered by federal, state, and local governments, livestock associations, and individual ranchers, and the initiation of federal eradication efforts in 1915 (U.S. Fish and Wildlife Service, 1995). The Mexican gray wolf was first listed under the U.S. Endangered Species Act as an endangered subspecies of the gray wolf in 1976.[1] In 1998, the first Mexican gray wolves were released in the Blue Range Wolf Recovery Area (BRWRA) as part of an ambitious program to reintroduce the Mexican gray wolf in the wild in parts of its historic range.[2] The BRWRA comprises all of the Gila and Apache National Forests in east-central Arizona and west-central New Mexico. Mexican gray wolves currently existing in the wild in the BRWRA are designated as a non-essential experimental population under the ESA.

The reintroduction of large predators to human-inhabited areas often is a contentious issue. In the case of wolves, which do not constitute a threat to human life, opposition to reintroduction generally is based on economic arguments. Wolves cause costs to ranchers through livestock depredation, primarily of cattle, calves, and sheep, and, in rare cases, horses, and through the occasional taking of dogs. In addition, wolf predation on elk and deer may reduce game populations. This can reduce the attractiveness of game hunting and may lead to a decline in hunting activity, reducing benefits to hunters and income of outfitters and guides. Finally, reduced income to ranchers, outfitters and guides and reduced hunting activity can lead to reduced earnings in the regional economy through multiplier effects on associated industries. These potential negative economic impacts, or costs, associated with wolf reintroduction are shown in Table 1.

However, reintroduction of a locally extinct species such as the Mexican wolf also may generate a number of economic benefits (see Table 1). These benefits fall into different categories of economic value depending on the form of use the associated valued activities take. For example, direct use of wolves in the wild occurs through observing them or listening to them howl. Wolves also generate indirect use benefits through their impact on the provision of ecosystem services in wolf habitat that benefit human economic activity. Ecosystem services include the maintenance of hydrological and nutrient cycles, soil formation and erosion control, pollination, habitat provision, nursery for fish or game species, provision of food and water for livestock, climate regulation, disturbance regulation, waste management, and biological control (Daily *et al*., 1997; Balmford *et al*., 2002). Wolves have been documented to exert a biological control function through their impacts on the trophic structure of ecosystem (White *et al*., 2003; Ripple and Beschta, 2004; Ripple *et al*., 2001). Specifically, wolves may reduce forage competition for livestock from other ungulates such as deer and elk that constitute wolves' primary prey (Unsworth *et al*., 2005); reduce predation by other livestock predators such as coyotes, wild dogs, and mountain lions through interspecific competition with those predators (Crabtree and Sheldon, 1999; Smith *et al*., 2003); and improve riparian vegetation by causing changes in the browsing behavior of deer and elk in reoccupied wolf habitat (Ripple *et al*., 2001; Ripple and Beschta, 2004; White *et al*., 2003). Increased riparian vegetation reduces water temperature, thereby improving habitat conditions for

[1] See *Federal Register* Vol. 41(83):17736-17740 (1976).
[2] See *Federal Register* Vol. 63(7):1752-1772 (1998).

trout, which in turn may increase the attractiveness of streams to anglers.[3]

Table 1: Potential economic impacts from reintroduction of Mexican wolves

Type of value	*Benefits*	*Costs*
Direct use vales	Increased recreation tourism	Reduced profits for livestock operations and hunting outfitters
	Agency/NGO expenditures *	Agency/NGO expenditures *
	Positive multiplier effects in local economy from above impacts	Negative multiplier effects in local economy from above impacts
	Increased utility for recreationists	Reduced utility for hunters
	Educational activities	
Indirect use values	Increased provision of ecosystem services in reintroduction area (***e.g.***, more trout due to lower water temperatures, more forage for livestock b/c of reduced competition from deer and elk, control of other predators through interspecific competition)	n.a.
	Positive multiplier effects in local economy from market impacts of indirect benefits (sport fishing industry, livestock operations)	
Non use values	Existence, stewardship, and bequest values for supporters of reintroduction	Negative existence values for opponents of reintroduction

Notes: * Resources spent locally in the reintroduction effort have positive employment and revenue impacts in the area, while they carry opportunity costs for society as a whole. Whether or not these expenditures count as costs or benefits in a given case depends on the spatial boundary of analysis.

Wolves also generate benefits that are not related to any direct use of the species. Many people assign value to the existence and preservation in the wild of charismatic species such as the wolf, even though they may never come into contact with the species. In economics, these non-use values are known as existence, stewardship, and bequest values (Krutilla, 1967). The high importance of non-use values of wolves has been documented in a number of studies. For example, Manfredo ***et al.*** (1994) examined perceptions and attitudes of Colorado residents towards wolf reintroduction to the state, and found that non-use values are a strong motivation in residents' attitudes toward reintroduction. Their findings are confirmed for other states (***e.g.***, Chambers and Whitehead, 2003) as well as for the U.S. as a whole (Duffield, 1992; U.S. Fish and Wildlife Service, 1994). However, to date no analysis has been carried out of the non-use values of Mexican gray wolves. The objective of the present paper is to fill this gap, and to generate a comprehensive estimate of the economic costs and benefits associated with reintroducing Mexican gray wolves to the Southwest.

[3] Reintroduction of wolves also may generate impacts that do not affect humans but benefit other species. For example, in Yellowstone, wolves appear to dampen climate change impacts on other predators and improve habitat conditions for other species, such as beavers (Wilmers and Getz, 2005).

Methods

We employ a variety of approaches to quantify the monetary value of the impacts associated with reintroduction of the Mexican gray wolf to the BRWRA. Non-use and direct use values of wolves are estimated on the basis of willingness-to-pay (WTP), both observed and stated. Observed WTP of individuals is estimated on the basis of the results of a market experiment with "wolf-friendly" beef conducted in New Mexico in 1998 (Aquino and Falk, 2001). Stated WTP is estimated using two approaches. First, we apply a single point benefit transfer of WTP estimates generated for gray wolf reintroduction to central Idaho (U.S. Fish and Wildlife Service, 1994). In addition, we estimate a meta-analysis WTP regression function over all WTP studies on gray wolf conservation that we were able to locate in the literature, and then apply that function to the Arizona and New Mexico context. Most of the studies on WTP for gray wolf conservation have been carried out for other subspecies of the gray wolf. Nevertheless, the results of those studies are relevant. Evidence suggests that individuals' WTP for species conservation is a function, among other things, of the type of species (Loomis and White, 1996) and of its physical appearance and public profile (Samples *et al*., 1986). Given that the Mexican gray wolf is only marginally smaller than the gray wolf species that were the subject in the other studies and that all gray wolf subspecies in the U.S. share the same public image, there is no reason to suspect that WTP for reintroduction of Mexican gray wolves is different from that for other subspecies.

For the remaining benefit and cost categories, we rely mainly on estimates developed in a recent study by the Fish and Wildlife Service (Unsworth *et al*., 2005), which we discuss and modify where appropriate.

WTP is the appropriate indicator of economic value because it is based on an assessment if impacts by the impacted individuals themselves (Arrow *et al.*, 1996). When impacts to be valued affect goods or services not commonly traded in markets, stated WTP is the preferred approach, because it captures both use and non-use values. When the impacts carry primarily use values and are traded in markets (such as livestock, or goods and services purchased by National forest visitors), observed WTP (market transactions) serve as a reasonable approximation of their economic value.

Because reintroduction may generate impacts beyond the reintroduction area, we estimate costs and benefits for two spatial boundaries. The first contains the states in which reintroduction takes place (Arizona and New Mexico), while the second includes the U.S. as a whole. The latter is the conceptually correct impact accounting boundary from a public policy analysis perspective because reintroduction of the Mexican wolf took place as a result of the wolf's listing under the ESA, a federal law, and because reintroduction causes impacts across the U.S.

Benefits of reintroducing Mexican gray wolves

Estimating willingness-to-pay for reintroduction of the Mexican Wolf

The published economics literature contains several studies that estimate people's willingness to pay (WTP) for the conservation of the gray wolf (*Canis lupus*) in the United States. We briefly review these studies below.

Aquino and Falk (2001) is the only study to date that has examined WTP for wolf conservation in New Mexico. An additional feature that makes this study interesting is that it is the only one to examine people's revealed, as opposed to stated, WTP for wolf conservation. The authors examined the WTP of Albuquerque, New Mexico residents to pay a price premium for "wolf-

friendly" beef. Although the authors did not ask people for their WTP for wolf conservation in New Mexico, and despite of concerns that this measure is not an unbiased indicator of people's WTP for wolf conservation, their findings can be used to construct an approximate estimate of New Mexico residents' WTP for wolf conservation in the State.

Table 2: Studies reporting mean WTP for gray wolf conservation or reintroduction

	Location of proposed action	*Proposed action*	*WTP(2004$)*				*Response rate*
			Residents		*Visitors*		
			Area	*Out-of-region*	*Local*	*US*	
Aquino & Falk (2001)	NM/AZ	Conserv.	*(21.71[a])*				n.a.
Chambers & Whitehead (2003)	Minnesota	Conserv.	5.00	-	-	-	59%
Chambers & Whitehead (2003)	Minnesota	Conserv.	-	22.52	-	-	54%
Duffield (1992)	Yellowstone area	Recovery	-	-	142.60	84.54	86%
Duffield *et al.* (1993)	Yellowstone area	Recovery	32.90	-	-	-	47%
Duffield & Neher (1996)	Yellowstone area	Recovery	25.44	11.07	-	-	70/48%
Frederick & Fischhoff (1997)	Maine/Wisconsin	Reintrod.		22.4 /year[b]			87%
U.S. FWS (1994)	Yellowstone area	Recovery	25.44	11.07	-	-	70/48%
U.S. FWS (1994)	Central Idaho	Recovery	19.36	10.83	-	-	70/48%

Notes: [a] Estimate not given by Aquino and Falk, but rather derived from data reported in their study. See text for details. [b] Respondents were students at Carnegie Mellon University. Hence, it is likely that the survey sample included potential visitors to and residents of the reintroduction areas, but that it was mostly composed of people not falling into either of these categories. Conserv. - Conservation; Reintrod. - Reintroduction. All values are one-time payments, except where indicated otherwise.

Several other studies on individuals' WTP for wolf conservation have been conducted in other parts of the U.S. Duffield (FWS, 1994; see also Duffield and Neher, 1996) examined the WTP of area households (*i.e.*, households in Idaho, Montana, and Wyoming) and of out-of-region households for or against reintroduction of Gray Wolves to Yellowstone or central Idaho. The payment vehicle presented to respondents was a lifetime membership in a trust fund that would support or oppose, respectively, reintroduction of wolves to each of the two areas. The survey format was dichotomous choice, with respondents presented with varying payment amounts. For both areas, supporters of reintroduction expressed a higher WTP than opponents, and area residents expressed a higher WTP than out-of-region residents. WTP of region households supportive of reintroduction was about one-third (31 percent) higher for reintroduction to Yellowstone than for reintroduction to central Idaho, at $25.44 vs. $19.36 (see Table 2). Locally, supporters of wolf reintroduction to Yellowstone outnumbered opponents, but only by a small margin (49 percent to 43 percent; 8 percent did not know). Reintroduction to central Idaho yielded almost identical results, with the number of supporters among area residents 13 percent higher than the number of opponents (FWS, 1994). At the national level, supporters of reintroduction to Yellowstone outnumbered opponents by a ratio of two to one (57 percent to 29 percent; 14 percent did not know) (Duffield and Neher, 1996). This two-to-one ratio also held true for reintroduction to central Idaho (FWS, 1994).

Duffield (1992) examines WTP for wolf recovery of both local and out-of-region visitors to Yellowstone National Park. The survey format was dichotomous choice, with respondents presented with varying payment amounts. The payment vehicle used was membership of

respondents in a lifetime trust fund supporting wolf reintroduction. The mean WTP of both groups is several times higher than the estimates generated by all other studies (Table 2). This is likely due to the fact that Duffield's sample consisted only of Park visitors, not of residents as a whole. As shown by Loomis and White (1996), WTP of visitors generally surpasses that of residents. Visitors of National Parks tend to have a large recreation component in their total value, and often have stronger preferences, and hence a higher WTP, for the conservation of species and natural areas than the average person. This interpretation is supported also by the extraordinarily high response rate to Duffield's survey of 86 percent.

Duffield *et al.* (1993) examine the WTP of region households for wolf recovery to Yellowstone. The payment vehicle used again was membership of respondents in a lifetime trust fund that support wolf reintroduction, and the survey format was dichotomous choice with varying payment amounts. Their elicited WTP is about a third (29 percent) higher than that found in Duffield's study for the Fish and Wildlife Service (FWS, 1994).

Chambers and Whitehead (2003) estimated the WTP of residents in Ely and St. Cloud, Minnesota, for the introduction of a Wolf Management Plan that would maintain a minimum wolf population in Minnesota of 1600 animals. To achieve this goal, activities under the plan would include the monitoring of the population and the health of wolves, and the preservation of their habitat and that of their prey. Respondents were informed that as a result of the passing of the plan, a stable wolf population of 1600 animals would be sustained and wolves would not be returned to the threatened and endangered species list in the near future. The elicitation context presented to respondents was that the expected delisting of wolves would result in the funding for protection of wolf population levels falling to the state. Respondents were asked if they were willing to pay a one-time tax increase to fund the plan, and could choose among the answer categories "yes," "no," and "don't know." The survey employed a dichotomous choice format, with payments varying across surveys, from $5 to $25, $50, $75 and $100.

The authors selected two respondent samples. The local residents sample was drawn from Ely, located in the center of wolf habitat. The non-local sample was taken from St. Cloud, situated outside of FWS-designated primary wolf habitat.

Mean annual per capita WTP for the wolf management plan was $21.49 (2001$) in St. Cloud, significantly higher than the mean WTP in Ely of $4.77. In both cities, opponents of the plan outnumbered supporters. In St. Cloud, 33 percent of respondents stated that they would be willing to pay the requested amount to support the tax-funded management plan, and 44 percent said that they would not; the remainder (23 percent) stated that they did not know. In Ely, 67 percent of respondents stated that they would not be willing to pay the requested increase in taxes to support the plan, while 23 percent stated that they would, and 10 percent said that they didn't know. The authors also tested residents' WTP for an alternative plan, the Wolf Damage Program, which would compensate farmers and pet owners for animals lost to wolves. The tax increase presented to each respondent was either $1, $10, $15, $25, $35, $50, or $75, again with the response choices of "yes," "no," and "don't know." WTP for this plan was very similar to that for the Wolf Management Plan, with mean WTP of $20.16 in St. Cloud, and $4.43 in Ely.

The higher mean WTP of St. Cloud respondents is a function of the higher percentage of supporters and lower percentage of opponents of the wolf plans in that city compared to Ely. In addition, the results indicate that increasing requested tax amounts had a substantially higher likelihood in Ely of generating "don't know" responses as opposed to "yes" responses, compared to

St. Cloud.[4] Therefore, the frequency distribution across requested payment amounts of St. Cloud respondents voting "yes" on the plan is skewed towards higher payment amounts compared to that of Ely supporters of the plan. Chambers and Whitehead's findings suggest an explanation for the higher mean WTP of St. Cloud respondents. Their survey indicates that a higher percentage of St. Cloud respondents were holding non-use values for wolves. Specifically, in St. Cloud, more people revealed altruistic (62 percent vs. 50 percent for Ely), bequest (72 percent vs. 56 percent), existence (74 percent vs. 53 percent), and "general ethical" (85 percent vs. 72 percent) motives for wolf conservation.

Frederick and Fischhoff (1997a, 1997b) elicited WTP of a sample of students at Carnegie Mellon University for the reintroduction of timber wolves to Maine and/or Wisconsin.[5] They found that median stated annual WTP was $20 (1997$), whether the proposed action was reintroduction to Maine *given that wolves had already been reintroduced to Wisconsin*; reintroduction to Wisconsin *given that wolves had already been reintroduced to Maine*; or reintroduction of wolves to both states. The authors argue that their results appear to suggest scope insensitivity, because respondents valued restoration of wolves to Maine ***and*** Wisconsin the same as restoration to either one of those states alone. However, scope insensitivity, or the so-called embedding-effect, need not always contradict economic theory, because steeply declining marginal welfare returns can in fact explain such results (Smith, 1992; Randall and Hoehn, 1996; Stevens ***et al***., 1997).
Some of the variation in WTP for wolf reintroduction presented in Table 2 is likely to be caused by differences in the payment schedules employed in the studies. Specifically, WTP expressed in the form of lump-sum payments tends to be relatively small compared to WTP expressed in annual payment form as reported by Frederick and Fischhoff (1997). Insensitivity of individuals' stated WTP to payment schedule is attributed to temporal embedding, leading to apparent implicit discount rates that tend to be substantially higher than those suggested by economic theory (see for example Stevens ***et al***., 1997).

Development of WTP estimates for reintroduction of Mexican wolves to the New Mexico and Arizona recovery areas

Based on the studies presented in the previous section, two approaches are available for estimating individuals' WTP for the reintroduction of Mexican wolves to New Mexico and Arizona. First, the findings reported by Aquino and Falk (2001) can be used to generate WTP estimates of New Mexico residents. The advantage of this approach is that the estimates are based on local data, and hence avoid the potential distortions that may be caused by the transfer of benefit estimates from other study areas. The second-best approach to estimating WTP for reintroduction of Mexican wolves to New Mexico and Arizona is benefit transfer. Benefit transfer commonly is defined as the adaptation of value estimates generated at one study site to another site (the "policy site", in our case, the Mexican wolf recovery zones) for which such estimates are desired but no primary data for their generation are available (Rosenberger and Loomis, 2001). Benefit transfer is a convenient tool for the efficient generation of benefit estimates, provided that several conditions are fulfilled that ensure the validity of the benefit estimates generated for the policy site. These conditions are: 1) that the policy context is defined precisely, including the type and magnitude of the expected policy impacts, the characteristics of the population affected, the type of value measure (average or marginal value) used, the category of value (direct use, indirect use, non-use, total economic value)

[4] This is indicated by the substantially higher tax coefficient of "don't know" responses in Ely.
[5] See also Frederick and Fischhoff (1998).

measured, and the degree of certainty surrounding the transferred data; 2) that the data available for the study site are of sufficient quality (sample size, sound economic method, sound empirical technique, and sufficient number of similar study sites to allow credible statistical inferences) and that the background information is sufficient (population characteristics); and 3) that study and policy site possess similar characteristics (similar resource, type and degree of change in resource, and source of change; similar demographic characteristics, especially income and cultural background; and, if recreation activities are valued, a similar condition and quality of the recreational experience at both sites) (Rosenberger and Loomis, 2001; Brower, 2000).

Although benefit transfer often is the approach of choice in cases where primary valuation studies cannot be carried out, it is not without problems (see for example Kirchhoff *et al.*, 1997). There rarely are policy sites whose most important WTP-relevant characteristics exactly match study sites for which original data have been generated. Furthermore, studies do not always measure all aspects of the perceived resource quality of the environmental amenities of a study site for which WTP is elicited and thereby prevent the incorporation of all relevant resource quality aspects into meta-analysis functions. Nevertheless, benefit transfer-based benefit estimates may provide a useful tool for estimating the order of magnitude of values (Kirchhoff *et al.*, 1997), and, in the case at hand, for the generation of a second set of WTP estimates against which estimates that can be compared with those generated on the basis of the local data from Aquino and Falk (2001).

We develop WTP estimates for the Arizona/New Mexico reintroduction area using three different approaches. First, since several WTP estimates for gray wolf conservation are available in the literature (see Table 2), it is possible to estimate a meta-analysis WTP function for gray wolves.[6] A meta-analysis-based benefit transfer generates WTP estimates for wolf conservation based on a statistical analysis of the relevant WTP studies found in the literature. Second, we apply a single-point value-based benefit transfer that identifies the most appropriate study in the literature and adjusts that study's WTP estimate to the Arizona/New Mexico context; and, finally, we develop WTP estimates for Arizona/New Mexico using the results of the market experiment described in Aquino and Falk (2001).

WTP estimates based on single-point benefit transfer

Based on the preceding discussion, we identify the characteristics employed in the selection of the study or studies in the literature that constitute the most appropriate sources for benefit transfer to the case at hand, that is, the reintroduction of gray wolves to New Mexico and Arizona. First, we include the characteristics of the affected population that have been shown to be of relevance in WTP estimates: per-capita income, whether or not the individual is residing in the reintroduction area, and whether or not the WTP data come from recreation visitors or residents at large (Loomis and White, 1996). In addition to these characteristics, we include individuals' attitudes toward endangered species and their income, both of which would be expected to influence WTP for wolf

[6] Loomis and White (1996) estimate a non species-specific meta-analysis based WTP function that can be used to generate WTP estimates for any given species. For an application of their benefit transfer function to the valuation of changes in the population of particular species, see Kroeger (2005) and Defenders of Wildlife (2004). Given that the gray wolf is a species that elicits stronger sentiments than most other species, we do not use Loomis and White's meta-analysis function, which is based on a sample of 18 species, to derive WTP estimates for the gray wolf. Rather, we estimate a function explicitly for gray wolves.

conservation.[7] As an important characteristic of the policy context we include the type and magnitude of the size in the species' population change (Loomis and White, 1996). We also include as an additional context characteristic the relative importance of cattle and calf sales in the economy characteristic. Unsworth *et al*. (2005) suggest that the relative size of the farming sector may be influencing people's WTP for wolf reintroduction. However, we argue that the relative importance of livestock sales, and specifically, sales of cattle and calves, would appear to be a more relevant factor than the size of the faming sector, as the farming sector includes many activities that are unaffected by wolves. Table 3 lists these characteristics for the studies in the literature that estimated WTP for gray wolves, and for New Mexico and Arizona.

Table 3: WTP-critical characteristics of studies examining WTP for wolf conservation

	Species pop. change	*Positive attitude toward endangered species' rights*	*Visitors/ Residents*	*Area residents*	*Avg. per-capita income*	*Livestock sales as share of output of respondents' economy* [1]
		% respondents			*1990$*	*% GP*
New Mexico & Arizona -2004	R	47			20,696 (2004)	<1
Chambers & Whitehead (2003)	+	72	R	yes	20,792 (2002)	<1
Chambers & Whitehead (2003)	+	85	R	no	20,912 (2002)	<1
Duffield (1992)	R	n.a. (64)	V	yes	14,885 (1991)	3
Duffield (1992)	R	63	V	no	19,203 (1991)	<1
Duffield *et al*. (1993)	R	n.a.(64)	R	yes	15,101 (1991)	3
Frederick & Fischhoff (1997)	R	n.a.	n.a.	n.a.	n.a.	n.a.
U.S. FWS (1994)-Yellowstone	R	n.a.(64)	R	yes	15,101 (1992)	3
U.S. FWS (1994)-Yellowstone	R	63	R	no	19,622 (1992)	<1
U.S. FWS (1994)-central ID	R	36	R	yes	15,868 (1992)	4
U.S. FWS (1994)-central ID	R	63	R	no	19,622 (1992)	<1

Notes: [1] Sales of cattle and calves. G.P. - Gross Product; multi-county, state or national, depending on residence of survey sample. R - reintroduction. + positive change in species population. For quantification of environmental attitudes, see the discussion in the text.
Sources: Bureau of Economic Analysis, *Regional Economic Information System*; U.S. Census Bureau, *Quick Facts*; U.S. Census Bureau, *Historical Income Tables for States*; Washington State University, *Northwest Income Indicators Project*; U.S. National Agricultural Statistics Service, *Census of Agriculture*; U.S. FWS (1994).

Pay frequency has been shown to be a significant predictor of an individual's WTP for species protection as well (Loomis and White, 1996). However, all studies in Table 3 except Frederick and Fischhoff (1997), which is not useful for our analysis for reasons that will be discussed below, elicited WTP in the form of a one-time (lump sum) payment. Hence pay frequency is not a criterion useful in the selection of a source study for our benefit transfer.

Finally, the type of value we are interested in is the total economic value generated by wolf reintroduction, that is, the sum of direct and indirect use values and non-use values (existence, stewardship, bequest, and intrinsic values). However, all studies listed in Table 3 measured total

[7] The results reported in Chambers and Whitehead (2003) indicate that attitudes towards the environment in general, and attitudes toward endangered species in particular, as measured for example by performance on the New Environmental Paradigm attitude survey (see Dunlap and Van Liere, 1978) may be a large factor in explaining differences in WTP for wolf conservation.

economic values, so this characteristic does not help in the identification of the most appropriate source for a benefit transfer.

We operationalize respondents' environmental attitudes as the percentage of individuals who agree or strongly agree with the statement that all species have a right to exist.[8] The respective information is available for all study areas except the Yellowstone area. Chambers and Whitehead (2003) report the percentages of respondents in their study areas who stated that it is important or very important "to allow all endangered species in Minnesota to exist." Roper (1992) reports that in 1992, 63 percent of U.S. residents agreed with the statement that "every species has a right to exist and it is our moral duty to help them."

For the central Idaho area, no survey has been conducted that uses a comparable question format. Instead, we use the results reported by Trent (1995), who surveyed the Eastside Columbia River Basin public. Trent found that 30 percent of respondents disagreed or strongly disagreed with the statement "Endangered species laws should be altered to maintain timber and ranching jobs on public lands", compared to 52 percent at the national level. Assuming that the same 30/52 ratio holds for views on endangered species in general, we construct a percentage estimate that is compatible with the ones cited above by multiplying the 30/52 ratio given in Trent (1995) by the percent of individuals at the national level who agreed with the statement that "every species has a right to exist and it is our moral duty to help them" (63 percent; Roper, 1992). This results in an estimated 36 percent of Idaho residents agreeing or strongly agreeing with the statement "every species has a right to exist and it is our moral duty to help them."[9]

Skaggs and VanLeeuwen (2004) report that 47 percent of New Mexico residents stated that it is important or very important that "all species have an equal right to exist on the planet." Finally, in a recent survey, 71 percent of Arizona residents stated that it is "very important that threatened and endangered species are properly managed and conserved in Arizona" (Duda *et al.*, 2002). However, the statement is sufficiently different from the ones used in the surveys cited above to make this number not directly comparable. Hence, we use the New Mexico percentage (47 percent) for the whole Arizona and New Mexico study area.

The average per-capita incomes shown in Table 3 are the incomes in the year in which the respective studies were conducted, adjusted to 1990 prices using the Consumer Price Index. Finally, the share of livestock sales is quantified as the ratio of the sales of cattle and calves to gross domestic product, gross state product, or gross county product, respectively, depending on the geographical scale of the survey in the respective studies. We exclude other livestock and their products from our livestock sales variable because these activities are less likely to be affected by the presence of wolves in the state.

In our screening of the literature for the most appropriate candidate study for a benefit transfer, we first eliminate Frederick and Fischhoff (1997). The respondent sample in that study was composed entirely of students, which may be problematic in a WTP study because of often unclear budget constraints and non-representative levels of discretionary spending. Also, the study makes no differentiation in WTP between regional and out-of-region residents, and provides no information

[8] All studies referred to here elicited respondents' opinions using a standard five-point Likert scale.
[9] The comparatively very low importance accorded by Idaho residents to endangered species-related issues is confirmed by Duda *et al.* (1998; see Ch. 8).

on the respondents' place of residence, average income, or environmental attitudes.

The New Mexico and Arizona policy context is the reintroduction of wolves, which constitutes an infinite increase in wolf populations over the baseline scenario. This is also the resource change examined in all studies shown in Table 3 except Chambers and Whitehead (2003). The change evaluated in that study is the prevention of a fall in wolf population levels below a predetermined threshold. However, since the authors did not give information to respondents on the size of wolf population in Minnesota at the time of the survey, respondents had no way of assessing the magnitude of the proposed change. *Ceteris paribus*, the reintroduction of an endemic species would be expected to yield a higher WTP than preventing the mere reduction in the population of a species, which is the base scenario (*i.e.*, absent the policy action proposed to respondents) given to respondents in Chambers and Whitehead's study. Therefore, the transfer of Chambers and Whitehead's WTP estimates to the New Mexico/Arizona context would be expected to result in a downward bias in the transferred estimates.

With respect to average per-capita income of respondents, Chambers and Whitehead's (2003) study is the one most similar to New Mexico/Arizona. The same is also true for the share of cattle and calf sales in total output, where the Minnesota study area is more similar to the New Mexico and Arizona context than either the Yellowstone or central Idaho areas studied by Duffield (Duffield, 1992; U.S. FWS, 1994) and Duffield *et al*. (1993). However, attitudes toward endangered species in New Mexico seem to be closer to those found in the Yellowstone and central Idaho areas at the time those surveys were conducted, as measured by the percentage of respondents who agree with the statement that all species have an equal right to exist.

Because the wolf is a high profile species with interest nationwide (Duffield, 1992), an estimate of the total economic value generated by wolf reintroduction needs to include the WTP of out-of-area residents, in addition to that of local residents and visitors (Loomis, 2000). Ideally, therefore, the study that serves as the base for a benefit transfer for the New Mexico/Arizona reintroduction case should estimate estimates for both local and out-of-area residents. Chambers and Whitehead (2003) develop separate WTP estimates for local and out-of-area residents, and so do Duffield's most recent study for the Yellowstone and central Idaho areas (U.S. FWS, 1994). His earlier studies did only generate estimates for visitors (Duffield, 1992) or local residents (Duffield *et al*., 1993), respectively.

In summary, then, Chambers and Whitehead (2003) and U.S. FWS (1994) constitute the most appropriate bases for a benefit transfer to the New Mexico/Arizona case. In a recent study for the Fish and Wildlife Service that examines the economic impacts of the reintroduction of Mexican gray wolves to the Southwest, Unsworth *et al*. (2005) state that it is not appropriate to transfer the Yellowstone WTP estimates reported in U.S. FWS (1994) to the Southwestern reintroduction area, because of the "unique character of Yellowstone as a highly prized national tourist attraction" (Unsworth *et al*., 2005: 6-13). Yellowstone unquestionably is one of the premier national recreation destinations. However, the Gila Wilderness, situated in New Mexico's Gila National Forest and inside of the Blue Range Wolf Recovery Area, was the world's first designated wilderness area (established at the urging of Aldo Leopold in 1924) and is one of the most sought-after wilderness recreation areas in the United States. Furthermore, the Gila National Forest, roughly co-extensive with the Blue Range Wolf Recovery Area, contains a total of 790,000 acres of wilderness (Gila, Aldo Leopold, and Blue Range wilderness areas), more than any other National Forest in the Southwest. According to the U.S. Forest Service, the Gila National Forest

"is one of the more remote and least developed National Forests in the southwest. Covering 3.3 million acres of publicly owned forest and range land, the Forest is the sixth largest National Forest in the continental United States" (U.S. Forest Service, 2005), attracting, despite its remoteness, more than 1.3 million visits in 2002, of which 115 thousand were wilderness visits (U.S. Forest Service, 2002). "The Gila, Aldo Leopold, and Blue Range Wildernesses offer unparalleled hiking and horseback riding. The magnificence of these mountainous regions imparts an indescribable feeling of awe and wonderment" (U.S. Forest Service, 2005). It is therefore not obvious a priori why the Yellowstone values are not suitable for transfer to the New Mexico and Arizona reintroduction area. However, in the interest of generating a conservative assessment we choose Duffield's (FWS, 1994) central Idaho estimates as the basis for our value transfer, which are 24 percent lower for local residents than the central Idaho estimates, and two percent lower for out-of-area residents.

Chambers and Whitehead's (2003) WTP estimate for local residents with $5 is substantially lower than the average WTP of $25.90 reported in the other studies for residents in wolf reintroduction areas who support reintroduction (2004 prices; see Table 2). It is also considerably lower than their estimate of $22.52 for out-of-area residents. It must be noted that Chambers and Whitehead's (2003) and Duffield's (U.S. FWS, 1994) WTP estimates for out-of-area residents are not directly comparable, as the former are for St. Cloud (MN) residents who live within approximately 50 to 100 miles of populated wolf habitat (U.S. FWS, 2004), while the latter are from a national sample, *i.e.*, for individuals who on average are residing at a far greater distance from wolf habitat. Given that individuals' WTP for protecting a species has been shown to decline with increasing distance from the locale of protection (Loomis, 2000), one would therefore expect Duffield's out-of-region WTP estimates to be lower than those reported by Chambers and Whitehead, which indeed they are.[10] For the same reason, it would not be appropriate to apply Chambers and Whitehead's out-of-region WTP estimates to the United States' population as a whole outside of the reintroduction region, because for the country as a whole, the distance of the average individual from the New Mexico/Arizona reintroduction area is approximately 900 miles, not 50 to 100 miles as in St. Cloud.[11] By comparison, the central Idaho reintroduction area is located some 1,200 miles from the U.S. mean center of population. Taking into account in addition the previously pointed out low WTP estimates observed by Chambers and Whitehead and fact that their study elicited WTP for the prevention of a decline in the wolf population as opposed to WTP for reintroduction, Duffield's central Idaho estimates are the most appropriate base for a benefit transfer to the New Mexico/Arizona area than are Chambers and Whitehead's.

In transferring Duffield's estimates to the New Mexico/Arizona area, we need to adjust these estimates for income differences between the central Idaho area and New Mexico/Arizona, because

[10] The decay in WTP as a function of distance observed by Loomis (2000) could be used to correct Chambers and Whitehead's out-of-region WTP estimates for the difference in distance between St. Cloud and Minnesota wolf habitat and the U.S. population as a whole and Mexican wolf habitat. Multiplying Chambers and Whitehead's WTP estimate for St. Cloud residents ($22.52) by the WTP distance decay coefficient observed by Loomis (2000) for a group of 62 threatened and endangered species at a distance of 900 miles from the locale of protection, yields WTP estimates for Mexican wolves of $13.51 and $16.44, respectively, depending on whether Loomis' log or linear estimations are used. These values are higher than the $10.83 (2004$) reported by Duffield (U.S. FWS, 1994).

[11] In 2000, the mean center of population was located in south-central Missouri (U.S. Census Bureau, 2001).

income is a critical determinant of WTP.[12] This income adjustment is not straightforward, however, because no study exists that estimates the income elasticity (ε) of WTP for the protection of threatened and endangered species.[13] The literature does provide estimates of ε of WTP for environmental quality. These studies show that the ε of WTP ranges from values of zero to larger than one. Commonly, it is assumed that WTP for environmental goods increases disproportionately with income, because environmental quality is often seen as a luxury good whose relative importance to an individual increases with his or her wealth. However, here we assume conservatively that WTP for the protection of endangered species increases linearly with income, that is, $\varepsilon = 1$.

We do not adjust for differences between the central Idaho and New Mexico/Arizona areas in people's attitudes toward endangered species and in the relative importance of cattle and calf sales in the local economy, because of the lack of studies that prove that these are significant determinants of WTP. This increases the conservative bias in our estimates. If the association of these factors with WTP is as expected (positive for attitudes toward endangered species, negative for importance of cattle and calf sales), then the omission from our analysis of adjustments for differences in these factors would lead to a downward bias in our transferred WTP estimates, given the New Mexico/Arizona area's apparent higher concern for the protection of endangered species and the lower importance of cattle and calf sales in the region's economy.
Table 4 shows the WTP estimates for the New Mexico/Arizona study area for regional and out-of-region residents.

Table 4: WTP estimates based on benefit transfer of Duffield's 1992 central Idaho estimates to the New Mexico/Arizona reintroduction region

	WTP 2004$, lump sum	
	Area residents	*Out-of-region residents*
U.S. FWS (1994) - Central Idaho reintroduction area	$19.36	$10.83
Avg. per-capita income ratio, NM/AZ in 2004 / Central Idaho in 1992	1.30	1.28 *
WTP estimate for NM/AZ reintroduction area at $\varepsilon = 1$	$25.25	$13.82

Notes: * In 2004, the U.S. average per-capita income was $33,044, or $25,035 in 1990 prices. ε denotes income elasticity of WTP.

Duffield (U.S. FWS, 1994) does not provide estimates of WTP for wolf reintroduction for recreation visitors as a separate group. However, his earlier study (Duffield, 1992) estimated WTP for both local and national visitors for Yellowstone (see Table 2). The ratio of the WTP of visitors and that of the average individual for wolf reintroduction to Yellowstone from his more recent study (U.S. FWS, 1994) is 5.6:1 for local visitors and 7.6:1 for visitors from outside of the region.

[12] Schläpfer (2005), in a recent analysis of the income elasticity of WTP for public goods, reports that in the 64 percent of the studies surveyed in his literature review that gave an income coefficient, this coefficient was significantly larger than zero (at $p<0.1$).
[13] The income elasticity of WTP is defined as the percent change in WTP that results from a one percent change in income.

By comparison, in Loomis and White's (1996) survey of the endangered species WTP literature, the three studies that estimated WTP for both visitors and residents showed ratios between 1.5:1 and 2.8:1. We use the average of the ratios reported in Loomis and White (1996), 2.0:1, to generate a conservative estimate of the WTP for wolf reintroduction of recreation visitors to the New Mexico/Arizona reintroduction area. This yields the WTP estimates for the four relevant population groups shown in Table 5.

Table 5: Single-point based WTP estimates for reintroduction of Mexican wolves, for recreation visitors/non-visitors and for local and out-of-area residents

	WTP per capita, $2004, lump sum	
	Visitor to National Forest	*Not visiting National Forest*
AZ and NM residents	$49.99	$25.25
Out-of-area residents	$27.37	$13.82

WTP estimates based on meta-analysis benefit transfer

We use a meta-analysis regression model to estimate the size of the impact of the variables that are expected to influence people's WTP for wolf protection. We include all the variables shown in Table 3: environmental attitude, regional or out-of-region residence, visitor or not, income, and relative importance of livestock sales in the respondent's economy. In addition, WTP has been shown to be influenced by the magnitude of the proposed change in species population (Loomis and White, 1996). However, all the studies shown in Table 3 elicited respondents' WTP for the same, infinite change (reintroduction of wolves), with the exception of Chambers and Whitehead (2003) who did not give respondents information on the size of the proposed change. Therefore, we omit size of change from our model. Pay frequency (annual vs. one-time payment) has also been shown to have a significant impact on respondents' WTP (Loomis and White, 1996), confirming Stevens *et al.*'s (1997) findings of the importance of temporal embedding. Since all studies included in our analysis elicited WTP in the form of a one-time (lump sum) payment, we exclude that variable as well. We include all studies shown in Table 3, except Frederick and Fischhoff (1997). The respondent sample in that study was composed entirely of students, which may be problematic in a WTP study because of often unclear budget constraints and non-representative levels of discretionary spending. Also, the study makes no differentiation in WTP between regional and out-of-region residents, and provides no information on the respondents' place of residence, average income, or environmental attitudes.

Our model takes the following form:

$$\ln \mathrm{WTP} = c + b_1 \ln \mathrm{ENV\_ATT} + b_2 \mathrm{VISIT} - b_3 \mathrm{REGION} + b_4 \ln \mathrm{INCOME} - b_5 \ln \mathrm{LIVESTOCK} + e \ ,$$

where ln is the natural logarithm, the *b*s are coefficients indicating the elasticity of WTP to changes in the respective variables, VISIT and REGION are dummy variables, and ε is the error term. The VISIT variable assumes a value of 0 if respondents were not visitors, and 1 if they were visitors. The REGION variable assumes a value of 0 of respondents were from outside of the wolf conservation region, and 1 if they resided in the region. We report here only the results of the double-log models as they provided a slightly better fit than the unlogged models.

The hypothesized sign of the coefficient is positive for the environmental attitude variable, because it would be expected that individuals with more concern for endangered and threatened species would have a higher WTP for species conservation in general (Loomis and White, 1996) and, by extension, for wolf conservation. The sign is also expected to be positive for the VISIT variable, because in the source studies visitors were individuals visiting a national park, who, *ceteris paribus*, are expected to have a higher WTP for species protection than the public at large (Loomis and White, 1996). The sign on the REGION variable is expected to be negative, because in general, support for wolf reintroduction is smaller in the reintroduction areas than outside of these areas (see Chambers and Whitehead, 2003; U.S. FWS, 1994; Duffield and Neher, 1996). Income is expected to have a positive sign, because an individual's WTP is limited by his or her ability to pay, which is a positive function of income. Finally, the sign on the LIVESTOCK variable is expected to be positive, because, all other things equal, individuals in areas with an important livestock industry would be expected to have a less positive attitude toward wolf reintroduction.

Table 6 shows the coefficients of the variables for both the full and the reduced double-log models. The reduced model includes only variables that are significant at the 0.05 level. All variables except the LIVESTOCK variable have the expected sign, and all except the INCOME variable are significant at the 0.05 level or higher. The positive sign of the LIVESTOCK variable appears to be due to strong negative correlations between that variable and the INCOME and ENV_ATT variables.

Table 6: Estimation results for the meta-analysis regression models

	Full model	*Reduced model*
CONSTANT	-23.796	-0.524
(*t*-statistic)	(-1.090)	(-0.355)
ENV_ATT	1.055*	1.033**
	(2.944)	(2.838)
VISIT	1.859**	1.757**
	(10.320)	(11.278)
REGION	-0.909**	-0.907**
	(-4.655)	(-4.564)
INCOME	2.384	
	(1.068)	
LIVESTOCK	0.628**	0.459**
	(3.744)	(7.995)
Adj. R^2	0.97	0.97
N	9	9
F	48.80	64.29

Notes: * and ** denote significance at the 0.1 and the 0.05 level, respectively.

The variables included in the model explain most of the variation in WTP estimates reported in the studies included in our analysis.

WTP estimates for the Arizona/New Mexico study area can now be generated by substituting the coefficients shown in Table 6 and the Arizona/New Mexico study area characteristics shown in Table 3 into the meta-analysis equation. No recent poll on individuals' attitudes on species

protection has been conducted that uses the question employed in the 1992 Roper poll cited above. However, more recent studies suggest that the nation-level attitude towards endangered species is likely to remain similar to that observed in 1992. For example, Brunson and Steel (1994) found that 75 percent of the respondents sample agreed with the statement that "Humans have an ethical obligation to protect plant and animal species." Tarrant *et al.* (1997) found that 72.5 percent of respondents in their nationwide poll agreed that "Land that provides critical habitat for plant and animal species should not be developed." And in a March 2004 Gallup poll, 62 percent of respondents stated that they "worry a great deal" or "worry a fair amount" about the extinction of plant and animal species (Gallup, 2005). In generating our out-of-study area WTP estimates, we therefore use the 1992 Roper value of 63 percent for the ENV_ATT variable.

The resulting estimates of individuals' WTP for reintroduction of gray wolves to the BRWRA are presented in Table 7, for both local residents and out-of-area residents, as well as for individuals visiting the National Forests in the area and those who do not visit.

Table 7: Meta-analysis based WTP estimates for wolf reintroduction to Arizona and New Mexico reintroduction area

	WTP per capita, $2004, lump sum	
	Visitor to National Forest	*Not visiting National Forest*
	model: full / reduced	model: full / reduced
AZ and NM residents	$76.86 / $48.78	$11.98 / $8.41
Out-of-area residents	$24.23 / $20.81	$3.78 / $3.59

As is evident from Table 7, the differences in the WTP estimates generated by the full and reduced models are much larger in absolute terms for visitors than for non-visitors. Given that the meta-analysis includes only one study (Duffield, 1992) that reports WTP estimates for visitors, the estimates for National Forest visitors should be interpreted with considerable caution. Due to the small sample size (N=9), the same is true to a lesser degree also for the remaining estimates.

WTP estimates based on "wolf-friendly" beef market experiment

During a month-long test, beef produced at a ranch located more than 150 miles southwest of Albuquerque was offered for sale at the restaurant of the Albuquerque Zoo, and at two grocery stores in the city. The zoo and the grocery stores deployed informational materials and posters to draw people's attention to the special nature of the beef, which was approved as "wolf-friendly" by two environmental organizations, Defenders of Wildlife and Forest Service Employees for Environmental Ethics. At the zoo cafeteria, "wolf-friendly" burgers were sold at a 55 percent premium compared to standard burgers. At the two grocery stores, the "wolf-friendly" ground beef was sold at a 30 percent premium over the high-quality, grain-fed, lean ground beef sold at the store, and at a more than 90 percent premium over the regular ground beef.[14] The store manager concluded after the trial that customers were interested in the "wolf-friendly" attribute, but that the asking price for the beef was too high given its comparatively "bland" taste and lack of leanness when compared to their other high-priced, and even their regular, beef (Aquino and Falk, 2001). The results at the zoo likewise demonstrated that the premium deterred consumers from purchasing

[14] These figures take into account that all sales of "wolf-friendly" beef were with "$0.50 per pound off" coupons.

the wolf-friendly burgers. Most likely there were not many repeat visitors to the zoo's cafeteria during the month-long market trial. Therefore, unlike regular visitors to the grocery stores, individuals at the zoo cafeteria did not have a chance to take into account differences in beef quality such as taste and leanness when making their purchase decisions. Such differences can act as confounding factors when estimating WTP based on purchase behavior of "wolf-friendly" beef. Therefore, the results from the zoo beef market experiment would be more appropriate than those from the grocery store market for estimating people's WTP for "wolf-friendly" beef.[15]

The sale of "wolf-friendly" burgers at the Zoo's cafeteria and in the grocery stores, as well as anecdotal evidence provided by the grocery store manager, suggests that WTP for wolf-friendly beef exists. However, because of the lack of information on the demand-relevant comparative characteristics of the wolf-friendly and regular beef, it is not possible to conduct a hedonic analysis in order to determine the WTP of individuals for the wolf-friendliness attribute. Nevertheless, the observations from the Albuquerque Zoo experiment permit the generation of a cautious estimate of State residents' WTP for wolf protection.

The zoo cafeteria sold 50 pounds (200 burgers) of the "wolf-friendly" beef during the month-long trial in 1998. This amounts to 2.9 percent of the cafeteria's average monthly burger sales of 1,750 pounds (Aquino and Falk, 2001). The "wolf-friendly" burgers sold at a 55 percent premium over the standard burgers ($4.25 vs. $2.75 apiece). Assuming the zoo's cafeteria is representative of the New Mexico ground beef market, and that the same premium could be obtained in other segments of the beef market (*i.e.*, non-ground beef), "wolf-friendly" beef potentially could attain a 2.9 percent share of the total retail beef market in the State at a 55 percent price premium.[16]

No information is available on the total value of beef sold at retailers and food establishments with in-house meat processing facilities in New Mexico. However, in 2002, total farm sales of beef cows and calves in the State had an estimated value of $306 million (in 2002 $; U.S. Department of Agriculture, 2004). This does not include cows whose primary function was not beef production, but that were sold to meat producers after their death. In addition, after passing through the value added chain, the final retail sales value of beef products is far higher than the $306 million associated with farm sales of beef cows and calves. Therefore, WTP estimates based on the farm sale value of beef cows and calves will necessarily understate actual WTP for "wolf-friendly" beef. Nevertheless, working with this available value and assessing a 55 percent premium on 2.9 percent of this sales volume, yields an estimate of annual WTP for "wolf-friendly" beef in New Mexico of $4.9 million (in 2004$). Given an estimated population in the state in 2003 of 1,874,614 persons, this translates into an estimated average WTP for wolf protection ***through the***

[15] In addition, due to the lack of information on the monthly quantity of all types of ground beef sold at the two grocery stores, the data on the performance of "wolf-friendly" beef at those stores is insufficient to estimate potential total WTP for "wolf-friendly" beef.

[16] This assumes, among other things, that the attitudes of zoo customers towards wolf conservation (or, more precisely, wolf conservation through purchase of "wolf-friendly" beef) are representative of those of the State's population at large. It is not possible to test this assumption, as no attitude survey was taken of the customers of the cafeteria. Aquino and Falk (2001) report that, in addition to the two retail market tests, a half-day promotional event for "wolf-friendly" beef took place at the Albuquerque Zoo, during which a survey was administered to elicit respondents' attitudes toward "wolf-friendly" beef, among other things. 85 percent of survey participants stated that they would purchase beef that protects predators, and 87.5 percent said they would pay a premium for beef that protects riparian areas and predators (ibid.). However, this sample was not representative as it was composed mainly of people holding membership in environmental organizations, and hence is not useful as a basis for generalizations.

purchase of "wolf-friendly" beef of $2.62 per person per year, or $6.89 per year for each household in the State. Using a discount rate of 15 (ten) percent, the present value of such annual payments over a 20-year time frame is $19.02 ($24.93).[17] We conservatively choose the WTP based on the 15 percent discount rate. This WTP is lower than the mean of the lump-sum values reported in the literature shown in Table 2, which is $25.05 if Chambers and Whitehead's (2003) WTP estimate for St. Cloud residents is used.[18] For Arizona, adjusting for income differences and assuming an income elasticity of one for WTP for wolf reintroduction, average WTP is $20.66. For the two states combined, the population-weighted average is $21.71. Deriving the WTP estimates for out-of-region residents and visitors on the basis of the ratios shown in Table 5 yields the set of estimates for the four relevant population groups shown in Table 8.

Table 8: WTP estimates for reintroduction of Mexican wolves, for recreation visitors/non-visitors and for local and out-of-area residents, based on market experiment by Aquino and Falk (2001)

	WTP per capita, $2004, lump sum	
	Visitor to National Forest	*Not visiting National Forest*
AZ and NM residents	$42.99	$21.71
Out-of-area residents	$23.53	$11.89

Although revealed WTP for "wolf-friendly" beef under certain circumstances may serve as a proxy for people's WTP for wolf conservation, there are several reasons why it is imperfect indicator. First, people's WTP for "wolf-friendly" beef may partly reflect their attitude towards the suggested payment mechanism for wolf conservation. Individuals may see private, individual "good-will" actions such as purchasing "wolf-friendly" beef as an inferior approach than a more broadly conceived government conservation program that would distribute the burden more evenly, given that species conservation is a public good and a societal objective. Hence, the WTP imputed based on Aquino and Falk's results in the beef market may be partly a function of the payment mechanism, and not merely a function of the value people attach to wolf conservation (Loomis and White, 1996).

Furthermore, the single-point estimate ($4.25 per quarter pound of "wolf-friendly"burger) does not permit the estimation of the WTP function of all potential consumers of "wolf-friendly" beef. Therefore, as with all WTP estimates based on observed market transactions at a single price point, part of the WTP (the part that exceeds the price) of consumers is not captured and hence is not included in a WTP estimate based on observed purchasing behavior. This part of WTP is represented by area ***a*** in Figure 1. Likewise, the WTP of potential consumers of "wolf-friendly" beef that are crowded out by the relatively high (55 percent) price premium in the market test at the Zoo goes unaccounted for. This part of total WTP for "wolf-friendly" beef is represented by area ***c*** in Figure 1. The only part of WTP for wolf conservation through "wolf-friendly" beef that is captured in the zoo market experiment is that represented by area ***b*** in Figure 1. The lower the price elasticity of demand for "wolf-friendly" beef, the smaller the share of total WTP that is captured by estimates based on a single data point.

[17] Use of a high discount rate is supported by the often-observed weak insensitivity of individuals to payment schedules (Stevens *et al*., 1997).

[18] As discussed above, Chambers and Whitehead's WTP estimate for their "local" sample is uncharacteristically low. Furthermore, use of the WTP of their "out-of-region" St. Cloud sample is appropriate because St. Cloud residents live in closer proximity to occupied wolf habitat in Minnesota than the majority of New Mexico and Arizona residents live to Mexican occupied wolf habitat.

For these reasons, we expect that our WTP estimates represent underestimates of actual WTP of State residents for wolf conservation in New Mexico.

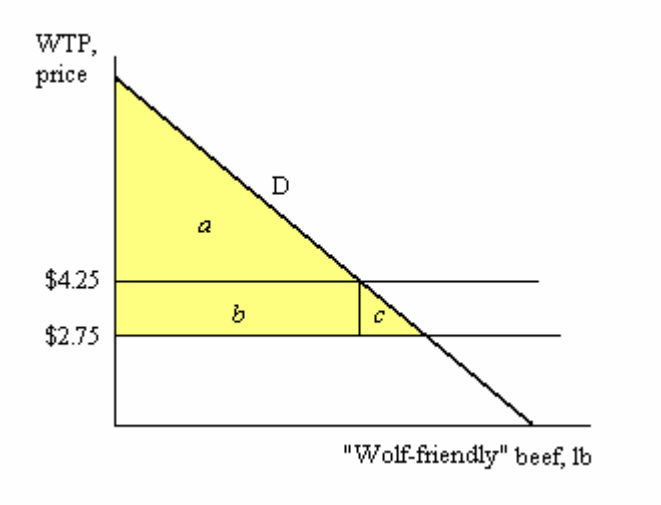

Figure 1: WTP for "wolf-friendly" beef

Establishment of lower and upper-bound WTP estimates

To incorporate the uncertainty surrounding the actual WTP for reintroduction of wolves to the New Mexico and Arizona region, we generate low, mean, and high WTP estimates. Our low and high estimates are those generated by the reduced-form meta-analysis model and those generated by the single-point transfer model, respectively. We generate a mean estimate for each population segment that is equal to the average of the three WTP models (see Table 9).

Table 9: Comparison of the three sets of per-capita WTP estimates

	WTP, 2004$ (lump sum)			
Population	*Single-point benefit transfer*	*Meta-analysis benefit transfer (reduced model)*	*Beef market experiment*	*Average*
AZ/NM resident	25.25	8.41	21.71	18.46
AZ/NM resident, NF visitor	49.99	48.78	42.99	47.25
Out-of-area resident	13.82	3.59	11.89	9.77
Out-of-area resident, NF visitor	27.37	20.81	23.53	23.90

Note: NF - National forest.

Using our sets of low, high, and mean per-capita WTP estimates, we can now generate estimates of total WTP for the four groups of individuals shown in Table 9. In doing so, we make the conservative assumption that non-respondents in the source studies have zero WTP for reintroduction of wolves. This assumption is extremely conservative because it implies that the reason why individuals chose not to reply to a survey was a complete lack of interest in or appreciation for the particular topic addressed in the instrument. However, individuals may have a variety of other reasons for not responding to a survey, such as time constraint, inconvenient

timing, or privacy concerns, among others. Interpreting all non-replies as expressing zero WTP therefore is likely to substantially underestimate total WTP. As response rate for out-of-region residents we use the mean of the share of Duffield's (U.S. FWS, 1994) national survey respondents (45 percent) that were in favor of reintroduction to central Idaho (67.9 percent), and of Chambers and Whitehead's (2003) response rate (54 percent), which is 42 percent. For local residents, we use the mean of Duffield's and Chambers and Whitehead's local residents' response rates, 48 percent. Finally, for visitors, we use Duffield's (U.S. FWS, 1994) 86 percent response rate for local and out-of-region visitors. In other words, we assume that 52 percent of local respondents, 58 percent of out-of-region respondents, and 14 percent of recreation visitors have a zero WTP for wolf reintroduction.

Total WTP in New Mexico and Arizona is derived as the New Mexico and Arizona population, multiplied by the non-response rate, multiplied by per-capita WTP. WTP for out-of-region residents and visitors is derived analogously.

Approximately 3.2 million recreation visits occur per year to the two National Forests in the Blue Range Wolf Recovery Area (Unsworth *et al*., 2005). Available data show that for the Gila Wilderness area, as much as 80 percent of visitors are not from New Mexico or Arizona, but for the non-wilderness areas in the Gila National Forest, the ratio appears to be reversed (U.S. Forest Service, 2002). Unsworth *et al*. (2005) report that for the National Forests in the recovery area (the Gila and the Apache-Sitgreaves) as a whole 36 percent of visitors are local.

When estimating the total WTP of visitors, one must account for the fact that local visitors in particular may make multiple visits to the two National Forests in a given year. Unfortunately, the forest visitor reports do not provide information on the average number of trips the average National Forest visitor takes per year. We therefore use information available for an important subset of all National Forest visitors, wildlife watchers, to estimate the average number of trips made to National Forests by all National Forest visitors. According to the National Survey National survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. FWS and U.S. CB, 2002a), New Mexico residents engaging in wildlife watching took an average of 10.9 trips in 2001. However, taking into account that only 91 percent of all participants visited public lands, and that the two National Forests in our study area accounted for only 14 percent of all visits to Forest Service lands in New Mexico and Arizona (Unsworth *et al.*, 2005), the estimated number of trips per year that the average National Forest visitor from New Mexico takes to the Apache and Gila forests was 1.4. In other words, the 1.2 million local recreation visits received by the two forests were taken by an estimated 830,000 local residents. We assume that out-of-state residents visited the forests only once in the year of their visit, so the 2.1 million out-of-state visits (64 percent of a total of 3.2 million visits) are assumed to be equivalent to 2.1 million out-of-region visitors.

Table 10 shows the estimates of the total WTP for reintroduction of Mexican gray wolves to the Southwest, for regional and out-of-region residents, and for local and out-of-state visitors to the two National Forests located in the reintroduction area. Total WTP over all four groups is estimated to be between $204 million and $703 million, with a mean estimate of $504 million. For comparison, Duffield estimated that reintroduction of wolves to central Idaho would produce total non-market benefits to all domestic supporters of reintroduction of $573 million (2004$) for a recovered population of 100 wolves (based on U.S. FWS, 1994, table 4-18). Given that at the time of reintroduction it was expected that the projected final total population of Mexican wolves would number around 120 individuals (U.S. FWS, 1995), and that all of our estimates incorporate a number of conservative assumptions, our low estimate of total WTP for Mexican wolf

reintroduction appears extremely conservative.

Table 10: High, low, and mean estimates of total WTP for Mexican wolf reintroduction

	total WTP, 2004$ (lump sum)		
Population	*High estimate*	*Mean estimate*	*Low estimate*
AZ/NM residents *	31,249,049	22,844,897	10,414,133
AZ/NM residents, NF visitors	13,516,257	12,776,151	13,189,371
Out-of-area residents *	639,332,199	451,715,448	166,043,120
Out-of-area residents, NF visitors	19,330,326	16,884,222	14,699,914
Sum	703,427,831	504,220,719	204,346,538

Notes: * Excludes NF visitors. High estimate based on single-point benefit transfer; Mean estimate based on average WTP of three estimation approaches; Low estimate based on meta-analysis benefit transfer (reduced model).

Although the non-use benefits associated with reintroduction of the wolf to the Southwestern U.S., reintroduction dominate all other benefits, wolves generate a number of additional economic benefits. We briefly discuss these in the following paragraphs.

Sale of wolf-related products

The renewed presence of wolves in the BRWRA has led to an increase in the sales of wolf-related products in the region, such as wolf-friendly beef and books.[19] This study does not attempt to compile comprehensive estimates of the sales of wolf-related products. Nevertheless, Unsworth *et al.* (2005) report that one local bookstore has been experiencing greatly increased sales of two books on Mexican wolves, one of which was brought back to print after the reintroduction program was proposed. Gross sales of the two books at this bookstore alone totaled $27,500 since 1998. To the extent that these wolf-related products generate additional sales in their respective categories, the associated profits constitute a social benefit attributable to reintroduction.

Tourism

Reintroduction of wolves to the National Forests in the BRWRA may attract additional visitors to the area who seek the use benefits (seeing wolves or listening to them howl) associated with wolves, or who simply are attracted by the idea of recreating in an area inhabited by wolves.[20] Unfortunately, the lack of comprehensive annual visitation estimates for the area's National forests makes it impossible to detect a trend in visitation levels that might be attributable to wolf reintroduction (Unsworth *et al.*, 2005). Consequentially, it is not possible to construct estimates of wolf-related increases in tourist expenditures and associated regional multiplier impacts.

Education

Reintroduction of wolves to the BRWRA also has generated educational benefits for people both in and outside of the region. Local school classes have conducted several field trips and programs focusing on wolves, and a Mexican wolf workshop for educators was held in 2003. In addition,

[19] For example Ervin's Natural Beef, a consortium of ranchers.
[20] The latter would be attributed to non-use benefits received by recreationists.

many of the over 160 community outreach activities conducted by the Mexican Wolf Reintroduction Program carry educational benefits, or have specifically educational purposes.[21] In addition, several media productions have featured the Mexican wolf recovery program. In June 2002, the BBC filmed the newly released Bluestem Pack for a wolf documentary released in 2003, and in April 2003, Animal Planet filmed the capture and processing of six wolves at the Sevilleta facility, for an episode of "The Jeff Corwin Experience" featuring wolf recovery programs. In 2004, the DVD "Wildlife Survivors - El Lobo: The Song of the Wolf/Coyote" was released, featuring the story of the reintroduction of the Mexican wolf. The profits generated by these productions constitute net social welfare benefits of wolf reintroduction. Quantification of these benefits is beyond the scope of this paper.

Ecosystem service benefits

Reintroduction of wolves into their former habitats can have multiple impacts that indirectly benefit economic output. Wolves may affect browsing behavior by deer and elk, resulting in an increase in riparian vegetation and a decrease in stream temperature (Ripple *et al.*, 2001; Ripple and Beschta, 2004; White *et al.*, 2003). This in turn is likely to improve habitat conditions for trout, which lie at the heart of a mayor sport fishing industry. Trout are the leading game fish in both Arizona and New Mexico, with an estimated total of 219,000 and 210,000 participants, respectively, in 2001 (U.S. FWS and U.S. CB, 2002a; 2002b), accounting for 39 percent of all fishing days in Arizona, and 72 percent in New Mexico (*ibid.*). The economic impact of sport fishing is substantial; freshwater fishing related trip expenditures alone amounted to $142 million in Arizona, and $91 million in New Mexico (*ibid.*). The total economic output associated with freshwater sport fishing was $827 million in Arizona and $363 million in New Mexico (American Sportfishing Association, 2002). Hence, even a small increase in the quantity of trout fishing in the reintroduction area could yield substantial increases in local expenditures.

Predation of wolves on deer and elk may also lead to decreased forage competition for livestock, with concomitant positive impacts on livestock production (Unsworth *et al.*, 2005). However, since Mexican wolves do not appear to have had a significant impact on the numbers of deer and elk (*ibid.*), this benefit may be rather small in the study area. Potentially more important is the effect of interspecific competition between wolves and coyotes, especially that of predation by the former on the latter. This may reduce the number of livestock depredation episodes by coyotes, which in 2001 accounted for 50 percent of all cattle and calf kills by predators in Arizona, and 29 percent of cattle kills and 80 percent of calf kills by predators in New Mexico (National Agricultural Statistics Service, 2001). Interspecific competition between wolves and coyotes is well documented (Crabtree and Sheldon, 1999; Smith *et al.*, 2003), but its extent may vary by locale (*e.g.*, see Arjo and Pletscher, 1999).[22] Unfortunately, no studies exist on the magnitude of this impact in the BRWRA.

Recent research suggests that wolves could substantially reduce the prevalence of chronic wasting disease (CWD) in deer and elk populations (Wild *et al.*, 2005). The extent of this impact however remains to be seen. So far, it is based exclusively on the results of simulation modeling, because of the current lack of overlap between CWD and occupied wolf habitat.

[21] See U.S. Fish and Wildlife Service (2001) and later reports.

[22] After their reintroduction to Yellowstone, wolves reduced coyote density in the park by 50 percent, and by up to 90 percent in core areas occupied by wolf packs (Crabtree and Sheldon, 1999).

Regional expenditures on reintroduction

Reintroduction of the wolf to the BRWRA has resulted in substantial expenditures by state and federal agencies involved in the reintroduction effort. Since 1998, the year of reintroduction, an estimated $7.76 million (2004$) have been spent in the reintroduction area by state and federal agencies (Unsworth *et al*., 2005). From the perspective of the region (*i.e*., the reintroduction area and the surrounding counties), these resources likely would not have been spent in the area but rather would have been spent elsewhere. Hence, these expenditures, as well as their associated multiplier effects in the regional economy, an estimated total of $2.8 million during the period 1998-2004 (*ibid.*), represent an economic benefit from the perspective of the region. From a national-level perspective, the resources spent on wolf reintroduction to the BRWRA represent opportunity costs. This is not true for the multiplier effects associated with these expenditures, which simply would have occurred in another region of the country where the agency resources would have been spent had they not been devoted to reintroduction of wolves to the BRWRA.

The cited impacts are those associated with expenditures by state and federal agencies. They do not include impacts associated with expenditures by private individuals and non-governmental organizations (NGOs) that participated in the reintroduction process. Although expenditures by the agencies are likely to dwarf those by private individuals and NGOs, the latter have not been insubstantial.[23] For example, Defenders of Wildlife spent $136,000 in the BRWRA area on Mexican wolf reintroduction, for salaries and housing for wolf guardians, equipment used for pro-active measures aimed at preventing livestock depredation by wolves and for wolf monitoring, and salary for a range rider. These expenditures generated an additional estimated regional output of $49,000.

Costs of reintroducing Mexican gray wolves

WTP of opponents of reintroduction

Just as some individuals have a WTP for wolf reintroduction, others have a WTP to prevent reintroduction. In the studies reported in this paper, the survey instruments were generally eliciting respondents' WTP to support reintroduction. The exception to this is Duffield's Yellowstone and central Idaho study (FWS, 1994), in which respondents also were given the option to state their WTP to prevent reintroduction of wolves to the areas. In the other studies, opponents of reintroduction had a choice between entering a zero WTP amount or not responding to the survey (which in this study we treat as expressing a zero WTP). Hence, our upper-bound ("high") benefit estimate of WTP for reintroduction, which is based on Duffield's central Idaho WTP, requires a corresponding estimate of the negative WTP for reintroduction.

For opponents of reintroduction, reintroduction represents a cost that is measured by their WTP to prevent the event. Locally, supporters of reintroduction to central Idaho outnumbered opponents by a ratio of 1.1 to one, while nationally, the ratio was 2.1 to one. Since no WTP survey was

[23] For example, since 1998 a minimum of 277 meetings occurred between agency personnel and others (Unsworth *et al*., 2005). Cost share investments in the proactive measures on the part of other NGO's and government organizations also represent regional benefits, as long as the funds associated with them would otherwise have been spent outside of the BRWRA. For example, the community herding project by the White Mountain Apache tribe has been supported by EQIP (Environmental Quality Incentives Program) funds, by contributions by Defenders of Wildlife, and by contributions (including in-kind) by the White Mountain Apache tribe.

conducted on the reintroduction of Mexican wolves to the Southwest, we use Duffield's central Idaho supporter-opponent ratios to estimate total WTP to prevent reintroduction in New Mexico and Arizona. Average WTP among local opponents of reintroduction to central Idaho was $10.83 (2004$). Adjusted for the income difference between New Mexico/Arizona and central Idaho, this is equivalent to an estimated average WTP of $13.26 of local opponents for New Mexico/Arizona. For out-of-area residents opposing reintroduction to central Idaho, average WTP was $1.89 (2004$), or an income-adjusted $2.41 for the New Mexico/Arizona area. Assuming that 33 percent of the local and 14 percent of the national population are opposed, total WTP to prevent reintroduction to New Mexico/Arizona was $11.2 million for area residents and $38.2 million for out-of region residents.[24] As already discussed, this cost applies only in the high impact estimate. We assume that National forest visitors are not opposed to wolf reintroduction.

Depredation impacts on livestock

Unsworth *et al.* (2005) develop three estimates of livestock depredation by Mexican wolves. Their low estimate is based on confirmed kills. Their medium estimate is derived as the product of confirmed kills and the ratio of total losses to confirmed losses, based on findings reported in Bjorge and Gunson (1985), Oakleaf *et al.* (2003), and Naughton-Treves *et al*. (2003). As Unsworth *et al.* themselves state, Oakleaf *et al.*'s estimate (a ratio of 8:1) may be too high as that study only analyzed losses of calves which are particularly difficult to recover because they are consumed more rapidly. Bjorge and Gunson estimated a ratio of total to confirmed losses of 6.7:1 based on their study in northern Alberta, while Naughton-Treves *et al*. estimated a ratio of 2:1. Because differences in husbandry practices such as pasture rotation, deployment of guard dogs, fencing, carcass removal, number of times stock is checked, *etc*. and differences in terrain and vegetation cover may impact depredation rates, it is difficult to assess the validity of transferring those literature ratio estimates to the New Mexico/Arizona study area. In addition, Fritts (1982) found that sometimes wolf depredations on livestock are exaggerated, kills by other carnivores, especially the coyote (*Canis latrans*) are misattributed to wolves, and non-existent missing animals (especially calves, lambs) often falsely are blamed on wolves. It is easy to understand how such misattributions can occur, given the difficulty in many cases of clearly distinguishing kills by wolves from kills by dogs or coyotes, and the large number of depredations by the latter two. For example, a survey by the Idaho Agricultural Statistics Service showed that in 2000, total depredation of cattle and calves by coyotes and dogs combined was 69 times as high as that by wolves (Mack *et al*., 2002), similar to the national-level ratio of 75:1 (National Agricultural Statistics Service, 2001). In Wyoming, the ratio in 2004 was four to one (National Agricultural Statistics Service, 2005). No comparable estimates exist for New Mexico and Arizona. However, coyotes and dogs combined accounted for an estimated 59.4 percent of total cattle and calf depredations in Arizona, and 84 percent in New Mexico (National Agricultural Statistics Service, 2001). Because of these distorting factors, Zimen and Boitani (1979) estimated that wolves may in some circumstances account for only 20-50 percent of the depredations for which they are held liable. In addition, recent research suggests a "wilderness discount" effect on livestock depredation by wolves (Haney *et al*., 2005), showing that depredation is lower in areas characterized by a lesser degree of human use and higher share of wilderness. Given the large share of remote and wilderness areas in the BRWRA, it is conceivable therefore that the number of actual depredation episodes by wolves is lower than that attributed to them.

[24] These percentages are the products of the survey response rate (70 percent for the local and 45 percent for the national sample; see FWS, 1994) and the share of respondents opposing reintroduction to central Idaho (47 percent for the local and 32 percent for the national sample), respectively.

Undoubtedly, some livestock depredations by wolves go undocumented. On the other hand, for the reasons discussed in the previous paragraph, it is reasonable to assume that some depredations caused by other predators, especially coyotes and dogs, are misattributed to wolves. It is impossible to identify the net effect of these two opposing factors. However, we believe that Unsworth *et al.*'s (2005) medium estimate of livestock losses by wolves is likely biased upward, because they ignore the possible impact of misattributions, and because their ratio is based on three ratios from the literature of which one (Oakleaf *et al.*, 2003) is likely to be too high for the reasons discussed above. We ignore the misattribution problem, but we exclude the 8:1 ratio reported by Oakleaf *et al.*, and derive a ratio of confirmed to undocumented cattle and calf losses of 4.4, which is the average of the ratios reported by Naughton-Treves *et al.* (2003) and Bjorge and Gunson (1985). This represents our high estimate of cattle and calf depredations. Our high estimate of sheep depredations is that developed by Unsworth *et al.*, which is the number of confirmed sheep kills multiplied by the ratio of total to confirmed kills of 2.3:1. Our high estimate of dog and horse depredations is the sum of confirmed and probable kills reported by Unsworth *et al.* Our low estimate of livestock depredations is identical to Unsworth *et al.*'s low estimate, *i.e.*, it is based on confirmed kills only. Our estimates of depredations and associated costs are shown in Table 11.

Table 11: Estimates of depredations by Mexican wolves and associated costs, 1998-2004

Depredations								
Low estimate	1998	1999	2000	2001	2002	2003	2004	Total
Cattle	0	5	1.3	5	8.7	5.3	7	32.3
Sheep	0	0	0.7	0	0	0.7	1	2.3
Horses	0	0	0	0.3	0	0	0	0.3
Dogs	1	0	0	0	0.7	0.3	0	2
High estimate								
Cattle	0	21.8	5.8	21.8	37.7	23.2	30.5	140.7
Sheep	0	0	1.5	0	0	1.5	2.3	5.4
Horses	0	0	0	1	1	1	0	3
Dogs	1	0	0	0	1	1	0	3
Value per head, 2004$								
Cattle	760	740	780	810	820	790	840	
Sheep	120	90	100	100	90	110	120	
Horses	1,740	1,700	1,650	1,600	1,580	1,540	1,500	
Dogs	580	570	550	530	530	510	500	
Total value of depredations, 2004$								
Low Estimate								
Cattle	0	3,700	1,040	4,050	7,107	4,213	5,880	25,990
Sheep	0	0	67	0	0	73	120	260
Horses	0	0	0	533	0	0	0	533
Dogs	580	0	0	0	353	170	0	1,103
High Estimate								
Cattle	0	16,095	4,524	17,618	30,914	18,328	25,578	113,057
Sheep	0	0	153	0	0	169	276	598
Horses	0	0	0	1,600	1,580	1,540	0	4,720
Dogs	580	0	0	0	530	510	0	1,620

Notes: Depredations are averages of estimates reported by the Fish and Wildlife Service, USDA

Animal and Plant Health Inspection Service, and Defenders of Wildlife's Bailey Wildlife Foundation Wolf Compensation Trust. See Unsworth *et al.* (2005). Confirmed and probable depredations and values of cattle, sheep, horses, and dogs are those reported in Unsworth *et al.* (2005).

Our low estimate of total livestock depredation cost since reintroduction, $27,887, is identical to that by Unsworth *et al.*, while our high estimate, $119,995, is one-fifth below their medium estimate of $152,510. We ignore their high estimate of depredations, which is based on estimates by ranchers, because of its high potential for misattributions. Livestock injuries attributable to wolves are estimated to total $4,520 since reintroduction (Unsworth *et al.*, 2005). Unsworth *et al.* (2005) also consider additional costs to ranchers that are related to wolf reintroduction. For example, all ranchers combined are estimated to have spent an average of $890 per year since reintroduction in applying for compensation for wolf-caused livestock losses, for a total of $6,240. Sufficient data are not available to quantify the cost of additional ranch supplies (*e.g.*, guard dogs) attributable to wolf reintroduction (*ibid.*).

Costs to ranchers from wolf-caused livestock kills and injuries are partially offset by compensation payments ranchers received from Defenders of Wildlife's Bailey Wildlife Foundation Wolf Compensation Trust. Such payments totaled $33,640 between 1998 and 2004 (Unsworth *et al.*, 2005), amounting to 87 percent (low depredation estimate) and 26 percent (high depredation estimate), respectively, of total wolf-associated costs to ranchers.[25] Compensation payments shift the cost incidence from ranchers to the conservation community. As such, they simply constitute intrasocietal resource transfers; they do not reduce opportunity costs for society as a whole. In other words, livestock depredations by wolves carry opportunity costs for society, regardless of whether these are borne by ranchers themselves or by others.

Lost livestock production and associated reductions in rancher income also produce negative regional economic impacts.[26] Unsworth *et al.* estimate the value of lost regional output using the common IMPLAN model. However, their estimates of annual output losses are based on livestock depredation costs in 2002, the year with the highest depredation costs (see Table 11). Instead, we use the total output multipliers reported in their results together with our estimates of the annual uncompensated depredation costs for ranchers to estimate the annual losses in total regional output associated with livestock depredation by wolves. Total losses in regional economic output since reintroduction are estimated at $4,375 for the low depredation estimate and $126,011 for the high depredation estimate (Table 12).

Table 12: Uncompensated livestock losses and associated loss in regional output

	1998	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*TOTAL*
Uncompensated livestock losses, 2004$								
Low estimate	560	1,930	-273	623	2,940	-2,563	1,800	*5,017*
High estimate	560	14,325	3,297	15,258	28,504	13,527	21,654	*97,125*
Total lost regional economic output associated with uncompensated livestock losses, 2004$								
Low estimate	488	1,683	-238	544	2,564	-2,235	1,570	*4,375*
High estimate	727	18,586	4,278	19,795	36,982	17,550	28,094	*126,011*

[25] Total wolf-related cost to ranchers is the sum of the value of livestock losses, livestock injuries, and cost of preparing compensation claims.

[26] Total regional impacts are defined as lost economic output in the five-county Mexican wolf reintroduction area that results from direct, indirect, and induced effects associated with uncompensated losses in livestock production and reduced rancher income.

Notes: Uncompensated losses are the sum of lost livestock value (Table 11) and costs associated with livestock injuries and compensation claim preparation, minus compensation received by ranchers.

Hunting

Reintroduction of gray wolves to the Gila and Apache National Forests has had no measurable impact to date on deer and elk populations or on hunting activities (Unsworth *et al.*, 2005). Hunting effort, measured as the total number of elk and deer hunting days, has increased in both the New Mexico and the Arizona portions of the reintroduction area, as has the number of hunters. Hunting success, measured as elk and deer harvests by hunters, has also increased since reintroduction. Overall, elk hunting success *rates* in New Mexico and Arizona show a marginal decrease over the study period. This decrease is likely due to the combination of a larger group of elk hunters pursuing a smaller number of prey (Unsworth *et al.*, 2005). The success rate for deer permits also declined, however the change corresponds to the decline in the deer population, which is the most likely reason for the declining success rate.[27] Reintroduction has caused no negative impacts on revenue of outfitters and guides, as overall hunter numbers actually increased since reintroduction.

Discussion

Our analysis shows that reintroduction of the Mexican gray wolf to the BRWRA has generated substantial net benefits at both the regional (Arizona and New Mexico) and the national levels of analysis (Tables 13 and 14). Total benefits are dominated by WTP for wolf reintroduction.

Table 13: Regional economic impacts of Mexican wolf reintroduction

	Benefits		*Costs*		*Net benefits*	
	High	*Low*	*High*	*Low*	*High*	*Low*
	million 2004$ (lump sum)					
WTP for reintroduction	44.77	23.60	11.23	n.a.	33.53	23.60
Livestock depredations	n.a.	n.a.	0.13	0.04	-0.13	-0.04
Associated lost regional output	n.a.	n.a.	0.13	0.004	-0.13	-0.004
Compensation payments to ranchers	0. 03	0. 03	n.a.	n.a.	0. 03	0. 03
Agency expenditures	7.76	7.76	n.a.	n.a.	7.76	7.76
Associated regional output	2.80	2.80	n.a.	n.a.	2.80	2.80
Defenders of Wildlife local proactive expenditures	0.14	0.14			0.14	0.14
Associated regional output	0.05	0.05			0.05	0.05
Total	55.54	34.37	11.49	0.04	44.04	34.33

Note: WTP for reintroduction includes WTP of regional residents, including those who visit the National Forests in the reintroduction area. Impacts of livestock depredations include costs of injuries and costs of preparation of compensation claims.

Because much of this WTP occurs outside of the region, net benefits are larger at the national level than at the local one. The total impact estimates presented in Tables 13 and 14 are somewhat misleading. Reintroduction generates a stream of non-use value benefits and costs that reaches far into the future, while the remaining cost and benefit estimates are for impacts that have occurred up

[27] The decline in the deer population is attributed to the combined effect of overall forest succession and a lack of natural fires, resulting in a lack of deer forage (Unsworth *et al*., 2005).

to the year 2004. Hence, it is more useful to compare costs and benefits on the basis of annual impacts (Table 15). For this, we convert total WTP (both positive and negative) for wolf reintroduction, which in Tables 13 and 14 is measured in form of a lump sum payment, into the corresponding annual values, assuming a seven percent interest rate. Depending on the use of high or low impact estimates, annual net benefits of reintroduction are estimated to range from $3.2 million to $3.8 million at the regional level. These estimates include Arizona and New Mexico residents as well as out-of-state visitors to the Gila and Apache National forests. The corresponding annual net benefits at the national level range from $13.2 million to $44.6 million.

Table 14: National-level economic impacts of Mexican wolf reintroduction

	Benefits		*Costs*		*Net benefits*	
	High	*Low*	*High*	*Low*	*High*	*Low*
	million 2004$ (lump sum)					
WTP for reintroduction	703.43	204.35	49.40	n.a.	654.02	204.35
Livestock depredations	n.a.	n.a.	0.13	0.04	-0.13	-0.04
Associated lost regional output	n.a.	n.a.	0.13	0.004	-0.13	-0.004
Agency expenditures	n.a.	n.a.	7.76	7.76	-7.76	-7.76
Associated regional output *	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Defenders of Wildlife local proactive expenditures			0.14	0.14	-0.14	-0.14
Total	703.43	204.35	57.55	7.93	645.88	196.41

Note: WTP for reintroduction includes WTP of out-of-region residents including those that visit National Forest in the reintroduction area. * Agency expenditures in the BRWRA do not result in output loss at the national level; rather, reintroduction simply relocates the multiplier effects of expenditures from where they would have occurred absent wolf reintroduction to the BRWRA.

Table 15: Average annual impact estimates under different boundary settings, 1998-2004

	Benefits		*Costs*		*Net benefits*	
	High	*Low*	*High*	*Low*	*High*	*Low*
	2004$					
Regional boundary	4,669,816	3,188,490	823,103	6,147	3,846,713	3,182,343
National-level boundary	49,239,948	14,304,258	4,619,785	1,131,011	44,620,163	13,173,247

Note: Annual value of WTP for wolf reintroduction is derived as the annual benefit stream from a one-time trust fund deposit amortized at a 7 percent real interest rate.

These numbers may appear large. However, if one considers that they represent the total impacts of reintroduction on 4.4 million households (Arizona and New Mexico, plus National forest visitors from other states) and 113 million households, respectively, it becomes clear that they translate into very small impacts on a per-household or per-capita basis. This is the result of several conservative assumptions we made in deriving our WTP estimates for wolf reintroduction. In addition, even if one followed Duffield (U.S. Fish and Wildlife Service, 1994) and assumed that the amount individuals would actually pay is only about 30 percent of their stated WTP, annual net benefits of reintroduction would still be $2.0 million to $2.1 million at the regional level, and $3.0 million to $11.9 million at the national level. Our analysis therefore strongly suggests that reintroduction of

Mexican gray wolves to the southwestern U.S. has generated substantial net benefits at both the regional and the national levels.

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