NRDC ISSUE PAPER

AUGUST 2012
IP:12-05-A

Fuzzy Math

Wildlife Services Should Improve Its Economic Analysis of Predator Control

PROJECT MANAGER
Whitney Leonard
Natural Resources Defense Council

AUTHOR
Dr. John Loomis,* Professor
Department of Agricultural and Resource Economics, Colorado State University

Acknowledgments

Great thanks to the following people for reviewing the contents of this report. Reviewers do not necessarily concur with the paper's recommendations, but have advised on portions of its content.

* Conclusions and recommendations expressed in this report are those of the author, and not necessarily his institution.

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EXECUTIVE SUMMARY

About 100,000 coyotes, bobcats, foxes, wolves, bears, and mountain lions are killed each year by Wildlife Services, a U.S. Department of Agriculture federal agency. Much of this lethal control is partly justified by economic analyses that are often incomplete, and sometimes incorrect. This paper provides for the first time, an evaluation of the economic analysis used by Wildlife Services for predator management and sets forth recommendations to improve these analyses.

Most federal agencies in the United States have formal guidance about how to perform economic analysis. Wildlife Services does not. Yet Wildife Services uses economic analysis to determine what species and how many animals will be killed each year (about 100,000 currently) as part of a its predator management program.

Most economic analyses of predator control done by Wildlife Services are often incomplete and sometimes incorrect because they (1) are inconsistent with economic analysis guidelines used by most federal agencies, and (2) omit the economic values to society that are lost when large numbers of predators are killed, especially in the case of wolves, a species with well documented ecological value, well documented economic value, and for which great effort at great expense was taken to recover the species. Worse, according to the U.S. General Accounting Office (the agency responsible for ensuring our federal tax dollars are spent wisely), there has never been an independent study of the costs and benefits of Wildlife Services' activities, largely paid for by our federal tax dollars. This evaluation answers that implicit call for an independent economic assessment of Wildlife Services' use of economic analysis.

This report strongly recommends that Wildlife Services improve its economic analyses of predator control. At a minimum, the analysis should be consistent with that of other federal agencies. Fortunately, there are no-cost corrections to current economic analyses that can be implemented immediately, as well as medium- and long-term recommendations, including:

- Develop a manual with instructions for performing benefit-cost analyses using procedures consistent with federal agency benefit-cost guidelines.
- Provide economics training courses by Wildlife Services' National Wildlife Research Center (NWRC) staff economists to state offices and field offices or support equivalent outside training.
- Develop Wildlife Services' NWRC economic tools website to aid field offices in performing economic analysis.
- Hire 1 or 2 economists at Wildlife Services or NWRC in Washington, D.C., or contracting out.
- Wildlife Services should stop using the Bodenchuck, et al. (2000) study as blanket economic justification for other state-level programs.
- Each state should conduct state specific benefit-cost analysis of a wide range of alternative predator control programs ranging from lethal to several non-lethal methods.
- When performing future economic evaluations of predator control programs, include a range of alternatives with and without predator control; include a valuation of the loss of predators that are killed when lethal control means are employed; include all costs to all parties in the analysis, and move away from sole reliance on minimum cost methods to reduce livestock loss.
- Conduct a prospective or exante economic analysis on significant predator control management actions before such actions are to be selected for implementation.
- Conduct a contingent valuation method (CVM) study of public willingness to pay for coyotes in the western United States.
- After this CVM study is completed, future Wildlife Services benefit-cost analyses should use these values to perform a more complete economic analysis that includes the reduction in economic benefits to society from coyote control.

If implemented, these recommendations will result in Wildlife Services including the true costs of its predator control program. Hopefully, these recommendations will produce a more complete and balanced analyses to guide Wildlife Services' predator control decisions.

WILDLIFE SERVICES HAS BROAD LEGAL AUTHORITY AND NEEDS STRONG ECONOMIC ANALYSES TO HELP GUIDE THAT AUTHORITY

Wildlife Services, formally known as Animal Damage Control, is a federal agency housed within the U.S. Department of Agriculture.[1] Created in 1931, the agency is charged with "…conduct[ing] a program of wildlife services with respect to injurious animal species and tak[ing] any action the Secretary considers necessary in conducting the program." When it comes to fulfilling this charge, the agency often focuses on the lethal removal of animals, particularly carnivores, which can cause damage to livestock and other agricultural interests. This broad legal guidance leaves a great deal of discretion to the Secretary of Agriculture—and hence to Wildlife Services—about how to go about predator management.

> ***"While the financial impacts of predation on livestock production are measurable, they remain small relative to the total value of production."***

Wildlife Services Uses its Broad Authority

With its broad legal authority, the agency has continued to engage in significant lethal predator control. Wildlife Services data indicate that more than 100,000 animals were killed by the agency each year in 2006 and 2007. According to Wildlife Services data, aerial gunning alone killed about 36,000 mammals annually between 2001 and 2007. Most of these animals were coyotes; for example, nearly one-quarter of the coyote population was killed in Wyoming in the 1994-95 time period as a preventative control program to reduce predation rates on domestic livestock. But significant numbers of bobcats, foxes, and wolves were also killed.

Livestock Loss is Overemphasized

Some argue that culling is necessary to prevent the loss of livestock, but the relative loss of livestock from predators is small. About 1 percent for calves and about 2 percent for sheep (5 percent for lambs) (Taylor et al. 2008 from Bodenchuck et al. 2000). Although Wildlife Services and ranchers emphasize the loss of more than 50,000 calves or 80,000 sheep per year, a recent analysis by University of Wyoming agricultural economists (Rashford et al. 2008) notes: "*While the financial impacts of predation on livestock production are measurable, they remain small relative to the total value of production*."

The primary focus of much of the economic analysis of predator control has been on financial losses to ranchers. The analyses have not included the benefits that predators provide to ecosystem services and people. The ranchers benefit, but it is federal taxpayers that are paying between 30 percent (Taylor et al. 2009: 29) and 40 percent (GAO, 2001: 55) of Wildlife Services' costs for its predator control programs.[2] There may be other ways to support agricultural profitability besides predator control, as noted by Rashford, et al. (2008). A broad economic analysis can assist in identifying alternatives that might contribute more toward agricultural profitability.

MAKING ECONOMIC ANALYSIS OF PREDATOR MANAGEMENT BETTER

Most federal agencies have issued formal guidance for performing economic analysis or benefit-cost analysis (Wildlife Services is one of the few exceptions). These agencies include: Environmental Protection Agency (EPA), Army Corps of Engineers, Tennessee Valley Authority, Bureau of Reclamation, Federal Emergency Management Agency (FEMA), Bureau of Land Management, and the Department of Transportation. Some of these agencies, such as EPA, have issued formal guidelines (EPA, 2000); others provide toolkits to their field offices to follow (FEMA, 2006). The Army Corps of Engineers and Bureau of Reclamation, for example, are required to follow the Economics and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (U.S. Water Resources Council, 1983: iv) when performing benefit-cost analyses.

For agencies without formal benefit-cost analysis guidelines, the U.S. Office of Management and Budget (OMB) provides general benefit-cost analysis guidelines. OMB's requirement for the use of these guidelines is fairly narrow: "The agencies are to use these guidelines in preparing the 'accounting statements' on the benefits and costs of regulations that OMB can then include in a report to Congress on the benefits and costs of Federal regulation." (U.S. Office of Management and Budget, 2000.) However, the intent of OMB's guidelines, as stated in the introduction to the document, also includes the broader purpose of helping the agencies do their job "more effectively" through better economic analysis. Additionally, as the guidelines note in the second paragraph,

> "An economic analysis helps you evaluate the consequences of regulatory actions. It provides a formal way of organizing the evidence on the key effects—good and bad—of the various alternatives you are considering in developing the regulation. This allows you to assess whether the benefits of an action are likely to outweigh the costs." (U.S. Office of Management and Budget, 2000.)

While most predator control analyses do not involve development of new regulations, the spirit of the OMB guidance is certainly relevant to Wildlife Services. Not only is technical guidance available at a federal level, but also the federal government (through OMB) has demonstrated an understanding of the purpose and importance of cost-benefit analysis, one that Wildlife Services should heed.

PURPOSE OF BENEFIT-COST ANALYSIS

Benefit-cost analysis is defined by Sassone and Schafer (1978:3) "…as an estimation and evaluation of net benefits associated with alternatives for achieving defined public goals." This definition contains several key elements of benefit-cost analysis: (a) net benefits, which equals total benefits minus total cost; (b) alternatives; and (c) public goals. Thus, benefit-cost analysis is not about minimizing costs of government programs, but maximizing either the total net benefits or the benefits gained per dollar expended.

Government programs, for example, often require industry to incur more than the minimum cost of production by requiring these industries to install pollution control equipment. This is justified because the gains in public health outweigh the added cost, at least up to a point. Similarly, most people do not drive the cheapest car on the market because the added benefits of a larger but more expensive car outweigh the added cost. Part of the purpose of benefit-cost analysis is finding that most efficient point where the difference between total benefits and total cost is the greatest. This is the most economically efficient level of production, which is often different than the cheapest way to do something.

The other important element of the definition of benefit-cost analysis is public goals. Benefit-cost analysis conducted by government takes a social viewpoint—meaning that it includes the costs and benefits to the whole society, rather than a narrow private firm viewpoint. As is well known, there are benefits and costs that occur outside of the market (e.g., external costs such as pollution). These benefits and costs affect citizens, and citizens often value and are willing to pay to increase these benefits or reduce these external costs imposed upon them. A government acting to allocate resources of its citizens efficiently, on those citizens' behalf, should consider these social values, not just private market values. Benefit-cost analysis is an instrument for government agencies to do this. In fact, much of the justification of government intervention, whether in environmental protection or wildlife management, is the fact that private markets do not work for many of these public goods. Thus, it makes little sense for an agency to perform a benefit-cost analysis or economic evaluation that is focused solely on financial values of private businesses (e.g., livestock producers) without considering the broader values to society, such as non-consumptive uses of wildlife or ecosystem services, that wildlife provide.

Measures of Costs

Benefit-cost analysis deals with both financial costs and opportunity costs. Financial costs are direct out-of-pocket expenditures, such as fencing or purchase and maintenance of guard dogs. Opportunity costs include foregone benefits to society. In the case of Wildlife Services predator control, opportunity costs would include the value of the predators to society. For example, Duffield (1992) and Duffield et al. (1993) have documented the use value to wolf viewers and existence value to the general public from wolves. Killing wolves thus involves a loss in benefits and hence an opportunity cost of reducing wolf predation via lethal means.

Measures of Benefits

Benefits are defined in benefit-cost analysis as a consumer or producer's net willingness to pay (WTP), or willingness to pay over and above costs, also known as consumer surplus and producer surplus, respectively (WRC, 1979, 1983; OMB, 1992; EPA, 2000; Freeman, 2003). Price is the willingness to pay for one more unit of the good. But absence of price does not mean absence of value. If a good provides a person (not necessarily everybody) with enjoyment/satisfaction and is scarce, it has an economic value (Schuhmann and Schwabe, 2000:4). As OMB (1992:7) notes, "[P]rices sometimes do not adequately reflect the true value of a good to society." This is certainly the case of many natural resources, which are purposely non-marketed. For example, the fact that wildlife is not privately owned but held in public trust by government agencies does not diminish the fact these species have an economic value to people. In the case of wildlife, the general concept of net WTP or consumer surplus applies, since the market price is zero for many species.

Use of Accounting Stance

Since federal expenditures provide about half the funding for predator management, amounting to nearly $24 million (GAO, 2001), a federal accounting stance is appropriate. An economic "accounting stance" provides a delineation of whose benefits and costs count when performing an economic evaluation. For example, while Wildlife Services' local project cooperators (e.g., counties or a state) may want to restrict the measurement of benefits and costs to just its local beneficiaries, this would run counter to the spirit of benefit-cost analysis. This is particularly apparent in evaluating government programs run by or paid for (even if partially) by the national taxpayers via the federal government.

Even though local cost sharing occurs, this is not uncommon among federal programs. The Army Corps of Engineers performs benefit-cost analysis using a federal or national accounting stance (hence the name National Economic Development account), even though locals are required to cost-share on many projects. In the case of recreation projects like beach nourishment, local cost-share can represent the majority of funding, yet a federal accounting stance is still used.

IMPORTANT VALUES IN ECONOMIC ANALYSIS

Economic Value of Wildlife Recreation

For decades people have recognized that many wildlife species provide direct use values to hunters and non-consumptive wildlife viewers. These benefits are also measured by their WTP or consumer surplus. There have been dozens of studies of these hunting and viewing benefits. Loomis and Richardson have summarized these and they are available at: http://dare.colostate.edu/tools/benefittransfer.aspx. While deer is the most commonly studied, values also exist for pronghorn in the intermountain west as well as elk and bighorn sheep. Wildlife viewing values have been estimated for most regions of the U.S. by the National Survey of Hunting, Fishing and Wildlife Viewing performed every five years by the U.S. Fish and Wildlife Service. Loomis and Richardson (2008) have a summary of these studies as well (see http://dare.colostate.edu/tools/benefittransfer.aspx for downloading these tables). As will be noted below, there is no need to use fines/penalties for poaching as a measure of legal hunting values.

These direct, often on-site, use values are commonly included in benefit-cost analysis by federal agencies including the Army Corps of Engineers, Bureau of Reclamation, Forest Service (which has published several reports from its Rocky Mountain Research Station starting in 1985; see Sorg and Loomis, 1985; and Rosenberger and Loomis, 2001), Natural Resources Conservation Service, Fish and Wildlife Service, and EPA, to name just a few.

Value of Ecosystem Services

There is a growing recognition that maintaining a functioning ecosystem with all of its inter-related species provides many use values to society in the form of ecosystem services (Daily, 1997). These include services which have direct use values, such as water purification for drinking purposes, erosion control, pollination of crops, control of pests, and renewal of soil fertility (Brown, et al. 2007). Formal federal government recognition of the economic values of these ecosystem services was advanced by the National Research Council's (2004) report entitled Valuing Ecosystem Services: Toward Better Environmental Decision Making. The U.S. Department of Agriculture (the department Wildlife Services is part of) established an Office of Ecosystem Services and Markets in 2008. Many of these ecosystem services are non-marketed at the present time, in part due to the fact they have characteristics of so-called "public goods." For instance, the benefits of ecosystem services are non-excludable (meaning no single entity controls access to them—they are accessible to everybody) and non-rival (meaning that one person using it does not diminish its value or its availability to others). However, valuation of these use values follows the same approach for valuing any other non-market good, willingness to pay (Goulder and Kennedy, 1997: 29).

Existence or Passive Use Value

As first noted in 1967 (Krutilla, 1967) and empirically demonstrated since the early 1980s (Brookshire, et al. 1983) wildlife also has an existence value to people who may never see the species in the wild. These people are often willing to pay for protection of these species. Evidence of this willingness to pay is seen in donations to conservation groups such as the National Wildlife Federation and Audubon Society as well as donations to numerous state Non-Game Wildlife check-offs on State Income Tax forms. Others would pay for protection of habitats for wildlife species to keep them intact for future generations. This is known as bequest value. These values are recognized in federal natural resource damage assessment. One U.S. District Court termed existence and bequest values "passive use values" (*Ohio v. U.S. Department of Interior, 880 F. 2d. 432, 444 (D.C. Cir. 1989)*). Sometimes also called non-use values, these are considered compensable damages from natural resource damages (e.g., old hardrock mines) under the Superfund legislation as well as oil spills under the Oil Pollution Act of 1990. CERCLA § 301(c)(1)–(2), 42 U.S.C. § 9651(c)(1)–(2) (2000); OPA 33 USC § 2701 et. seq.

The monetary amount of these existence values is also measured by WTP. Typically it is measured using the contingent valuation method, described below. While the dollar amounts stated by people are not actually paid, the method has shown to be reliable in test-retest reliability studies (Loomis, 1989, 1992; Reiling et al., 1990). Richardson and Loomis (2009) provide a listing of these passive use value studies of wildlife and a meta-analysis of them as well. Species studied range from raptors, such as eagles and hawks to coyotes and wild turkeys (see Stevens et al. 1991). Existence values of bighorn sheep in Arizona have also been studied (for more details, see Richardson and Loomis 2009).

As noted above, functioning ecosystems also provide ecosystem services that have use values to people. In addition, functioning ecosystems—because they provide habitat to native plants and animals—may also provide ecosystem services in the form of existence and bequest values. Specifically, this means the benefits people receive from knowing that functioning ecosystems exist, and that native species are maintaining self-sustaining populations (Gonzalez-Caban and Loomis, 1997). With regard to valuing entire ecosystems, the economic valuation of wetlands

is probably the most advanced in this area, particularly using the contingent valuation method described below (see Woodward and Wu, 2001, for more details on wetland valuation studies).

TECHNIQUES FOR VALUING BENEFITS

Market Goods

While it would seem straightforward to value market goods because they have prices, correctly valuing market goods is actually more difficult than it might appear. Market prices measure the dollar amount received by the producer. However, from this gross revenue the producer's costs must be deducted, to arrive at their profit or net income or what is sometimes referred to as net willingness to pay of the producer (i.e., producer surplus). It is the net income foregone, not the entire sale revenue associated with the animal at auction, which is the loss to the rancher if an animal is lost to predation. Thus, measuring the loss of livestock at its market price assumes there would have been no savings to the rancher from having to transport fewer animals to market, for example (i.e. no decreased costs of production). Analyses by Bodenchuck et al. (2000:82) and Taylor et al. (2009), using market prices only as a measure of net income foregone to the rancher, presume that most of the rancher costs are fixed and paid prior to the livestock beginning to graze pastures where they are subject to predation. Thus, they assume the rancher's costs after the livestock are turned out to pasture are minimal. If there is little or no incremental cost to the rancher, then, as they note, the market price could be equated with the profit or net income. To the extent this assumption of no incremental cost is not true, however, the value of livestock is overstated.

Non-market Goods

Wildlife in most of the United States, and in the western U.S. in particular, is a publicly owned resource. Resident wildlife is owned and held in trust by state governments, while the federal government has jurisdiction over migratory wildlife crossing state and international borders (see, e.g. 252 U.S. 416, 435 (1920) and 441 U.S. 322, 326 n. 2 (1979)).

Most state "fish and game" agencies set license fees only at a level to recover the cost of their management. Therefore, these license fees do not reflect all the benefits that hunters obtain from purchasing a license. Likewise, the hunter and viewer expenditures are a cost to the participant, not a benefit. As noted above, benefits are the amount the hunter or viewer would pay in addition to their costs. To estimate this willingness to pay, there are at least three methods used by economists to measure the value of wildlife. These techniques are also used by many federal agencies, including, among others, the Army Corps of Engineers, Bureau of Reclamation, Fish and Wildlife Service, and EPA. These are techniques recommended for use by federal agencies in the US Water Resources Council Principles and Guidelines (1983), and by the EPA in its Benefit-Cost Guidelines (EPA, Chapter 7: 2000). Here, we review the three most relevant to Wildlife Services, the Travel Cost Method (TCM), Contingent Valuation Method (CVM) and Benefit-Transfer of TCM and CVM values.

Estimating Recreational Benefits with Travel-Cost Method

TCM uses travel cost paid as a proxy for price to trace out a demand curve for the recreational activity. From the demand curve, the consumer surplus or net WTP in addition to cost is calculated (see Loomis and Walsh, 1997 or Parsons, 2003 for more details). The strength of this method is that it uses actual trips taken and actual travel costs to trace out the demand curve. Hence the measures of net WTP reflect actual behavior. Application of TCM can be accomplished using hunter permit zip codes, but is typically performed using a short survey. This survey can be administered by the state fish and game agency during it post-season hunter survey. For example, in Idaho, this interagency approach was implemented by the U.S. Forest Service cooperating with Idaho Fish and Game (Donnelly, et al. 1985). TCM is a well established methodology, as nearly a hundred valuation studies of hunting and wildlife viewing have been conducted in the U.S., including many by state fish and game agencies, such as those in Alaska, California, and Idaho (Peterson, et al. 1992; Loomis, et al. 1989 and 1990; Donnelly, et al. 1985).

Estimating Use and Existence Values with Contingent Valuation Method

This method involves constructing a hypothetical or simulated market and asking individuals if they would pay an increase in their trip costs (for use values) or an increase in their taxes/utility bills/overall prices for increasing environmental quality, such as an increase in wildlife populations. This carefully constructed market states what the current conditions are, how improved conditions would be provided, and the cost of providing improved conditions. Then the respondent is asked to state the amount of money they would pay for improved conditions. With a dichotomous choice or referendum method, the individual indicates they would or would not pay a particular dollar amount for the improved conditions. The dollar amount is varied across the sample. From the "yes or no" responses to these dollar amounts, the average WTP can be calculated. One consistent

measure of the internal validity of this dichotomous choice CVM is that the higher the dollar amount respondents are asked to pay, the lower the probability they would pay. This indicates that respondents are paying close attention to the dollar amount they are asked to pay, otherwise there would be no statistically inverse relationship between the dollar amount they are asked to pay and the likelihood they would pay.

Like TCM, the CVM approach has also been used by numerous state and federal agencies to estimate the passive use values in a variety of natural resource issues. The CVM approach has been applied for example, by the U.S. Fish and Wildlife Service in its Environmental Impact Statement (EIS) evaluating the economic benefits of wolf reintroduction (Duffield, 1991; Duffield, et al. 1993), by the National Park Service in its EIS estimating the economic benefits of Elwha Dam removal (Loomis, 1996) and by the U.S. Bureau of Reclamation in an evaluation of the effects of improving instream flows in the Grand Canyon (Welsh, et al., 1995). State fish and game agencies have also applied CVM to valuing wildlife in Alaska, California, Idaho and Montana (Peterson, et al. 1992; Donnelly, et al. 1985; Loomis, 1989; Loomis, et al. 1988 and 1990).

Benefit Transfer to Other Locations

This method is designed as a practical approach to transfer values from existing TCM and CVM studies to other locations. There is well-developed literature on benefit transfer starting in 1992 (see special issue of Water Resources Research introductory article by Brookshire and Neil, 1992), and continuing to today (see 2006 special issue of Ecological Economics). The basic idea of this method is to adapt existing values of hunting, viewing and existence values of wildlife from studied areas to unstudied areas in need of these values. Hence, benefit estimates are transferred to other sites. This is no different in spirit than transferring predation rates from one state or area of a state to another. Of course, these transfers, whether of biological functions or economic functions, are approximations. But these approximations are better than simply giving up and either ignoring economic values of wildlife because there are no existing valuation studies in that area or using inappropriate concepts of values such as license fees or fines for illegal take of wildlife. An approximate estimate of the correct concept (WTP) is far better than a precise estimate of the wrong concept (fines).

Benefit transfer is widely used by federal agencies, including the U.S. Forest Service, Army Corps of Engineers, Bureau of Reclamation, and EPA, as a short cut approach when an original CVM or TCM study cannot be conducted due to time or budget limitations.

Wildlife Services recognizes that TCM and CVM are relevant tools for valuing wildlife (Engemann, et al. 2002; Shwiff, 2004). However, the agency appears to use not these methods for valuing game animals such as pronghorn or protecting endangered species, let alone for valuing losses of predators such as wolves.

Wildlife Services also appears dismissive of using TCM and CVM values derived for similar species in nearby states. The agency or its local cooperators appear unwilling to use benefit-transfer, despite its widespread adoption by other federal agencies, including those within the Department of Agriculture. For example, the U.S. Forest Service (a Department of Agriculture agency) has helped catalog recreation values of hunting and wildlife viewing, as well as other recreation valuation, publishing these studies in 1985 (Sorg and Loomis, 1985); and continuing into 2000 (Rosenberger and Loomis, 2000) and 2005 (Loomis, 2005).

While every state feels its wildlife or hunting or fishing experiences "are unique" and not comparable to nearby states, the reality is these wildlife recreational experiences are usually fairly similar across states in a given geographic region of the country. Hence, the values of fishing, hunting and viewing in one state are reasonable proxies for the values of these same activities (e.g., trout fishing) in adjacent or nearby states. Meta-analysis that uses regression analysis of recreation values can be used to explicitly test whether there are regional differences between recreation values by regions of the country. For example, a meta-analysis by Rosenberger and Loomis (2001) found that only about half the USDA Forest Service Regions had recreation values that were significantly different from others. It also must be stressed that, even if the values between states were not very

similar, failure to include a value of wildlife for a state without its own wildlife values results in an implicit value of zero in the benefit-cost analysis. It is very unlikely that zero WTP is more accurate than the value of hunting, viewing or wildlife populations from a nearby state.

Examples of Economic and Ecological Values of Wildlife

To provide an example of benefit transfer values of hunting, viewing and existence values we provide the following tables from Loomis and Richardson (2008). These are sample averages, with the underlying individual study values, including specific states of the study are provided at http://dare.colostate.edu/tools/benefittransfer.aspx.

As one can see from this table, despite likely differences in socioeconomic characteristics of the regions, there is a great deal of similarity between average and median values per hunter day for hunting big game across the country. It may be that while the socioeconomic characteristics of the general populations differ somewhat across regions, the hunter's socioeconomic characteristics are more similar across the regions. Only the intermountain region is significantly above the other regions when using the average, and there is only about a 10 percent difference when median values are used. There is, of course, more variation and a larger spread of values when there are fewer studies, as in the case of small game hunting. Waterfowl hunting has a significant number of studies, and there is some variation across regions, although some of this may relate to abundance of waterfowl relative to populations.

As shown in the next table (Table 2), the average net WTP or consumer surplus per visitor day for wildlife viewing is fairly similar across the Northeast, Southeast and Intermountain regions and Alaska. It is about 20 percent higher along the Pacific coast. Median values are even more similar between the Northeast, Southeast and Intermountain regions. These wildlife viewing values represent composite values of bird watching, big game viewing, etc. Only a few studies have separate values for watching particular species. The database that underlies this table provides the details of both the general wildlife viewing studies as well as the specific species viewing. The detailed tables can be found at http://dare.colostate.edu/tools/benefittransfer.aspx.

Unfortunately, Wildlife Services' analysis (see, e.g., Wildlife Services 2010: 100) generally discusses the existence and bequest values of wildlife species, but does not go the next step in incorporating these values into their economic analysis. This is particularly important when the species being targeted for lethal control is a rare species such as the wolf or a raptor species.

The next table (Table 3) shows measures of existence values per household drawn from the literature for wolves, bald eagles, and falcons, with each row representing an independent study.

Table 1: Net WTP or Consumer Surplus per Hunter Day from Hunting in Five Regions of the U.S.

Species Category	N (Sample Size)	North-East	N	South-East	N	Inter-Mountain	N	Pacific	N	Alaska
Big Game	142		66		141		30		13	
Average		$58.45		$54.94		$71.37		$59.16		$62.82
Median		$52.15		$50.34		$58.43		$54.31		$50.07
Small Game	11				27		4			
Average		$32.40				$65.51		$155.62		
Median		$33.88				$46.67		$140.07		
Waterfowl	39		24		31		12			
Average		$35.99		$45.85		$51.77		$64.82		
Median		$29.21		$35.42		$35.42		$47.98		

Table 2: Net WTP or Consumer Surplus per Visitor Day from Wildlife Viewing in Five Regions of the U.S.

Species Category	N (Sample Size)	North-East	N	South-East	N	Inter-Mountain	N	Pacific	N	Alaska
Wildlife	88		62		65		16		9	
Average		$46.48		$42.89		$47.86		$58.87		$51.68
Median		$37.29		$36.14		$39.56		$44.38		$48.89

Table 3: Examples of Net WTP per Household for Existence Values of Wildlife Species

Species	STATE	WTP per household
Mammal		
Wolf	ID, MT, WY	$37.43
Wolf	ID, MT, WY	$28.37
Wolf	ID, MT, WY	$21.59
Wolf	MN	$22.64
Bird		
Bald Eagle	WI	$21.21
Bald Eagle	New England	$45.21
Bald Eagle	New England	$31.85
Falcon	ME	$32.27

Source: Developed from data in Richardson and Loomis, 2009

As Table 3 indicates, there are a variety of animals that have been valued. While many of these were classified as threatened or endangered at the time of the valuation studies, some were not, such as falcons in Maine. Given that these are values per household, and existence values for preservation of habitat for these species is a public good, the existence values are received by millions of households. For example, values of bald eagles in New England involved a survey of New England residents. Hence the benefits can be generalized to the millions of households in New England. Thus, even small values per household can become tens of millions of dollars in existence value benefits. The same is true for wolves, where values of $22 to $37 per household, when applied to millions of households in the intermountain west, provide sizeable values for wolf protection. This has important implications for conducting benefit-cost analysis of predator control on wolves. These lost existence values of reducing wolf populations need to be included when evaluating the benefits and costs of lethal control of wolves.

In addition to the use and existence values described above, native wildlife also provides ecological value. Large predators such as wolves often play a regulating function in maintaining the structure of ecosystems (Beschta and Ripple, 2009). Apex predators such as wolves keep large grazing ungulate populations (e.g., elk) in check, allowing young aspen, cottonwoods and willows to establish to replenish stands (Beschta and Ripple, 2009, 2010), especially in riparian areas important to birds.

By contrast, elimination of wolves allows second-tier predators such as coyotes to flourish with associated impacts on pronghorn populations (Berger and Conner, 2008). Berger and Conner (2008) note that areas with wolves had significantly lower predation rates on pronghorn than areas without wolves. Thus, maintaining wolves would naturally regulate coyotes, and hence yield more pronghorn. In the spirit of the analysis of the gains in pronghorn hunting of Taylor et al. (2009) and Shwiff and Merrell (2004), it is possible to quantify these gains in pronghorn hunting benefits and include them as an additional benefit of protecting wolves. Thus one benefit of non-lethal wolf control such as sterilization is that it would increase pronghorn hunting benefits. It is beyond the scope of our study to conduct an original site specific analysis of the gain in pronghorn hunter days. But to illustrate the process, consider the approach used by Taylor et al. (2009: 20). They note in their regression that each pronghorn in the population supports 0.35 hunter days. Thus, for example, 100 more pronghorn in the population due to a wolf pack's control of coyote populations would add 35 hunter days. Using the $112 per pronghorn hunter day in Taylor, et al. (2009: 20) would yield about $4,000 of additional benefits for this wolf pack's control of coyotes. These added benefits could help to offset any additional cost of non-lethal control.

Thus, overall these ecological functions of top level predators provide ecosystem services that people value. Ecosystem services are defined by many authors differently, but common elements in all these definitions include results of ecosystem functions and processes that directly sustain or enhance human life or maintain the quality of ecosystem goods such as water quality (Brown, et al, 2007; Boyd and Banzhaf, 2005). While it is beyond the scope of this research and report to estimate a monetary amount for these ecosystem services, it is worth noting that this can and has been done in a number of riparian ecosystems (see Loomis, et al. 2000; Brookshire, et al. 2010).

WHY WILDLIFE SERVICES AND OTHER PREDATOR CONTROL STUDIES ARE WEAK

In this section we review past economic studies of predator control. These studies include those reviewed by General Accounting Office (GAO) in 1995 and 2001. Included in this review are studies performed not only by Wildlife Services but also those by other economists as well. In addition, critiques of the predator management program by others were reviewed. Note some authors call benefit-cost analysis by its other synonymous name, cost-benefit analysis or CBA.

As noted by Taylor, et al. (2009, p. 41) in their review of economics of predator management:

> *More often CBA is applied to a specific project with a narrowly defined scale. Cost benefit analyses of federal predator control programs in specific states are a case in point. In these cases the costs and benefits are generally restricted to a small subset of society, such as the costs borne by the federal agency and the benefits accruing to the state's livestock producers. When CBA is applied in this manner, the relevant question becomes: Do the gains of agricultural producers exceed the costs borne by the agency? If the answer is yes, then the federal expenditures may be deemed attractive from the perspective of the federal agency and livestock producers. This does not imply, however, that the control program is efficient on a broader scale. Specifically, there may be costs borne by individuals not considered in the analysis that would deem the program inefficient and thus unattractive. Readers of CBAs should therefore be cognizant of the scale of analysis implied because the scale can greatly impact the utility of the analysis for informing policy debates.*

As the authors note in their report, these concerns are common to Wildlife Services' and other prior benefit-cost analyses. Comparing this quote to the discussion of federal agency benefit-cost procedures, such as those employed by EPA, Army Corps of Engineers and Bureau of Reclamation, indicates that these other federal agencies usually take a national or societal viewpoint when conducting their benefit-cost analyses. The same standard should apply to benefit-cost analyses of federally funded predator management programs.

A useful transition between the broad principles of benefit-cost analysis applied by federal agencies and the specifics of predator management is provided by Schuhmann and Schwabe. The principles laid out by Schuhmann and Schwabe (2000) can be used as evaluation criteria to judge the adequacy of the Wildlife Services' and others' economic analysis of predator management programs.

Schuhmann and Schwabe (2000) note the following principles:

- While damages and costs to agriculture may "beg for immediate intervention, optimal management strategies must consider the costs and benefits of wildlife resources" (p. 3). As they note, predator management is just a part of overall wildlife management, and state wildlife management agencies balance the costs imposed by wildlife against the public's values of wildlife including hunting, viewing and photography (p. 3).
- "[C]ost is not an accurate representation of value" (p. 5). In absence of a well defined non-market value, often times some analysts will substitute the cost of producing the (often endangered) species for its value. As Schuhmann and Schwabe (2000: 5) note, there is not a necessary relationship here. In some cases the cost may greatly understate the value (e.g., drinking water), and in others costs may greatly exceed the value.
- Opportunity costs are the value of what society must forego to achieve a specific objective (p. 5). In the context of predator management, the reduction in populations of wolves or coyotes carries with it an opportunity cost of reduced benefits to the general public from reduced populations of these species and other ecosystem services they provide.
- Fines, whether levied in courts or set by agencies, may not bear a strong relationship with the values hunters and viewers have for the species (p. 10-11). In their comparison, fines were nearly $1,000 per deer, while economic values to hunters and viewers were closer to $200 per deer from two non-market valuation studies (p.10-11). One might expect fines to exceed the value of the game wildlife to the hunter, since fines are set high enough to have a deterrent component to discourage illegal behavior and serve as a penalty for engaging in illegal behavior. If the fine only equaled the actual value of the wildlife, such a fine would have little deterrent effect, since the probability of being caught is much less than 100 percent. The criminal would only pay the value of the game obtained IF they were caught. Thus use of fines will likely greatly over-value wildlife.

Schuhmann and Schwabe (2000) conclude with two additional important points:

1. "There is little uncertainty that wildlife-human conflicts impose significant costs on society. Yet…there is also enormous values associated with these same wildlife resources."

2. "We showed that a stand-alone market-based approach to wildlife resource management will fail to balance the full range of costs and benefits from maintaining these wildlife resources" (p. 13).

Given that the paper was presented at and published as part of the USDA National Wildlife Research Center Symposia in 2000, one would hope these principles would be embraced by analysts performing economic evaluations of predator management, particularly by agencies also within the Department of Agriculture.

Review of Wildlife Services' Current Economic Evaluations of Predator Damage Control Studies Compared to Accepted Benefit Cost Procedures

In a Wildlife Services publication by Sterner (2004), it mentioned that Wildlife Services' staff "are preparing a Benefit-cost Analysis Handbook that will be published for use by NWRC (National Wildlife Research Center) scientists and WS specialists." Recent interviews with Wildlife Services' economists indicate that earlier efforts to develop the Benefit-cost Handbook have been discontinued (Shwiff, 2011). Thus, there is no official guidance to review and we have relied upon our review of Wildlife Services economic evaluations to describe the procedures that are used by Wildlife Services economists and Wildlife Services field staff.

Wildlife Services does perform benefit-cost analysis on their entire predator control program in states such as California (see Shwiff et al. 2005). However, in other states like Nebraska and Nevada, state specific benefit-cost analyses are not preformed. Rather they cite older general benefit-cost studies such as Bodenchuck et al. (2000), that, as will be noted below, have flaws that substantially overstate the benefit-cost ratio. This is true even of the Nevada Environmental Assessment for Predator Damage Management, completed in 2010. Between 2000 and 2010, however, the capability for sound economic analysis in Wildlife Services has significantly progressed. Thus, use of an older, inaccurate study and omission of a state-specific economic analysis of a statewide damage assessment program is a serious weakness in the current predator control program.

Some people have a demonstrated positive willingness to pay to open up more habitat and restore wolves by compensating ranchers for the damages wolves sometimes impose on society in the form of livestock depredations. Compensation funds established by conservation organizations and primarily funded by private citizens are one indication of this willingness to pay, which should be recognized in Wildlife Services' economic analyses.

TOO FEW ALTERNATIVES EVALUATED AND OVEREMPHASIS ON MINIMIZING COSTS

One element missing from many Wildlife Services and other predator control economic analyses is a wide range of alternatives. Usually only "with" and "without" current predator control are evaluated. In most federal agency benefit-cost analysis there are several alternatives: a continuation of existing management, and then several different alternative means of achieving a given end. Alternatives in water planning include structural and non-structural approaches (e.g., zoning, restoring wetlands, demand management). In Wildlife Services' analyses, these alternatives could range from more emphasis on non-lethal control, including approaches ranging from sterilization to working with public land management agencies to encourage changes in timing or location of livestock grazing to reduce predation. On the individual side, some ranchers are increasingly employing guard dogs, herders, electrified fencing, and other non-lethal methods, which have proven very effective in many circumstances. Wildlife Services' analyses could consider working further with ranchers to demonstrate or fund these methods as another important alternative to lethal predator control. While some of these alternatives may be more expensive to federal, state or county agencies or the livestock producers, if the benefits to society (not just to livestock producers) more than compensate for the added costs, net benefits would be increased. If Wildlife Services were to include losses in economic values of the predators killed, more expensive non-lethal means may actually have higher net benefits than less expensive lethal control. Often times, the cost-minimizing or "cheapest" alternative may yield fewer social benefits than an alternative that maximizes the difference between benefits and costs. That is, if a more expensive non-lethal predator control program costs $100,000 more than a lethal control program but adds $250,000 in benefits, then net benefits increase by $150,000—making non-lethal control more economically efficient even though it costs more.

Evaluating a wide range of alternatives may result in other predator control options (possibly including discontinuing predator control efforts entirely) that yield higher net benefits even if the alternative is not minimum cost. Along these lines, the size or scale of the predator control program should be subject to economic analysis as well.

Incremental analysis of increasing or reducing the size of a given program is common in economic analyses performed by other federal agencies to determine the optimum size of a project or level of protection. For example, several alternatives could be analyzed that range from removing 20 percent fewer to 20 percent more predators, or increasing or reducing control costs by 10 percent.

Often times, the cost-minimizing or "cheapest" alternative may yield fewer social benefits than an alternative that maximizes the difference between benefits and costs. That is, if a more expensive non-lethal predator control program costs $100,000 more than a lethal control program but adds $250,000 in benefits, then net benefits increase by $150,000—making non-lethal control more economically efficient even though it costs more.

The need for Wildlife Services to use sound economic procedures and valuation techniques is more important than ever, given not only some stakeholders' desire for the increased use of non-lethal means of predator management but also Wildlife Services' own stated preferences. As discussed in GAO (1995), Wildlife Services' written policies and procedures state that preference should be given to non-lethal means of predator management. However, as GAO noted from interviews with field personnel, most often lethal means are used (GAO, 1995). In some cases, this is because non-lethal means are more expensive than lethal methods (Bodenchuck, et al. 2000). As a result, if Wildlife Services does not count the benefits that the wildlife predators provide to society, it may appear far more cost-effective to employ lethal means. However, when the benefits foregone by removing coyotes or wolves or bobcats in an area are considered, some more expensive non-lethal means might actually provide higher overall net benefits to society. That is, what matters in economics is *not choosing the cheapest means, but choosing the one that provides the greatest net benefits, i.e., benefits minus costs. However, for Wildlife Services to know what the net benefits are, they must calculate the benefits of the predators to society. As shown below, past analyses by Wildlife Services and others essentially treat the economic benefits of predators as zero. Thus, the cheapest means of control may appear to be most economical, when, in fact, the opposite might be true.*

INCONSISTENCIES WITH FEDERAL BENEFIT-COST ANALYSIS PROCEDURES

Problems with Wildlife Services' Bodenchuck, et al. (2000) analysis, widely used within the agency, illustrate several common weaknesses in Wildlife Services' economic analysis of predator management, as well as a couple of novel errors.

Mixing Benefit-Cost Analysis and Regional Economic Analysis: An unusual error in the Bodenchuck et al. (2000: 82-83) analysis is the inclusion of multiplier effects on the benefit side when conducting a benefit-cost analysis. Multipliers are a concept from regional economics and should never be applied in a federal-level benefit-cost analysis. The notion of a multiplier is that direct income to one primary industry has a ripple or multiplier effect on other industries due to the stimulation of other sectors to supply the primary industry. This is a concept that applies to a regional economy (e.g., county or group of counties). As is well documented in federal benefit-cost procedures (Office of Management and Budget, Circular A-94 Revised, 1992:7) and books on benefit-cost analysis (Young, 2004: 95-98; Boardman, et al. 2001; Sassone and Schaffer, 1978: 37-39), neither jobs resulting from a project nor the multipliers should be used in benefit-cost analysis. This is because gains in income in one county usually come at the expense of reductions in income in other counties.[3]

For example, with a given demand for sheep (as determined by price), protecting 1,000 lambs in the intermountain West from wolves means these lambs from the intermountain region will be available to supply the national market, and thus 1,000 fewer lambs will be demanded from West Coast states suppliers. There is still the same quantity demanded at any given price. Since predation affects about 2 percent to 5 percent of sheep, predator management does not change the supply of sheep sufficiently to change the price of wool or lamb, so the quantity demanded is relatively constant whether a predator control program in the West is in place or not.

Thus, the multiplier effects from the additional 1,000 sheep in the intermountain West saved from predators will be offset by the reduced multiplier effects in the region where 1,000 fewer sheep are demanded. As is well known, from a national standpoint (which, as described earlier, is the appropriate "accounting stance" when conducting benefit-cost analysis involving federal programs, even if not exclusively federal), such multiplier effects are merely transfers in an essentially zero-sum game. The error in merging benefit-cost analysis with regional economics becomes quite apparent when one reviews federal benefit cost procedures. The U.S. Water Resources Council Principles and Guidelines (used by USDA's Natural Resources Conservation Service, the Bureau of Reclamation and the Army Corps of Engineers) clearly indicate that benefit-cost analysis is done using estimates in the National Economic Development account. Jobs, wages and multiplier effects in the study or impact region (e.g., county or state) are counted and displayed in a separate Regional Economic Development account. The economic analysis of predator control in Wyoming by Taylor et al. (2009) illustrates how to correctly do separate benefit-cost analysis and regional economic impact analysis.

In essence, including multiplier effects in benefit-cost analysis is contrary to the purpose of benefit-cost analysis, which is to determine the net gain. Hence Bodenchuck's et al (2000) benefit cost ratio of 27:1 is an overstatement by a factor of three just from his application of the multiplier of three to benefits, let alone omission of any foregne opportunity cost of wildlife.

Omitting Opportunity Costs: Like all the other studies done by Wildlife Services, Bodenchuck et al. (2000) does not include the opportunity costs or benefits foregone to society from the reduction in predator species. Specifically, no value is given for coyotes, wolves, bobcats, etc. that are killed. This omission results in an understatement of the full social costs of the control program, or alternatively overstates the benefits because the lost benefits of reduced predator wildlife populations are ignored. This omission is particularly glaring in the case of killing wolves, a species for which great efforts have been taken to recover, and for which there are significant ecological values (Beschta and Ripple, 2009) and well documented public economic values (as documented in the U.S. Fish and Wildlife Service's Wolf Reintroduction Environmental Impact Statement).

As noted in the recommendations, Wildlife Services should stop using the Bodenchuck, et al. (2000) study as blanket justification for state-level programs. Its use violates at least two significant principles of benefit-cost analysis that lead to both substantial over-statement of the benefits (using a multiplier of three on the benefit side) and understatement of costs (ignoring opportunity costs). Each state should conduct state-specific benefit-cost analysis of a wide range of alternative predator control programs ranging from lethal to several non-lethal methods. This economic analysis would evaluate from the federal or national viewpoint the national benefits and national costs arising from a particular state's predator control program alternatives. That is, the proposed action would be what control options Wildlife Services is considering in that state, but the benefits and costs of that alternative to citizens of the U.S. would be evaluated. Assuming a benefit-cost ratio for predator control in one state applies in its entirety to another state without any state-specific analysis is inconsistent with federal agency benefit-cost procedures for program evaluation.

Use of Expenditures as a Measure of Benefits: Another Wildlife Services report (Wildlife Services, 2010) on the Predator Damage Management in Nevada uses hunter expenditures as a measure of benefits. While this may be a useful starting point to begin to calculate economic impacts to the Nevada state economy if decreases in game animals would cause hunters to leave the state to hunt, it is not an appropriate measure of benefits for *federal* benefit-cost analysis. As noted above, benefits are defined as hunter willingness to pay over and above costs. Further, not all the money from those hunter expenditures becomes income to the Nevada economy since many goods bought by hunters are not produced in Nevada (e.g., ammunition, hunting vests, stove fuel, etc.). If one is doing an economic *impact* analysis for the State of Nevada, then leakages of hunter expenditures out of state should be deducted when calculating income to Nevada. But if one is doing benefit-cost analysis, then willingness to pay—or a similar means of estimating true benefits—should be used.

Primarily Performing Ex-Post Benefit-Cost Analysis instead of Prospective Benefit-cost analysis for Decision Making: To date, most Wildlife Services economic analyses of predator control have been ex-post evaluations of programs that have typically been running for about 10 years. While this is somewhat useful for deciding whether to continue a particular predator control program at the current level, it is less useful for decision-making than prospective studies about current versus alternative predator control programs. Economic analysis is most useful in providing information to make a decision, not justifying what has been done in the past. Most federal agencies perform prospective economic analysis and benefit-cost analysis to determine which alternative is the most economically efficient to implement in the future. For example, the U.S. Army Corps of Engineers conducts benefit-cost analysis of several alternative projects to determine if any are economically justified. This is done to inform the decision of whether to build or not. The purpose of their benefit-cost analysis is to aid in decision-making, not to justify what has been done in the past or a decision already made and sent to Congress.

Omission of Federal Costs of Predator Control: The California Wildlife Services Study. Another problem is exemplified by California's economic analysis of predator control, which only compared the state's share of costs to the livestock costs savings (benefits), rather than accounting for the total cost including federal expenditures. Since the federal expenditures have provided as much as $2 for every $1 of state/operator cost share (GAO, 1995) , inclusion of the federal share of the cost in this analysis would reduce the calculated net benefits of the California predator control program from $10 million to $6 million, a 40 percent reduction. While federal cost share has been reduced since 1995, the principle of including all costs, regardless of which government entity pays them, has been well established in federal benefit cost procedures for decades. In this particular Wildlife Services analysis, there may be have been pressure to use only a State of California accounting stance, hence ignoring federal costs in the benefit-cost analysis so as to make the net benefits as large as possible.

OVERESTIMATION OF WILDLIFE SPECIES BENEFITS ENHANCED BY PREDATOR CONTROL

Past Wildlife Services studies (Shwiff and Merrell, 2004) and other studies (Smith, et al. 1986; Taylor et al. 2009) have evaluated benefits of predator control to improve hunted big game populations. Often these studies use various monetary measures that do not reflect benefits to the hunters, as defined in federal benefit-cost procedures as hunters' net willingness to pay. For example, Smith et al. used the sum of hunting license fees and hunter expenditures as a measure of benefits. As noted in microeconomic textbooks (for example see Varian, 1990), market expenditures are a measure of *cost* to the consumer, not a measure of benefits. Net benefits to the consumer are measured by consumer surplus, in which costs are subtracted out (Varian, 1990; Brent, 1996). Hunter expenditures are relevant for a regional economic impact study of the effects of hunting on the local/county economy. But as noted above, regional economic impact studies are not benefit-cost analysis.

The Wildlife Services study by Shwiff and Merrell (2004) adopted State of Wyoming civil penalties for pronghorn as an estimate of hunter willingness to pay, or hunter benefits. While a sensitivity analysis was performed using $400, $1,500, $3,000 and $10,000, there is reason to believe wildlife values based on civil fines or penalties significantly overestimate the value of legal hunting of pronghorn protected by coyote control. As noted previously, civil penalties contain punitive and deterrent amounts designed to punish illegal poaching and reduce its attractiveness. Thus, these values most likely exceed the economic value of pronghorn by these punitive and deterrent amounts. The degree of over-estimation can be assessed by looking at the valuation a hunted wildlife species such as deer (this is an example of benefit transfer method). Loomis, et al. (1989) used the Travel Cost Method (TCM) in Idaho and found marginal values for deer of between $167 and $333 ($286 to $569 in 2004 dollars, for comparison to Schwiff and Merrell (2004)). Using the Contingent Valuation Method (CVM), the marginal value of a deer harvested in California averages $164 ($280 in 2004 dollars).

The use of fines as an estimate of the values of wildlife protected from predators overstates the benefits of legal hunting activity associated with pronghorn by a large margin in three of the four benefit estimates used by Shwiff and Merrell (2004). The result is to boost the benefit cost ratio of coyote control, since the value of pronghorn protected is overstated.

In Taylor et al. (2009), use of the $3,000 and $4,000 fine per pronghorn and deer (what they call restitution value), respectively, results in nearly all the benefits of predator management in Wyoming being due to these two game species. In this case, less than 10 percent of the benefits from predator control are due to livestock losses. Taylor et al. (2009) also use a value of $851 per deer. As noted above, the marginal values for harvesting another deer are in the range of $300 to $500, so the $851 is somewhat high but not substantially so. Nonetheless, in this benefit-cost analysis scenario of Taylor et al. (2009), the big-game hunting benefits of predator control are calculated at $32 million while livestock benefits are $15 million. Thus big game hunting represents two-thirds (66 percent) and livestock one-third (33 percent) of the benefits from predator control.

However, when Taylor et al. (2009) use a value per hunter day more consistent with estimated hunter benefits from the literature (i.e., $112 per pronghorn hunter day and $97 per deer hunter day), their overall benefit-ratio of predator control drops to about 3 to 1 as compared to 33 to 1 using fines, and 8 to 1 using values per deer that are much higher than the literature. When using more realistic wildlife values, then, wildlife benefits represent a minority of the benefits from predator control. The $112 to $97 per hunter day are only somewhat (+25 percent) higher than intermountain big game hunting values, but these do seem reasonable relative to the literature (Loomis, and Richardson, 2007). However, in both Shwiff and Merrell (2004) and Taylor et al. (2009), no value associated with the killed coyotes is included in the benefit-cost analysis, as either a reduced benefit or opportunity cost to society. Even if reducing the coyote population through preventative control is a temporary reduction and the population grows back to its prior population level, this temporary reduction in economic value needs to be counted in the benefit-cost analysis. These temporary losses in fish and wildlife values were included in the natural resource damage assessment undertaken by governments for the Exxon Valdez oil spill in Alaska. No doubt short term losses to fish and wildlife losses in the Gulf of Mexico from the BP spill will be included in the federal and state damage assessments currently being conducted. Moreover, assuming the coyote population will bounce back, as studies have shown (see, e.g. Knowlton et al. 1999), the benefits of this predator control would also be temporary, further reducing the net total benefits.

HOW WILDLIFE SERVICES SHOULD IMPROVE ITS ECONOMIC ANALYSIS

The recommendations below are consistent with Wildlife Services' Strategic Plan (2010-2014) Goal #2 to "Develop Effective and *Economical* Methods for Managing Wildlife Damage for Some of our Most Pressing Wildlife Issues." Without economic evaluation procedures in place, it will be difficult to determine if economical methods are being used. Economics is the study of how to allocate limited resources (of all types) among competing priorities. Better use of economic principles would also aid Wildlife Services in addressing its first key challenge identified in its 2010-2014 Strategic Plan "1. Limited Resources for Wildlife Damage Management and Research."

In addition, the federal agency overseeing Wildlife Services, USDA-Animal Plant Health Inspection Service (APHIS), has as its first of six Strategic goals: "Safeguarding the health of animals, plants and *ecosystems* domestically and in other countries" (emphasis added). As previously discussed, removing top-level predators (sometimes known as keystone species) from ecosystems can often disrupt the ecological relationships between species, resulting in adverse effects on other plant and animal species as well as ecosystems (Beschta and Ripple, 2009).

Specific recommendations are:

Develop a manual with instructions for performing benefit-cost analyses using procedures consistent with federal agency benefit-cost guidelines.
The manual need not be extremely detailed, as it could incorporate by reference (and hyperlinks) other existing federal agency benefit-cost procedures most relevant to Wildlife Services.

Provide economics training courses by Wildlife Services' National Wildlife Research Center (NWRC) staff economists to State Offices and Field Offices or support equivalent outside training.
Many natural resource agencies have been conducting economics training for their non-economist field staff for more than a decade. The U.S. Forest Service, in conjunction with University of Georgia and Portland State University, conduct an annual training course called "Resource Policy, Values, and Economics." For a number of years, the Bureau of Land Management (BLM) has conducted annual training courses in social and economic analysis for planning. The last course was videotaped, and is now available as part of their online training courses.

Assistance to Wildlife Services economists in developing the agency's own training courses could be provided by USDA Economic Research Service, which is staffed by numerous economists familiar with natural resource and agricultural economics, non-market valuation and benefit-cost analysis. As a supplement to the full in-person class, Wildlife Services should post the training materials on-line. Wildlife Services could also work with economists in other agencies that do benefit-cost analysis to develop a refresher course in benefit-cost analysis and economic valuation. Further, as an extension to the course, more advanced reference materials could be posted on this site. This could involve independent readings and PowerPoint presentations. Universities use this method to present employee training modules in a number of areas (e.g., ethics training).

If time and resources preclude development of such a course in the near term (e.g., in the next 2 years), Wildlife Services employees that will perform economic analyses should be required to take an existing economics training course such as the U.S. Forest Service Resource Policy, Values, and Economics (the U.S. Forest Service has allowed non- Forest Service employees to take this course in the past), or take a course in benefit-cost analysis at local colleges and universities, etc.

Develop Wildlife Services' NWRC economic tools website to aid Field Offices in performing economic analysis.
One example is a website developed by USDA's Natural Resources Conservation Service (NRCS) at: http://www.economics.nrcs.usda.gov/index.html. Their menus on the left-hand side provide a tools section, and web links to a wide range of existing studies on recreation throughout the U.S. are posted there. Links to papers and databases on benefit transfer are provided there as well; see: http://www.economics.nrcs.usda.gov/technical/recreate/index.html.

Hire 1-2 economists at Wildlife Services in NWRC or Washington, DC, Office or contracting out.
These economists would:

1. Provide technical support to field offices in conducting economic analyses of alternative means of reducing livestock losses from predator control.

2. Review and provide quality assurance and quality control (QA/QC) of state level predator control economic analyses conducted by field offices.

Several agencies, including the Federal Emergency Management Agency (FEMA) and the Bureau of Reclamation, continue to employ a separate staff of agency economists serving both functions #1 and #2. In particular, the Bureau of Reclamation has an Economics and Resource Management team in the Denver Technical Service Center. This team issues technical guidance on performing economic analyses, including non-market valuation, and assists field offices in performing these analyses. The Institute for Water Resources, located in Ft. Belvoir, VA, performs the same tasks for the US Army Corps of Engineers.

The presence of just two economists in all of Wildlife Services is insufficient, given the tens of millions of dollars being spent annually by Wildlife Services. Economic evaluation can help Wildlife Services attain its goal of economical methods for

managing wildlife damage. An additional economist hired by Wildlife Services could, for example, provide field support for economic analysis like FEMA does through use of a benefit-cost analysis toll-free helpline, or via email.

If it proves difficult to hire 1-2 more full-time economists at Wildlife Services, another option occasionally used by other agencies for economic analysis of critical habitat for threatened and endangered species is to contract out the economic analysis to a reputable consulting firm. For example, the U.S. Fish and Wildlife Service has contracted several such economic analyses to Industrial Economics. Recently, Department of Interior contracted to Research Triangle Institute to evaluate salmon benefits, among others, of the Klamath Dam removal and National Oceanic and Atmospheric Administration has contracted out to Stratus an economic analysis of the value of ecosystem services gained from the Elwha Dam removal.[4] The Army Corps of Engineers contracts out for what it calls Independent External Peer Reviews of its draft Feasibility Report-EISs, including its economic analyses. The Corps of Engineers is required to respond to the comments of the 4-5 member peer review panel, including correcting, clarifying or noting any limitations of their analyses in the draft Feasibility Report-EIS.

As can be seen, there are several alternative options that other agencies use, which could enable Wildlife Services to bring its economic analysis up to the standard of other federal agencies.

Wildlife Services should stop using the Bodenchuck, et al. (2000) study as blanket economic justification for other state-level programs.

This analysis violates at least two significant principles of benefit-cost analysis that lead the Bodenchuck et al. study to both substantially over-state the benefits of predator control (e.g., using a multiplier of three on the benefit side) and understate the costs (ignoring opportunity costs).

Each state should conduct state-specific benefit-cost analysis of a wide range of alternative predator control programs ranging from lethal to several non-lethal methods.

These state-level benefit-cost analyses of predator damage management plans should be conducted with early input on design of the economic analysis from and review the Wildlife Services economists, as well as their subsequent review, to ensure sound economic analysis. This would result in more than "lip service" being paid to economics in evaluating alternatives.

When performing future economic evaluations of predator control programs:

A. A wide range of alternatives besides just "with" and "without" a predator control program should be evaluated. The "with predator management" alternatives could include the intensity of predator control methods (e.g., how frequently to perform—for example, only when there are repeated documented losses versus an occasional loss), the range of predator control methods to be used (e.g., lethal control versus other non-lethal means, relocation), etc.

B. Analyses should include a valuation of the loss of the predators that are killed when lethal control means are employed. For a more accurate benefit-cost analysis, the losses in economic benefits from reduction in predator populations should be included as either a reduction in benefits of the predator control program or as an additional cost of the program. This can be accomplished using benefit-transfer methods described above using a valuation study recommended below.

C. All costs to all parties should be included in benefit-cost analysis of predator control programs. That is, regardless of whether the benefit-cost analysis is for a county, state or federal program, the direct and opportunity costs incurred by all agencies (county, state and federal) must be included.

D. Move away from sole reliance on minimum cost methods to reduce livestock losses. Instead, include in the analysis predator control methods that may cost more and investigate whether the additional benefits to society from these higher cost methods are economically justified (i.e., incremental benefit-cost comparisons).

Conduct a prospective or ex-ante economic analysis on significant predator control management actions *before* such actions are to be selected for implementation.

For example, an economic analysis should be conducted when evaluating alternatives in state-level programmatic predator control programs to identify the most economically efficient control methods and decide at what scale to provide them. Economic evaluation of major programs should be conducted, such as was conducted by Shwiff, et al. (2008, 2010) for rabies vaccination programs. Economic analysis may also be warranted on individual predator control projects that involve killing rare and high-value species such as wolves, grizzly bears, etc.

Conduct a contingent valuation method (CVM) study of public WTP for coyotes in the western U.S.
There is presently no primary valuation information in the western U.S. on the public values of avoiding or reducing lethal control of coyotes. Hence, a CVM study on the valuation of these coyotes in the West is long overdue. There have only been a couple of surveys on coyotes, one in New England (Stevens, et al. 1991) and one in Canada (Martinez-Espineira, 2007). While these could be used until a new CVM study is completed, in the long run the agency will be on more solid ground if it completes a primary CVM study in the West. Tailoring the CVM survey to predator control would allow valuation of households' WTP to a variety of Wildlife Services scenarios: (a) killing large numbers of coyotes, as in Wyoming (e.g., 13,600 coyotes or 23 percent of the population—see Taylor, et al. 2009: 19)); (b) killing only "problem" coyotes, i.e., those that have been documented as repeatedly attacking sheep or calves; or (c) other damage control methods that are technically feasible for Wildlife Services to use on coyotes (e.g., non-lethal means). To the author's knowledge, this comparison of values associated with large numbers of coyotes in the wild versus valuation of the subset of those coyotes repeatedly attacking sheep and calves has not been made in past studies on wolves, coyotes or other predators. Existing studies such as Duffield (1992) and Duffield, et al. (1993; 2008) have valued scenarios (a) for wolf populations in the wild, while Martinez-Espineira, (2007) valued a scenario (b) for "problem" coyotes in Canada.

A well thought-out CVM survey of households living in selected western states would allow generalizing of the results to other similar western states for use in benefit-transfer to those states that were not surveyed. That is, targeting states where coyote control is most prevalent would provide direct WTP values of avoiding or reducing lethal control of coyotes. For example, surveying residents in two West Coast states (e.g., California and Oregon), two intermountain states (e.g., Nevada and Wyoming) and one desert southwest state (e.g., Arizona) would not only provide values for these states, but would also allow for benefit transfer to other states in the same socio-demographic and geographic sampling strata. Such a survey would be a worthwhile investment that could be used repeatedly for benefit-cost analysis of specific coyote removal projects.

Ideally, to ensure the study and its results cannot be faulted as biased, a neutral panel of economists experienced in conducting CVM studies and survey experts (neither of which have ties to the livestock industry or environmental organizations actively involved in predator control issues) should be selected to review the report and provide input on the study and sample design and analysis. This group could also help write the Request for Proposal (RFP) and aid Wildlife Services in reviewing the study proposals.

After this CVM study is completed, future Wildlife Services benefit cost analyses should use these values to perform a more complete economic analysis that includes the reduction in economic benefits to society from coyote control.
To estimate the lost value of wolves from predator control, the Wildlife Services should rely upon the research of Duffield and colleagues on wolves. For other species benefit transfer should be conducted where similar species non-market valuation studies have been conducted. To value the gain in big game hunting, benefit transfer from existing willingness to pay studies should be used.

Some of these recommendations can be implemented almost immediately at little cost to Wildlife Services (e.g., Recommendation #5) and several others within the next 2-3 years if the agency is serious about using economic analysis to evaluate its programs. Other recommendations may be expected to take several years to fully implement, particularly in this time of renewed scrutiny of federal program expenditures. But programming these recommendations into annual work plans, future staffing, and out-year budgets is a first step in bringing economic analyses conducted by Wildlife Services into consistency with professionally accepted benefit-cost principles and procedures used by nearly every other federal agency and implied in the Wildlife Services Strategic Plan.

In the long run, having defensible economic analysis that can honestly evaluate which programs are legitimately a high priority for funding may aid Wildlife Services in dealing with USDA and U.S. Office of Management and Budget (OMB). Incredibly high benefit-cost ratios of more than 20:1 do not always impress economists in OMB or elsewhere. Rather, they often raise suspicion that there is something questionable about the analysis. This may very well undercut the credibility of the budget request.

However, performing sound economic analysis is necessary for more than budget justification. The broader purpose of economic analysis is to ensure that scarce resources, whether budgets or wildlife, are managed to maximize benefits to society. While economics should not be the only factor considered in natural resource management, economics is frequently an issue raised by one side or another in these contentious debates over predator management. Having accurate and objective economic analysis can aid Wildlife Services in judging the validity of these claims.

References

APHIS-Wildlife Services. 2002. The Electronic Guard: A Tool in Predation Control. Factsheet. January 2002.

Bean, M. 1983. The Evolution of Wildlife Law, Revised Edition. Praeger, New York.

Berger, K.M and M. Conner. 2008. Recolonizing Wolves and Mesopredator Suppression of Coyotes: Impacts on Pronghorn Population Dynamics. *Ecological Applications* 18(3): 559-612.

Beschta, R. and W. Ripple. 2009. Large Predators and Trophic Cascades in Terrestrial Ecosystems of the Western United States. *Biological Conservation* doi10.1016/j.bicon 2009.015.

Beschta, R. and W. Ripple. 2010. Recovering Riparian Plant Communities with Wolves in Northern Yellowstone, USA. *Restoration Ecology* 18(3): 380-389.

Boardman, A., D. Greenbery, A. Vining, and D. Weimer. 2001. Cost-Benefit Analysis: Concepts and Principles, 2nd Edition. Prentice-Hall, NJ.

Bondenchuk, M., R. Mason and W. Pitt. 2000. Economic of Predation Management in Relation to Agriculture, Wildlife and Human Health and Safety. Human Conflicts with Wildlife: Economic Considerations. USDA National Wildlife Research Center Symposia. University of Nebraska, Digital Commons.

Boyd, J. and S. Banzhaf. Ecosystem Services and Government Accountingability: The Need for a New Way of Judging Nature's Value. 158 Resources 16. Resources for the Future, Washington DC.

Brent, R. 1996. Applied Cost Benefit Analysis. Edward Elgar, Cheltenham, United Kingdom.

Bromley, C. and E. Gese. 2001. Surgical Sterilization as a Method of Reducing Coyote Predation on Domestic Sheep. *Journal of Wildlife Management* 65(3): 510-519.

Brookshire, D., Eubanks, L. and Randall, A., 1983. Estimating option prices and existence values for wildlife resources. Land Economics, 59: 1-15.

Brookshire, D. and H. Neill. 1992. Benefit Transfers: Conceptual and Empirical Issues. *Water Resources Research* 28(3): 651-656.

Brookshire, D., D. Goodrich, M. Dixon, A. Brand, K. Benedict, K. Lansey, J. Thacher, C. Broadbent, S. Stewart, M. McIntosh and D. Kang. 2010. Ecosystem Services and Reallocation Choice: A Framework for Preserving Semi-Arid Regions in the Southwest. *Journal of Contemporary Water Research and Education* 144: 60-74.

Brown, T., J. Bergstrom and J. Loomis. 2007. Defining, Valuing and Providing Ecosystem Goods and Services. *Natural Resources Journal* 47(2): 330-376).

CERCLA § 301(c)(1)–(2), 42 U.S.C. § 9651(c)(1)–(2) (2000).

Chambers, C. and Whitehead, J., 2003. "A Contingent Valuation Estimate of the Benefits of Wolves in Minnesota." *Environmental and Resource Economics* 26: 249-267.

Connor, M., M. Ebinger and F. Knowlton. 2008. Evaluating Coyote Management Strategies using Spatially Explicit, individual-based, socially structured population model. *Ecological Modelling* 219: 234-247.

Daily, G. editor. 1997. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, Covelo, CA.

Donnelly, D., J. Loomis, C. Sorg, and L. Nelson. 1985. Net Economic Value of Recreational Steelhead Fishing in Idaho. Resource Bulletin RM9. Rocky Mountain Forest and Range Experiment Station, U.S. Forest Service, Fort Collins, CO.

Duffield, J., 1991. Existence and non-consumptive values for wildlife: application of wolf recovery in Yellowstone National Park. W-133/Western Regional Science Association Joint Session. Measuring Non-Market and Non-Use Values. Monterey, CA.

Duffield, J., 1992. An economic analysis of wolf recovery in Yellowstone: park visitor attitudes and values. In: J. Varley and W. Brewster (Editors), Wolves for Yellowstone? National Park Service, Yellowstone National Park.

Duffield, J., Patterson, D. and Neher, C., 1993. Wolves and people in Yellowstone: a case study in the new resource economics. Report to Liz Claiborne and Art Ortenberg Foundation. Department of Economics, University of Montana, Missoula, MT.

Duffield, J., C. Neher and D. Patterson. 2008. Wolf Recovery in Yellowstone. *Yellowstone Science* 16(1): 20-25.

Engeman, Richard, Stephanie A. Shwiff , Bernice Constantin, Margo Stahl, Henry T. Smith. 2002. An economic analysis of predator removal approaches for protecting marine turtle nests at Hobe Sound National Wildlife Refuge. Ecological Economics 42: 469-478.

Engeman, R., S. Shwiff, H. Smith and B. Constantin. 2000. Monetary Valuation Methods for Economic Analysis of Benefits and Costs of Protecting Rare Wildlfie Species from Predators. USDA National Wildlife Research Center Staff Publications. University of Nebraska, Digital Commons.

Federal Emergency Management Agency (FEMA). 2006. Mitigation BCA Toolkit, Version 3.0 CD. Also see: www.fema.gov/government/grant/bca.shtm.

Gonzalez-Caban, A. and J. Loomis. 1997. Economic Benefits of Maintaining Ecological Integrity of Rio Mameyes, In Puerto Rico. *Ecological Economics* 21: 63-75.

Goulder, L. and D. Kennedy. 1997. Valuing Ecosystem Service: Philosophical Bases and Empirical Methods. In, G. Daily, ed. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, Covelo, CA.

Jahnke, L., C. Phillips, S. Anderson and L. McDonald. 1988. A methodology for Identifying Sources of Indirect Cost of Predation Control: A Study of Wyoming Sheep Producers. *Vertebrate Pest Control and Management Materials*, 5th Volume. ASTM STP #974. S.A. Shumake and R.W., Bullard, eds. Aermican Society for Testing and Materials, Philadeliphia PA. pages 159-169.

Knowlton, F., E. Gese, M. Jaeger. 1999. Coyote depredation control: An interface between biology and management. *Journal of Range Management* 52: 398-412.

Krutilla, J. 1967. Conservation Reconsidered. American Economic Review 57(4): 777-786.

Loomis, J., J. Cooper and S. Allen. 1988. The Montana Elk Hunting Experience: A Contingent Valuation Assessment of Economic Benefits to Hunters. Montana Fish, Wildlife and Parks, Helena, MT.

Loomis, J. 1989. Test Retest Reliability of the Contingent Valuation Method: A Comparison of General Population and Visitor Responses. *American Journal of Agricultural Economics*, Volume 71(1): 76-84.

Loomis, J. D. Donnelly and C. Sorg-Swanson. 1989. Comparing the Economic Value of Forage on Public Lands for Wildlife and Livestock. *Journal of Range Management* 42(2):

Loomis, J., M. Creel and J. Cooper. 1989. Economic Benefits of Deer in California: Hunting and Viewing Values. Institute of Ecology Report #32, University of California, Davis, CA.

Loomis, J., D. Updike, C.W. Unkel, 1989. The Consumptive and Nonconsumptive Values of a Game Animal: the Case of California Deer. Transactions of 54th North American Wildlife and Natural Resources Conference. Wildlife Management Institute, Washington DC.

Loomis, J. 1990. Comparative Reliability of the Dichotomous Choice and Open Ended Contingent Valuation Techniques. *Journal of Environmental Economics and Management*, Volume 18(1).

Loomis, J. 1996. Measuring the Economic Benefits of Removing Dams and Restoring the Elwha River: Results of a Contingent Valuation Survey. *Water Resources Research*, 32(2):441-447.

Loomis, J. and R. Walsh. 1997. *Recreation Economic Decisions: Comparing Benefits and Costs*. 2nd, Edition. Venture Publishing, State College, PA.

Loomis, J. Paula Kent, Liz Strange, Kurt Fausch, and Alan Covich. 2000. Measuring the Total Economic Value of Restoring Ecosystem Services in an Impaired River Basin: Results from a Contingent Valuation Survey. *Ecological Economics*. 33, pp. 103-117.

Loomis, J. 2005. Updated outdoor recreation use values on National Forests and other public lands. PNW-GTR-658, Pac. NW Research Station, USDA Forest Service, Portland, OR. 26 pp.

Loomis, J. and L. Richardson. 2007. Technical Documentation of Benefit Transfer and Visitor Use Estimating Models of Wildlife Recreation, Species and Habitats. Dept. of Agricultural and Resource Economics, Colorado State University, Fort Collins, CO.

Martinez-Espineira, R. 2007. Adopt a Hypothetical Pup: A Count Data Approach to Wildlife Valuation. *Environmental and Resource Economics* 37:335-360.

Mech, D., S. Fritts, and M. Nelson. 1996. Wolf Management in the 21st Century: From Public Input to Sterilization: Alternative Methods of Alleviating Wolf Damages. *Journal of Wildlife Research* 195-198.

National Research Council. 2004. Valuing Ecosystem Services. http://www.nap.edu/openbook.php?isbn=030909318X.

OPA 33 USC § 2701 et. seq.

Peterson, G., C.Sorg-Swanson, D. McCollum and M. Thomas, eds. 1992. Valuing Wildlife Resources in Alaska.Westview Press, Boulder, CO.

Prugh, L., C. Stoner, C.Wpps, W. Bean, W. Ripple, A. Laliberte and J. Brashare. 2009. The Rise of the Mesopredator. *BioScience* 59(9): 779-791.

Rashford, B., J. Grant and B. Strauch. 2008. Economics of Predator Control to Protect Agriculture: The Unanswered Questions. *Western Economic Forum*. Fall 2008: 25-31.

Reiling, S., K. Boyle, M. Phillips and M. Anderson. 1990. Temporal Reliability of Contingent Values. Land Economics 66(2): 128-134.

Richardson, L. and J. Loomis. 2009. The Total Economic Value of Threatened, Endangered and Rare Species: An Updated Meta-analysis. *Ecological Economics* 68: 1535-1548.

Rosenberger, R. and J. Loomis. 2001. Benefit Transfer of Outdoor Recreation Use Values: A Technical Document Supporting the Forest Service Strategic Plan (2000 Revision). Generation Technical Report RMRS-GTR-72. Rocky Mtn Research Station, USDA Forest Service, Fort Collins, CO.

Sassone, and Schafer. 1978. Handbook for Cost-Benefit Analysis. Academic Press, San Diego, CA.

Schuman, P. and K. Schwabe. 2000. Fundamentals of Economic Principles and Wildlife Management. Human Conflicts with Wildlife: Economic Considerations. USDA National Wildlife Research Center Symposia. University of Nebraska, Digital Commons.

Shivik, J. 2004. Non-lethal Alternatives to Predator Management. *Sheep and Goat Research Journal* 19: 64-71.

Shwiff, S. 2004. Economics in Wildlife Damage Management: Common Problems and Some Solutions. USDA National Wildlife Research Center Staff Publications. University of Nebraska, Digital Commons.

Shwiff, S. 2011. Personal Communication. June 10.

Shwiff, S. and R. Merrell. 2004. Coyote Predation Management: An Economic Analysis of Increased Antelope Recruitment and Cattle Production in South Central Wyoming. *Sheep and Goat Research Journal* 19: 29-33.

Shwiff, S.,K. Kirkpatrick, R. Sterner. 2008. Economic Evaluation of an Oral Rabies Vacinnation Program for Control of a Domestic Dog-Coyote Epizootic: 1995-2006. JAVMA 233(11): 1736-1741.

Shwiff, S., C. Nunan, K. Kirkpatrick and S. Shwiff. 2010. A Retrospective Economic Analysis of the Ontario Red Fox Oral Rabies Vaccination Programme. *Zoonoses and Public Health*.

Smith, R. , D. Neff, and N. Woolsey. 1986. Pronghorn Response to Coyote Control—A Benefit: Cost Analysis. Wildlife Society Bulletin 14: 226-231.

Sorg, C. and J. Loomis. 1984. Empirical Estimates of Amenity Forest Values: A Comparative Review. General Technical Report RM107. Rocky Mountain Forest and Range Experiment Station, U.S. Forest Service, CO, March 1984.

Stevens, T., Echeverria, J., Glass, R., Hager, T. and More, T., 1991. Measuring the existence value of wildlife: what do CVM estimates really show? Land Economics, 67: 390-400.

Stevens, T., T. More and R. Glass. 1994. Public Attitudes about Coyotes in New England. Society and Natural Resources 7(1): 57-66.

Taylor, D., B. Rashford, R. Coupal and T. Foulke. 2009. An Economic Analysis of Predator Management in Wyoming. Dept of Agricultural and Applied Economics, University of Wyoming.

US Department of Agriculture. 2008. USDA Announces New Office of Ecosystem Services and Markets. Press Release # 0307.08, December 18, 2008. http://www.usda.gov/wps/portal/usda/usdahome?contentidonly=true&contentid=2008/12/0307.xml.

USDA Forest Service. Ecosystem Services. 2010. http://www.fs.fed.us/ecosystemservices/. Updated March 10, 2010.

U.S. Department of Interior (USDOI). 1994. Natural Resource Damage Assessments; Final Rule. 43 CFR Part 11. Federal Register 59(58): 14262-14288.

U.S. Department of Transporation. Economic Analysis Primer: Benefit-Cost Analysis. http://www.fhwa.dot.gov/infrastructure/asstmgmt/primer05.cfm.

U.S. District Court of Appeals for the District of Columbia Circuit. 1989. State of Ohio vs US. Department of Interior, et al. Cases # 86-1529 and # 86-1575. July 14, 1989.

U.S. Environmental Protection Agency. 2000. Guidelines for Preparing Economic Analyses. September 2000. Washington DC.

U.S. Fish and Wildlife Service, 1994. The reintroduction of gray wolves to Yellowstone National Park and central Idaho: Final Environmental Impact Statement. Helena, MT, pp. 4.21-4.27.

U.S. Fish and Wildlife Service. *2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation*. Washington, D.C., 2002.

U.S. General Accounting Office. 1995. Animal Damage Control Program. GAO-RECED 96-3. Resources, Community and Economic Development Division, Washington DC.

U.S. General Accounting Office. 2001. Wildlife Services Program. GAO-02-138. Washington, DC.

U.S. Office of Management and Budget. 1992. Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs. Washington DC. Available at http://www.whitehouse.gov/omb/circulars_a094.

U.S. Office of Management and Budget. 2000. Guidelines to Standardize Measures of Costs and Benefits and the Format of Accounting Statements. M-00-08, from Jacob Lew, Director. Washington DC.

U.S. Supreme Court. Hughes v. Oklahoma, 441 U.S. 322 (1979).

U.S. Supreme Court. State of Missouri v. Holland, 252 U.S. 416 (1920).

U.S. Water Resources Council. 1983. Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. U.S. Government Printing Office, Washington DC. March 10, 1983. http://www.usace.army.mil/CECW/Documents/pgr/pg_1983.pdf.

Varian, H. 1990. Intermediate Microeconomics: A Modern Approach, 2nd Edition. W.W. Norton and Company, New York, NY.

Welsh, Michael P., Richard C. Bishop, Marcia L. Phillips, and Robert M. Baumgartner. 1995. *Glen Canyon Dam, Colorado River Storage Project, Arizona—Nonuse Value Study Final Report*. Madison, Wisconsin: Hagler Bailly Consulting, Inc., September 8, 1995, pp. 400. Springfield, Virginia: National Technical Information Service, NTIS No. PB98-105406.

Whitehead, J., 1991. Economic values of threatened and endangered wildlife: a case study of coastal nongame wildlife. In: Transactions of the 57th North American Wildlife and Natural Resources Conference, Wildlife Management Institute, Washington, DC.

Whitehead, J., 1992. Ex ante willingness-to-pay with supply and demand uncertainty: implications for valuing a sea turtle protection programme. Applied Economics, 24: 981-988.

Wilson, M. and S. Carpenter. 1999. Economic Valuation of Freshwater Ecosystem Services in the United States 1971-1997. *Ecological Applications* 9(3): 772-783.

Woodward, R. and Y.S. Wui. 2001. The economic value of wetland services: a meta analysis. *Ecological Economics* 37: 257-270.

Young, Robert. 2004. Determining the Economic Value of Water: Concepts and Methods. Resources for the Future Press. Washington DC.

Endnotes

1 Animal Damage Control Act of March 2, 1931, 46 U.S. § 1468, provided broad authority for investigation, demonstrations and control of mammalian predators, rodents and birds.

2 With the rest of the agency's costs paid for by a combination of State and local governments, or by private associations or individuals.

3 Unless there had previously been substantial and persistent unemployment of the workers *employed in this project for the duration of the project*, labor is considered a scarce and costly resource to society. Employing more workers in one project means those works are not available for another project. The same is true with production in one part of the country versus another. As Young (2004) notes, spending the government funds on projects other than the one under study (here predator control) will also generate multiplier effects. The question is, what is the net gain from spending government funds on this project, as the multiplier effects will be similar for a given expenditure of government funds.

4 The mention of these company names should not be interpreted as an endorsement of these firms by the author or NRDC over other equally well qualified and experienced firms in these fields. A full, open Request for Qualifications or Request for Proposal should be undertaken by Wildlife Services if it should decide to go this route.