

**Coexisting with Carnivores:  
A cost-benefit analysis of non-lethal  
wolf-depredation management in central Idaho**

**By**

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**Abstract:**

The purpose of this masters project is to estimate the social net present value of a non-lethal, wolf-depredation management strategy in central Idaho. The strategy was developed by Defenders of Wildlife to reduce sheep depredation by gray wolves (*Canis lupus*). Defenders of Wildlife worked with three of the largest sheep producers in Idaho between 2008 and 2010 to demonstrate and test the effectiveness of non-lethal predation-management tools in central Idaho. While the Defenders project is preventative in nature, the status quo project is reactive -- Wildlife Services, a division of USDA Animal Plant and Health Inspection Service (APHIS), responds to depredation events using mainly lethal strategies of control.

Using a cost-benefit analysis model, this study calculates the incremental net value of the Defenders of Wildlife demonstration project. A benefit transfer is used to derive the non-market value of wolves. By including this estimate in the analysis, the results show that using non-lethal, preventative tools can yield greater benefits to society than the reactive status quo program. The social benefits derived from the demonstration project are estimated to range from approximately \$80,000 to \$4.66 million (\$2011).

The results have important implications for the future of the Defenders of Wildlife project and depredation management strategies utilized in the ranching industry. Perhaps more important is the example it provides of stakeholders with different priorities working together for the greater good of society.

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## **Introduction:**

There is a long history of conflict between wolves and livestock. By the 1930s, wolves had been eradicated from the conterminous United States, largely in response to livestock depredation (Bangs et al. 2006). Since then livestock producers have adopted farming practices designed for a wolf-free environment. To help maintain a viable livestock industry in the midst of predators the federal government created Wildlife Services, a division of USDA Animal Plant and Health Inspection Service (APHIS), to respond to depredation events. When a livestock producer has a problem, he or she can contact Wildlife Services to investigate the loss and either kill or move the predator suspected to be responsible. This method was controversial but accepted by the public and livestock producers. However, in 1995 wolves were reintroduced to central Idaho (Duffield et al. 2008) and lethal methods could only be used as a last resort in response to wolf depredations. Because wolves were protected under the Endangered Species Act (ESA) non-lethal control methods were encouraged to deal with wolf-depredation events. To help the transition from lethal to non-lethal depredation management, Defenders of Wildlife created "... [the] Proactive Carnivore Conservation Fund to prevent conflict between imperiled predators and humans by supporting the use of preventative measures, including nonlethal deterrents and best management practices" (Defenders of Wildlife 2010). Part of this fund has been used to fund a non-lethal wolf-depredation demonstration project in the Sawtooth National Forest located in central Idaho. This program utilizes non-lethal deterrents to prevent predation on livestock, rather than responding after the fact.

Anecdotally, the demonstration project has been very successful in its first three years. During this time, only fourteen sheep were lost to depredations, and no wolves were killed within the project area. At the end of the demonstration project timeline, Defenders of Wildlife must now decide the future of the project. If it provides benefits to society that are greater those provided by the status quo, the organization may choose to continue or expand its work. Furthermore, if the

net value of the project is positive, government agencies and livestock producers may adopt the non-lethal techniques in lieu of killing predators after a loss has occurred.

Using a cost-benefit analysis model, this study aims to answer these questions by estimating the incremental net value of the Defenders of Wildlife demonstration project. A benefit transfer is used to derive the non-market value of wolves. By including this estimate in the analysis, the results show that using non-lethal, preventative tools can yield greater benefits to society than the reactive status quo program. The results have important implications for the future of the Defenders of Wildlife project and depredation management strategies utilized in the ranching industry. Perhaps more important is the example it provides of stakeholders with different priorities working together for the greater good of society.

The remaining report will present background information, followed by analytical framework, study area characteristics, and data collection. Methods used for analysis will be discussed in detail, followed by results, discussion, and concluding remarks.

**Background:**

The Defenders of Wildlife demonstration project involved three sheep producers in central Idaho. Each producer has part of his sheep inventory managed under the status quo regime and the other portion under the demonstration project management scheme. Comparing sheep bands owned by the same three producers accounts for some of the unobserved variables that may affect the relative successes of each alternative management strategy (Boardman et al. 2011).

Under the status quo program, when sheep bed down for the night, the herders return to their camp; the herders leave the sheep unattended when the terrain is inhospitable to their camper. Sheep dogs remain with the herd at all times, but they are no match for wolves (Nieymeyer 2010). Their main purpose is to alert herders if predators are in the area, and often dogs will give their lives in an effort to protect the herd. At sunrise, the herders hike back out to the sheep and guide them throughout the day. If sheep are lost to depredation, the producer will call Wildlife Services to investigate the depredation event. If they confirm the cause to be predation, they will attempt to identify the species responsible and then incrementally kill the suspected predators until they stop coming to the site of the depredation. This process assumes predators that kill the sheep are the same predators that come back and feed from the carcass. However, predators may be scavenging on carcasses that have been killed by eagles, domestic dogs, or have died from disease (Nieymeyer 2010). If Wildlife Services can confirm that a wolf was responsible for the death of the livestock, then the producer can submit this report for compensation.

The Defenders of Wildlife demonstration project has the goal of preventing depredation events, rather than responding to them after the fact. Each night, field technicians hike to meet the sheep herds and set up camp where the sheep have bedded. Throughout the night, the Defenders technician tracks GPS-collared wolves with a telemetry device and conducts some combination of

disruptive stimuli (e.g. firing a starter pistol, shining a spot light around the area, talking out loud, etc.). When appropriate, fladry (a portable fencing system) is used to keep wolves away from the sheep (Bangs et al. 2006). In the morning, when the herders would usually come find the sheep, the Defenders technician leaves and normal grazing procedure follows until the next night when this is repeated. If a sheep is lost despite the preventative measures, Wildlife Services will investigate the depredation in order to determine if it was a wolf for compensation purposes, but the producers must agree to not seek lethal control regardless of the findings.

Because the program deals with federal agencies and a national non-profit, each US citizen has standing from an accounting perspective. Therefore, the analysis will be conducted from the perspective of the US economy as a whole. The analysis covers all three years that the demonstration project has been in existence (2008 to 2010).

## **Analytical framework:**

This study assesses the non-lethal, alternative management strategy through a method called cost-benefit analysis (CBA). CBA compares costs and benefits of policies or programs that accrue to society as a whole (Boardman et al. 2011). In the case of policy decisions, these are important factors to consider. In fact, the U.S. government requires federal agencies to conduct a CBA before promulgating any regulation that would have significant economic impacts (EO 13563, [http://www.reginfo.gov/public/jsp/Utilities/EO\\_13563.pdf](http://www.reginfo.gov/public/jsp/Utilities/EO_13563.pdf)). CBA assigns monetary values to impacts of a policy or program and uses these values to compare costs and benefits of alternatives. Because not all impacts will have market values, economists use non-market valuation techniques to compare program impacts in consistent terms.

Non-market valuation refers to the systematic attachment of monetary values to goods and services that are not typically traded using currency in order to fairly compare trade-offs made in decision making (Rosenberger and Loomis 2003). In a world of finite resources, allocation and use of these resources involves a delicate balance of benefits and costs that, ideally, increase social welfare (Freeman 2003). Environmental economists use non-market values to include values that would be omitted from traditional financial analyses. In this study, results from non-market valuation studies of wolf conservation are used as the basis for estimating the benefits associated with reducing wolf deaths. The process of putting a monetary value on an untraded item is a complex and often controversial science. Therefore, sensitivity analyses of CBA results is used to see how net values of policies and programs change in response to different parameter estimates.

Primary research was beyond the scope of this study, so a benefit transfer was used to estimate the value of a wolf. Several previous studies were used to determine a range for the value of a wolf. Duffield, Neher, and Patterson (2006) conducted a contingent valuation survey on Yellowstone National Park visitors to derive the willingness-to-pay (WTP) for wolf conservation.



The mail survey was sent to a random sample of park visitors from 2005; these respondents were initially contacted in the park and later mailed the survey. If the respondents supported wolf reintroduction, they were asked how much they would be willing to pay to support a wolf recovery fund. As the study only estimated WTP of pro-wolf visitors, the results were biased upwards. Overall the truncated mean WTP was estimated to range from \$22 to \$40 (\$2005) per household.

Chambers and Whitehead (2003) used contingent valuation to estimate WTP of residents in Minnesota for a wolf management plan that would maintain a minimum population of 1600 wolves. 800 surveys were mailed to residents in areas inhabited by wolves and areas absent of wolves. Those who lived within wolf-inhabited areas had a median WTP of \$4.77 per household, while those who lived outside of these areas had a median WTP of \$21.49 (\$2003). These results indicated that proximity to wolves could greatly decrease the WTP for wolf management.

Loomis & White (1996) conducted a meta-analysis to estimate the lump sum WTP for wolves by household nationwide. The data used in their study were derived from seven separate studies. Four of the studies were conducted in Yellowstone National Park between 1991 and 1992 and included both local and national visitors of the park (Duffield: 1991, 1992). The other three studies involved regional households and were conducted between 1986 and 1993 (Duffield et al. 1993, U.S. Department of Interior: 1986, 1989). The meta-analysis estimated three values from these studies to account for the variation and uncertainty involved in non-market valuation: a lower bound, average, and upper bound WTP. The estimated values were \$16, \$67, and \$118 (\$1993) respectively. The variability of estimates calls for a thorough sensitivity analysis to determine how much the value of a wolf will affect the outcome of this study. This will be covered in the discussion section of the paper.

In order to compare these estimates, the figures were adjusted for inflation using the Consumer Price Index Inflation Calculator, provided by the US Bureau of Labor Statistics

([http://www.bls.gov/data/inflation\\_calculator.htm](http://www.bls.gov/data/inflation_calculator.htm)). This resulted in a range of WTP from \$5.79 to \$168.06 (\$2011) per household, with an average WTP of \$86.93. Each estimate was derived using a lump sum payment vehicle. The methods section of this paper will explain how this was converted into value per wolf, which is required for the cost-benefit analysis model used in this study.

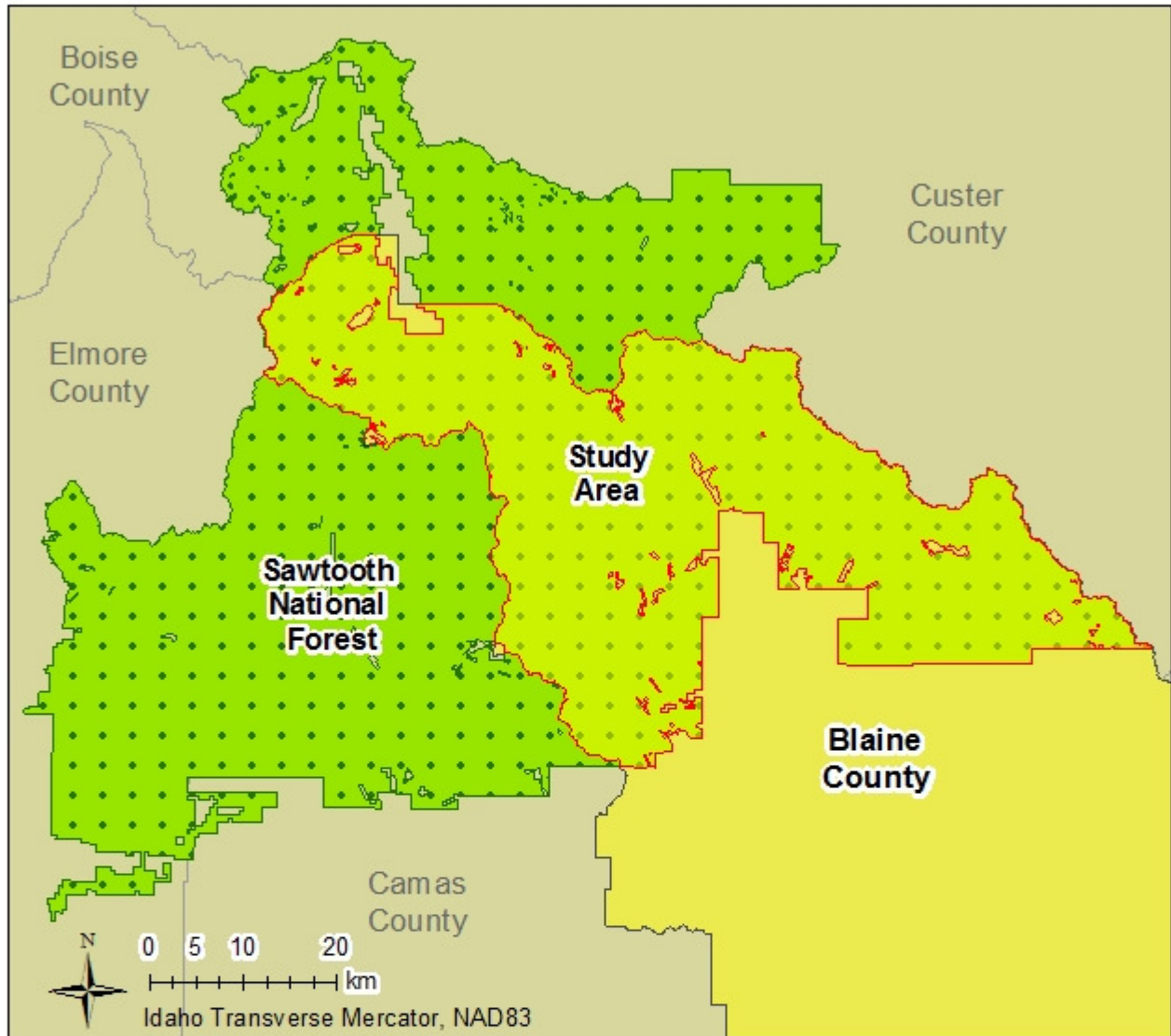
One limitation of the methods employed in this paper is the assumption of constant marginal values of wolves. Because the studies used to derive an estimated value for wolves do not include variables for population size, it is impossible to determine how the value of a wolf will change as the total population changes. Economic theory suggests that as wolf populations diminish willingness-to-pay for their existence may increase (Bulte and Van Kooten 1999.) However, the diminishing marginal utility is not factored into this study. Therefore the true value may be higher or lower than the values reported. The only way to truly understand how marginal values affect the estimated value of the project would be to conduct a new CVM study.

**Study Area:**

The demonstration project was conducted in the portion of the Sawtooth National Forest that lies within Blaine County, Idaho. Like other parts of central Idaho, the landscape ranges from grassy river valleys to sagebrush covered mountains and foothills, with elevation ranging from approximately 4,000 to 12,000 feet above sea level. Central Idaho, which encompasses the study area, is an important asset to the state, and to the nation, because it is one of the largest tracts of undeveloped, public lands in existence in the conterminous US (Nadeau et al. 2008). The benefits of this unfragmented, natural habitat can be seen by the variety of species found in the study area: elk, pronghorn antelope, mule deer, wolves, black bears, and mountain lions, to name a few. Figure 1 is a map depicting the study area and its position relative to the rest of Idaho.

Figure 1.

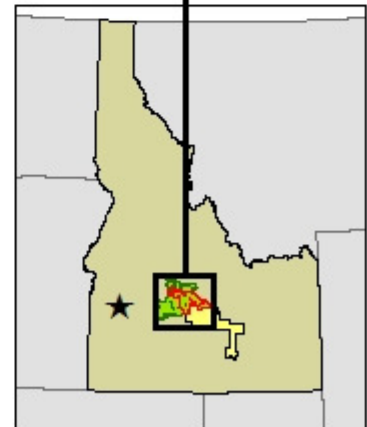
## Study Area: Sawtooth National Forest in Blaine County, Idaho



### Legend

- ★ Boise
- Study Area \*\*
- Blaine County
- Sawtooth National Forest
- Other Idaho Counties

*\*\* The study area is the portion of the Sawtooth National Forest that is encompassed by Blaine County, ID.*



Created by: Ashley Abernethy  
Data obtained from Idaho Department of Water Resources  
[http://www.idwr.idaho.gov/GeographicInfo/GISdata/gis\\_data.htm](http://www.idwr.idaho.gov/GeographicInfo/GISdata/gis_data.htm)

**Data:**

Data were collected on-site in August 2010. All parties involved were consulted on the effectiveness and costs associated with each project: the three sheep producers who participated in the non-lethal management program, the Idaho office of Wildlife Services, the Ketchum Ranger District of U.S. Forest Service, the Idaho Fish and Game Department, and the staff of Defenders of Wildlife who manage the program. Data collected include panel data from Wildlife Services on depredation investigation reports for the three producers who participated in the pilot program. In addition, government publications on livestock prices, wolf populations, and grazing rights were consulted. Previous research allowed a benefits transfer to estimate the economic value of a wolf.

**Methods:**

Cost-benefit analyses estimate the net value of alternative programs or policies as compared to a baseline or status quo (Jeuland et al. 2009). In this study, the status quo is the lethal alternative described in the introduction and the alternative is the non-lethal demonstration project. The net value of the demonstration project will be incremental to the status quo; that is, a positive net value represents an increase in social welfare, while a negative net value represents a decrease. Net value is calculated for the three year study period by subtracting total costs from total benefits. Equation 1 below illustrates the cost-benefit model.

**Equation 1.**

$$Net\ Value = \sum_{t=1}^3 [Total\ Benefits_t] - [Total\ Costs_t]$$

where t is the year of study: t = 1 for 2008, t = 2 for 2009, and t = 3 in 2010. Total costs for the alternative program are constant at \$30,000 per year. The budget was used to purchase equipment and pay wages of the field technicians. Equipment included spotlights, starter pistols, bear spray, GPS tracking devices for collared wolves, and replacement camping gear for field technicians who had damaged property as a direct result of the job. For the status quo program, Wildlife Services provided data on the amount of money spent on these three producers during the three year program time frame. These figures came in the form of dollars spent per depredation event. They include wages and any aerial gunning expenses, but they do not directly include equipment. This is because no additional equipment was purchased for the status quo program; all equipment would have been used regardless and is therefore difficult to extract an exact number. As a result, reported expenditures under the status quo program will most likely underestimate the true cost of the program.

Total costs for the status quo and the alternative are given and need no estimations. However, total benefits of the alternative must be estimated using equation 2 below:

**Equation 2.**

$$Total\ Benefits = \sum_{t=1}^3 [Value\ Wolves\ Saved_t + Value\ Sheep\ Saved_t + Value\ Dogs\ Saved_t]$$

Because the non-lethal alternative is preventative, the true value of animals saved cannot be determined without counterfactuals. However, the values can be estimated by finding rate of loss in the status quo program, estimating number of saved animals in the demonstration project, and subtracting the number of animals lost in the demonstration project. These calculations are shown in equations 3, 4, and 5, where “D” represents the demonstration project and “S” represents the status quo.

**Equation 3.**

$$Value\ Wolves\ Saved_t^D = \left[ \left[ \left( \frac{No.\ Wolves\ Killed_t^S}{Total\ No.\ Sheep_t^S} \right) * Total\ No.\ Sheep_t^D \right] - No.\ Wolves\ Killed_t^D \right] * Value\ of\ One\ Wolf_t$$

**Equation 4.**

$$Value\ Sheep\ Saved_t^D = \left[ \left[ \left( \frac{No.\ Sheep\ Killed_t^S}{Total\ No.\ Sheep_t^S} \right) * Total\ No.\ Sheep_t^D \right] - No.\ Sheep\ Killed_t^D \right] * Value\ of\ One\ Sheep_t$$

**Equation 5.**

$$\begin{aligned}
 & \text{Value Dogs Saved}_t^D \\
 & = \left[ \left[ \left( \frac{\text{No. Dogs Killed}_t^S}{\text{Total No. Sheep}_t^S} \right) * \text{Total No. Sheep}_t^D \right] - \text{No. Dogs Killed}_t^D \right] \\
 & \quad * \text{Value of One Dog}_t
 \end{aligned}$$

Total number of sheep was calculated by taking the average of two values: sheep numbers before shipping lambs to slaughter and sheep numbers after shipping. Sheep are measured in units called bands. A lamb band includes ewes and lambs (adult female sheep and their offspring). A dry band is composed entirely of ewes after the lambs have been shipped to slaughter. And a bucking band refers to rams (male sheep) that are used for breeding purposes. Because lambs are shipped in the fall, and because of depredation, disease, and theft, the total number of sheep in any given band can vary substantially throughout the year. This affects the CBA because estimates of sheep saved are calculated from the total number of sheep in a band. In order to account for this variability, an average number of sheep is calculated from the number of lamb bands allowed by the respective grazing permits. The number of permitted sheep was obtained from public grazing records accessed online; however, precise source data is withheld in order to respect the privacy of participating producers.

Equations 4 and 5 include the value of individual dogs or sheep, which are figures relatively simple to calculate from published compensation reports. The value of a sheep dog is highly variable, but a conservative estimate of \$700 was obtained from past compensation payments (Defenders of Wildlife 2009). The value of one sheep is calculated by taking the average replacement value for the year as published by the USDA (2010). Calculation of the value of wolves saved requires a more complex estimate. Equation 6 illustrates this calculation.



**Equation 6.**

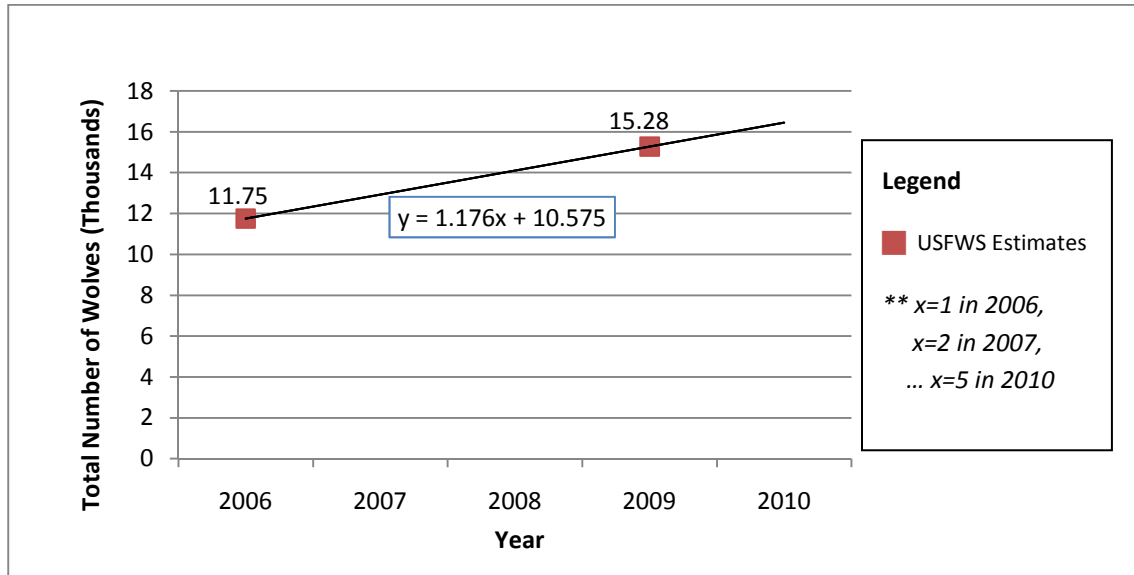
$$\text{Value of one wolf}_t = \frac{WTP^i * Household_t}{Wolf Population_t}$$

where i represents the WTP estimate level (upper, lower, or average) and t represents the year as in equations 1 through 5. Wolf Population is the estimated gray wolf population nationwide, including Alaska, which was calculated using US Fish and Wildlife Service data (US FWS 2006; US FWS 2009). Household is the number of individual households in the United States as reported by the 2000 Census ([www.census.gov/main/www/cen2000.html](http://www.census.gov/main/www/cen2000.html)). The 2010 data are not yet available for the entire United States; therefore, the 2000 numbers are used for each year. This will underestimate the value of wolves because the number of households trends upward from previous years.

**Results:**

In order to estimate the value of a wolf using the benefit transfer method (equation 6) the 2008 and 2010 wolf populations must be estimated. Nationwide wolf population estimates were only published for 2006 and 2009 (US FWS 2006; US FWS 2009). Assuming a simple linear increase in wolf numbers, the population numbers for 2008 and 2010 were calculated using the trend line equation shown in figure 2 below.

**Figure 2: Population estimates for gray wolves in the US for 2008 and 2010**



Using the chart above, wolf population estimates were 14,103 for 2008 and 16,455 for 2010. In reality, wolf populations would probably not increase linearly; however, they have been increasing in number since 2007 (US FWS 2009) and a linear equation should serve as a good indicator for the true number. Forcing a linear relationship on annual wolf population numbers will most likely overestimate the population, because factors such as hunting will prevent a constant growth rate, and yield a conservative, underestimated value of a wolf.

Using the population estimates from figure 2, an upper bound, lower bound, and average value of a wolf can be estimated (using equation 6) for each year of the project using the benefits transfer method from Loomis and White's (1996) meta-analysis. Table 1 presents the estimated values.

**Table 1: Estimated monetary value (\$2011) of one gray wolf by year using benefits transfer method**

<b>Level of Estimate</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>
Lower Bound	\$43,305	\$39,972	\$37,115
Average	\$650,135	\$600,095	\$557,208
Upper Bound	\$1,256,966	\$1,160,219	\$1,077,301

As illustrated above, the value of a wolf fluctuates over the three years of the project. This is because the values were calculated using the wolf populations for each respective year. This concept is covered in more detail in the discussion section of the paper. Consolidating the results above, the derived value of an individual wolf ranges from \$ 37,115 to \$ 1,256,966 for the purposes of this study. Table 2 shows the results of equations 3, 4, and 5, which estimate the value of animals saved by the demonstration project. There are three values for wolves to reflect the lower bound, average, and upper bound estimates of the value of a single wolf. Each value is denoted by the estimation method used, as described in the methods section.

**Table 2: Estimated value of animals saved by demonstration project ([value of animal]\*[estimated number saved])**

<b>Animal</b>	<b>Value of Saved Animals (\$2011)</b>	<b>Valuation Method</b>
Sheep	\$6,790	Replacement Value
Dog	\$410	Replacement Value
Wolf	\$163,244	Benefits Transfer: Lower Bound
Wolf	\$2,450,781	Benefits Transfer: Average Value
Wolf	\$4,738,317	Benefits Transfer: Upper Bound

Plugging these values into equation 1, the net value of the alternative program is obtained. These estimates are listed in Table 3 in order of increasing net value by valuation method.

**Table 3: Estimated net value of demonstration project as compared to status quo management**

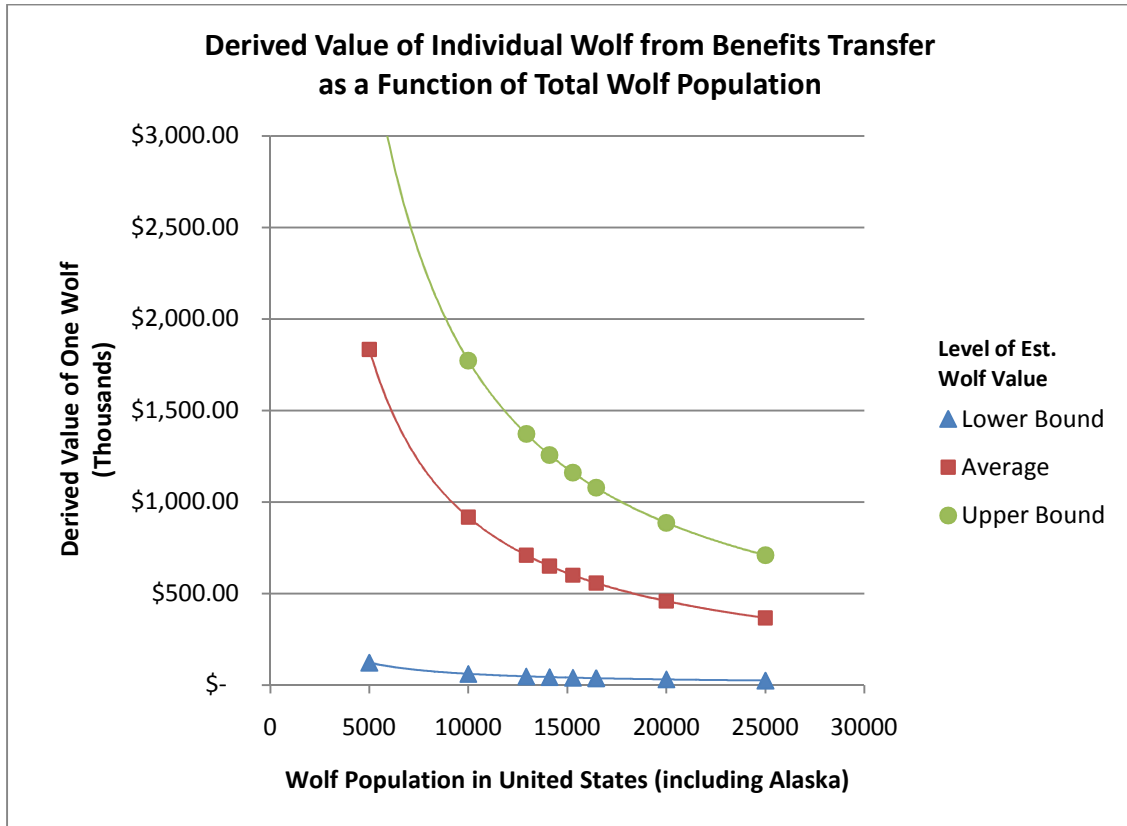
<b>Total Benefits</b>	<b>Total Costs</b>	<b>Net Value (\$2011)</b>	<b>Valuation Method</b>
\$170,453	\$90,000	\$80,444	Benefits Transfer: Lower Bound
\$2,457,990	\$90,000	\$2,367,980	Benefits Transfer: Average Value
\$4,745,526	\$90,000	\$4,655,517	Benefits Transfer: Upper Bound

The results show that the demonstration project provided net benefits to society that ranged from approximately \$80,000 to \$4.66 million (\$2011).

**Discussion:**

The value of an individual wolf fluctuates during the three-year demonstration project. This is due to structure of the equation used to derive the value; total willingness to pay is divided by the total wolf population in each year. The total WTP estimates do not change because they are reported as lump sum payments, and household numbers do not change because Census data for 2010 had not been released at the time of this paper. However, the population of wolves is a dynamic figure in the calculation. Figure 3 depicts the relationship between the total number of wolves and their individual values.

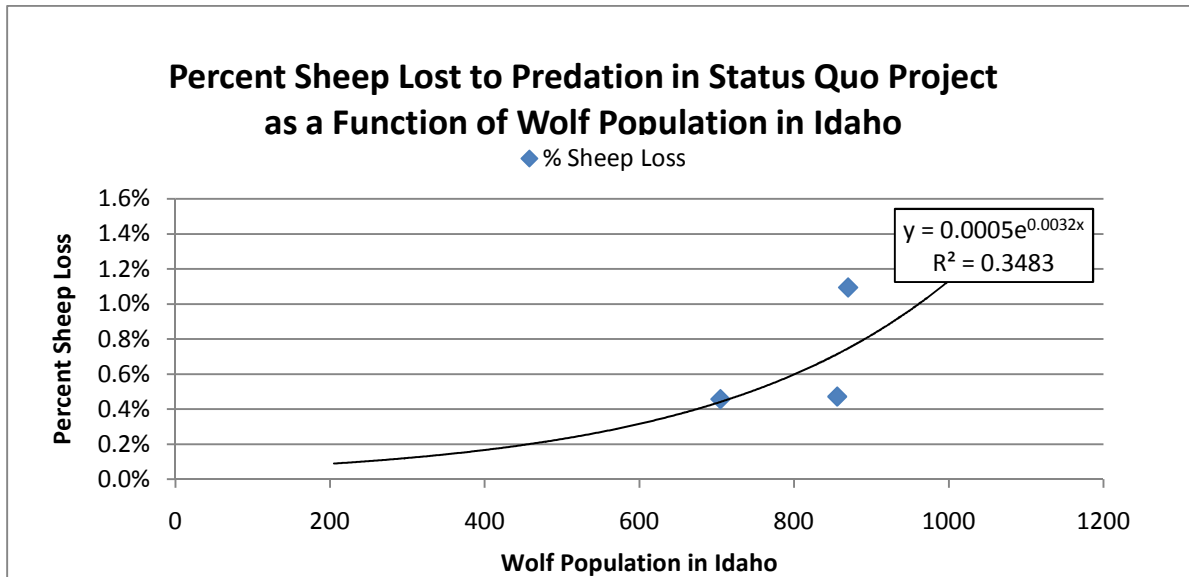
**Figure 3: Derived wolf value as a function of wolf population. This data is based on wolf populations in 2007 – 2010 and is reported in \$2011. In order to predict a trend, data is extrapolated to estimate the value of a wolf when population levels get as low as 5,000 or as high as 25,000.**



The results depict pseudo demand curves for wolves with diminishing marginal values (i.e. when there are fewer wolves households are willing to pay more than when wolf populations are flourishing.) This has important implications for predation management strategies. The reduction in wolf numbers results in increased value; therefore, each wolf killed has a greater cost to society than the one before it. This relationship should be considered when comparing the costs of sheep lost and the costs of wolves lost in order to decide which animal should be protected. The graph predicts WTP if a marginal estimate were derived, rather than assuming constant marginal values as discussed in the background section of this paper.

Increasing wolf numbers leads to the question of what happens to the amount of sheep depredations as wolf population numbers increase. To investigate this relationship, percent sheep loss in the status quo program for each year of the study is plotted against wolf populations in Idaho (US FWS 2009) in figure 4.

**Figure 4: Relationship between sheep loss and wolf population**



While there does seem to be a positive correlation between the number of wolves and the percent of sheep lost, the important aspect of this graph is the  $R^2$  value of 0.348. Simply put, this means that wolf population levels account for less than 35 percent of the variation in sheep loss. The exponential trend line, shown above, explained the highest percentage of variation and was chosen for that reason. Even with the best trend line, the  $R^2$  value still indicates that there are factors that are unaccounted for in this equation that cause the variation in sheep loss. However, one must take into account the low sample size; the equation is based on only three data points, which may account for the low  $R^2$  value. Despite the small sample size, the results do coincide with past reports that show coyotes and domestic dogs being responsible for most sheep depredations (NASS 2005.)

The results of this study have important implications for non-lethal predation management strategies. Under certain economic assumptions, the demonstration project yielded positive net values that indicate an increase in social welfare over the status quo program. This was an unexpected result because the demonstration project was not designed to be a stand-alone management scheme. Instead, it was intended to test the effectiveness of non-lethal management tools and provide alternative predation-management options. If the project were to be implemented on a wide-scale it would most likely involve a floating cadre of night shepherds that guard sheep in areas of known wolf activity (Jesse Timberlake<sup>1</sup>, personal communication). Therefore, modeling the intended implementation of the alternative would actually include a mixture of management strategies and entirely different total costs. The wolf conservationists, government agents, and sheep producers would need to design this program using their knowledge of wolves, budgetary restrictions, and sheep grazing patterns. While modeling the complete program would be ideal, the results of this study will help guide those decisions and important lessons can be learned from the demonstration project.

The alternative is estimated to provide a substantial increase in social welfare when wolves are valued by household WTP, but it is still not likely to be adopted over the status quo. This is because of the distribution of costs and benefits. Livestock producers are expected to have much lower values for wolves than the general public (Kroeger et al. 2006). One reason for this is that livestock loss due to wolves is a cost born by the individual farmer (Muhly and Musiani 2009). The majority of the benefits of non-lethal management would be in the form of increased utility for those who value wolves as represented by the WTP valuation. While the general public does share some of the costs of livestock loss through taxes that go towards the status quo management program, it is not a significant cost when compared to what an individual producer might suffer.

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<sup>1</sup> Jesse Timberlake was the Northern Rockies Associate for Defenders of Wildlife. Timberlake managed the field technicians and daily operations of the demonstration project.



There are other benefits gleaned from the demonstration project. First, by preventing sheep depredation by wolves and other carnivores, Wildlife Services will spend less time and money on investigations. This will allow the agency to focus on its other important obligations, such as rabies control. In addition, a larger wolf population can lead to delisting from the ESA, which would result in state-level management. This would reduce or eliminate Threatened and Endangered Species expenditures on wolves in the area and allow other species to be protected by the ESA (as there is currently a waitlist for species in peril due to budget and time constraints.) Also, federalism plays a major part in the tensions surrounding wolves in western states. Returning management to the states will reduce or eliminate federal involvement in what some consider a state issue<sup>2</sup>.

Perhaps the most important outcome from the demonstration project is that groups with different ideologies can put their differences aside to reach a common goal. Ranchers, government agencies, and an environmental non-profit collaborated to form an alternative predation management strategy. Not only that, but this strategy has great potential to increase social welfare beyond the status quo management scheme. The partnerships and successes provide a positive example for other stakeholders in the wolf-livestock conflict, as well as for many other contentious issues with opposing viewpoints.

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<sup>2</sup> Some western citizens would like to have state management of wolves and reduce federal involvement (Nieymeyer 2010). This is somewhat contradictory because many wolves are killed on public lands by a federal agency. A further discussion of the role federalism plays in this issue is beyond the scope of this paper.

## **Conclusions:**

The cost-benefit analysis of the Defenders of Wildlife demonstration project can be used to guide further decisions in predation management strategies. Under certain economic assumptions, the demonstration project increased social welfare over the status quo management scheme. The benefits to society can be increased by implementing the non-lethal strategies employed by the demonstration project only when needed. A floating cadre of night herders could be used to stay with sheep at night when wolves are suspected to be in the area. This would greatly decrease costs, thereby increasing the net value to society.

The Defenders of Wildlife demonstration of non-lethal predation management tools has important implications for the future of wolves and the livestock industry in the United States. Yet, the results of this cost-benefit analysis cannot be extrapolated beyond this study due to the lack of a counterfactual. However, the information can be used to guide further decisions in the Defenders of Wildlife project as well as inform others about the economic impacts of non-lethal predator management. Further research should include a control group in order to determine the actual effectiveness of the program. Additionally, the study would need to be conducted over a longer time period as three years provides a relatively small sample size for analysis.

It would also be beneficial to conduct primary research to derive the marginal value of the gray wolf through the contingent valuation method (CVM). CVM uses survey research methods to estimate the value of non-market goods to the general public. This study used a meta-analysis of several CVM studies; however, accuracy may be improved when primary research is done. CVM is a costly and time-intensive process, but a new study focused on the predation control program would further inform decisions on how to save gray wolves, other large predators, and the ranching economy in the West.

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