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PART 1 - COST EFFECTIVE SOLUTIONS: INCORPORATING WILDLIFE PASSIVE USE VALUES IN COLLISION MITIGATION BENEFIT-COST CALCULATIONS

September 2019

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Incorporating wildlife passive use values in collision mitigation benefit-cost calculations

Final Task Report

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Abstract

This document is a task report for a larger Wildlife Vehicle Collision (WVC) Reduction and Habitat Connectivity pooled fund study. It addresses the potential use of passive use economic values for wildlife to inform the mitigation of wildlife-vehicle collisions. Passive use, also known as non-use values, are the values individuals place on the existence of a given animal species or population as well as the bequest value of knowing that future generations will also benefit from preserving the species. This report provides a summary of the current literature of wildlife passive use value estimates and provides per-animal passive use values for selected species and populations. Additionally, an example of applying these values to a Montana road segment is outlined. Finally, a discussion of regional economic impacts of mitigation structure spending is outlined.

Summary

This report addresses the potential use of passive use economic values for wildlife to inform the mitigation of wildlife-vehicle collisions. Passive use values, also known as non-use values, are the values individuals place on the existence of a given animal species or population, as well as the bequest value of knowing that future generations will also benefit from preserving the species.

In past studies the values associated with collision avoidance related to the injured/killed animals have been limited to easily identifiable direct use values of the animals, such as the value of the animal to humans as a species for hunting. The second component of wildlife value, which has previously not been included in the analysis of the cost-effectiveness of mitigation measures, is passive use value for the animals. This report provides a summary of the current literature of wildlife passive use value estimates and provides per-animal passive use values for selected species and populations. Additionally, an example of applying these values to a Montana road segment is outlined. Finally, a discussion of regional economic impacts of mitigation structure spending is presented.

Sources of currently available passive use values

Given the broad diversity of species potentially impacted by road collisions, combined with a large spectrum of geographic settings, the current literature on wildlife passive use values potentially involved in collisions is spotty, at best. Several dozen species-specific passive use value estimates are found in the literature, but there are many gaps associated with species most at-risk in road collisions. To indicate the approximate scale of this literature, we provide in Appendix B a summary table from one of the better literature reviews (Richardson and Loomis 2008) which covers 22 species with a little over 60 estimates; however, only three of the species valued are terrestrial animals and most are marine mammals, freshwater fish, and birds. A 2018 literature review identifies 80 unique estimates, but the additional studies are mostly from other countries. In order to derive a specific passive use value for a species-location combination of interest, there are five possible sources of the values: using an available previously estimated value for that species-location pairing; conducting original valuation research or using an existing recent value estimate for the same species-location pairing; using benefit transfer to apply a passive use value from a separate, but similar, species/setting to the setting of interest; using a meta-analysis model to predict passive use values for a species or group of species based on a set of underlying original passive use value estimates; and using public policy spending decisions as a proxy for passive use values for a species.

Additionally, Appendix A provides a more extensive discussion of wildlife valuation concepts and methods, including types of values, drawing on the economics literature and a National Research Council 2005 panel report on valuing ecosystem services entitled *Valuing Ecosystem Services: Toward Better Environmental Decision Making* (Washington, D.C. National Academies Press).

While there do not appear to be cases where federal or state agencies have relied on passive use values for transportation infrastructure, there is a precedent of prior reliance on passive use value estimates in other wildlife and infrastructure settings as also discussed in Appendix A. This includes the use of passive use values for wildlife and fisheries to inform management of major water resource developments including Glen Canyon Dam on the Colorado River. In this case, hydroelectric production had impacted endangered fish and the riparian ecosystem for 250 miles of the Colorado through Grand Canyon National Park. In 1996, then Secretary of the Interior, Bruce Babbitt, signed a Record of Decision that limited hydropower operations to benefit ecosystem services. He noted that while changes in hydropower operations would result in losses of between $5.1 and $44.2 million per year in hydropower benefits, nonuse value studies

indicate that "the American people are willing to pay much more than this loss to maintain a healthy ecosystem in the Grand Canyon".

Passive use values have also informed the decision to remove some dams in the Western U.S. Elwah, and Glines Canyon dams on the Elwah River in and on the boundary of Olympic National Park were recently removed to restore historic salmon runs. The entire system of dams on the Klamath River including Iron Gate, J.C. Boyle, and Copco 1 and 2, are under consideration for removal, based in part on a Department of Interior passive use value study. One of the earliest passive use value studies (Duffield 1982) estimated the potential foregone value of a large falls, significant fishery, and whitewater that would be impacted by a proposed hydroelectric dam on the Kootenai River. In this case, only the second time the Federal Energy Regulating Commission (FERC) has ever rejected a proposed major hydropower project, the Administrative Law Judge explicitly ruled that "these indirect values are an important aspect of the decision that no license should be issued."

Passive use values have also been estimated for natural resource damage assessments of major oil spills and toxic releases, including the Exxon Valdez oil spill in Alaska. Passive use value studies and contingent valuation methods are explicitly authorized under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or "Superfund") and the Oil Pollution Act of 1990, and they were recently applied to the Deepwater Horizon oil spill in the Gulf of Mexico.

Estimates of Species and Population-Specific Passive Use Values

A goal of this analysis was to provide specific values associated with passive use of elk, wolves, grizzly bear, and one smaller terrestrial threatened or endangered species. The summary table outlines estimated per-animal passive use values for these species that have been derived and estimated from existing wildlife studies and other data.

Elk

A 1989 survey of Yellowstone National Park visitors provided data necessary to estimate per-elk passive use values as well as per-elk viewing values for the elk/YNP visitor pairing. Questions on park visitor willingness to donate to a trust fund set up to secure winter range for park elk adequate to protect 4,000 elk implied a marginal passive use (protection of species) value for elk by YNP visitors of nearly $37,000 per elk in 2019 dollars.

The same 1989 survey of park visitors as well as a 1990 survey developed a model of visitor willingness to pay for trips to Yellowstone. This model, along with a covariate that indicated whether elk had been seen on the trip, provided data used to estimate park visitor willingness to pay to see an elk on their park trip. This viewing value is estimated to be $17,227 per-elk in 2019 dollars based on a modeled wolf-predation related reduction of 2700 elk per year continuing over 20 years.

Wolves

Two estimates associated with passive use values for wolves in the Northern Rockies are presented. The first is based on a national household phone survey conducted in conjunction with the environmental impact statement (EIS) evaluating the reintroduction of wolves to Yellowstone NP and Central Idaho. In the context of reestablishing a population of 100 wolves in YNP, the net national passive use value per wolf was $1.2 million in study year dollars (1993) and in 2019 dollars is estimated to be just over $2.0 million per wolf. This <u>net</u> value considers both those in the sample who were willing to donate to support wolf reintroduction as well as those willing to donate to oppose the reintroduction. Within the much smaller 3-state region surrounding the park (ID, MT, and WY), the net passive use value for wolf reintroduction to Yellowstone NP was $22,300 per wolf (2019 dollars). The difference between these two values ($2.0

million and $22,300 per wolf) reflects that the national passive use value ($2 million) includes values for a much larger population of households, and that support/opposition for wolf reintroduction to YNP was much more evenly split in the smaller 3-state region than in the nation as a whole, where there was strong support for the reintroduction.

A 2005 year-round survey of Yellowstone NP visitors provides an estimate of passive use values associated with protecting wolves outside the park though funding a livestock compensation depredation fund. This park visitor survey placed a passive use value on the current recovery level of around 400 wolves in the Yellowstone recovery area but outside the park at $56,500 per wolf (2019 dollars).

Grizzly Bears

A 1996 regional and national household phone survey was undertaken in conjunction with a USFWS EIS process on reintroduction of grizzlies to the Bitterroot Wilderness Area of Central Idaho and Western Montana. This survey provided a passive use value for reestablishment of a population of 280 grizzlies in the wilderness area. The estimated passive use value per grizzly from this study in 2019 dollars is $4,133,000. The 95 percent confidence interval on this estimate is $3,311,700 to $4,955,600.

Desert Tortoise

A final species examined was the threatened desert tortoise. Two sources of passive use values for this species were examined. The first value source used a previously estimated meta-analysis model of passive use values for threatened and endangered species to predict the value associated with a specific species group (threatened reptiles). This estimate of national passive use value is $8,200 per desert tortoise (2019 dollars).

A second estimate for the tortoise came from the demonstrated value placed on species protection in the case of a large solar energy installation in the species critical habitat. Based on available information on mitigation spending and tortoises impacted, this spending decision implies a passive use value of $7,900 per tortoise for species protection. Although derived from very different data sources, the two estimates for the desert tortoise are similar.

As noted, there are not a lot of prior passive use studies and value estimates for terrestrial species. The applicability of the values presented is largely for specific locations and sub-populations of a given species. Future research on passive use values for other species and locations would be useful. It may also be that the passive use values summarized here are conservative in that besides existence and bequest motives, specifically for mitigation of wildlife-vehicle collisions, some individuals may also value just the more humane and respectful treatment of animals associated with mitigation.

Location and Population-specific Application of Passive Use Values

A plausible example where increased connectivity due to mitigation would result in an increased wildlife population and associated passive use values is the Ninepipes section of Highway 93 North in Western Montana between the towns of St. Ignatius and Ronan. This 13.7-mile section of road was partially mitigated. However, a substantial unmitigated section of highway crosses through wetlands on the valley floor where grizzly bears come out of Mission Mountains on the western edge of the Northern Continental Divide ecosystem (NCD).

This road section is a particularly active crossing area for grizzly bears in the NCD grizzly recovery zone. Between 2004 and 2017 ten grizzlies were killed in collisions on this road stretch. Most of these mortalities are in wetlands or stream crossings including the Ninepipes/Kicking Horse area and the Crow Creek and Post Creek crossings. In the most recent year, 2018, a record of six certain and 2 possible grizzly deaths occurred on the stretch of road. Over the 15 years from 2004 to 2018, an average of 1.26 grizzly bears a year have been killed on this 13-mile stretch of road, but in the last three years there have been more than 3 per year.

An estimate of per-animal passive use value for grizzly bears from the previously noted EIS study of recovery of 280 bears to the Bitterroot Mountains found a passive use value of approximately $4.13 million per grizzly. The Bitterroot Ecosystem is one of six grizzly bear recovery areas in the lower 48 states; the others are the greater Yellowstone area, the NCD (including Glacier National Park and the Bob Marshall Wilderness complex), the Cabinet-Yaak, the Selkirk Mountains, and the North Cascades. The grizzly bears being killed on Highway 93 are in the NCD recovery area which includes the Mission Mountains east of the highway. These mountains are largely in the federally designated Mission Mountain Wilderness and the Mission Mountains Tribal Wilderness, designated by the Confederated Salish and Kootenai in 1979. This is the first and only tribally-designated wilderness in the United States.

The total recovery area has a grizzly population of about 1,000 bears, though one might consider the population in the somewhat isolated Mission Mountains to be more relevant here. In any case, employing benefit transfer to use the Bitterroot recovery area value to conservatively value an individual bear in another lower 48 states recovery area, the NCD (but using a population of 1,000 bears rather than Bitterroot's 280 bears), would imply a passive use value per bear of $1.16 million, all other factors being equal.

Because the NCD grizzly population has increased over the last fifteen years, a shorter-term averaging period might be more appropriate to current population levels and for projecting expected mortality into the future.

Using average annual mortality of 1.26 to 3.0 grizzly bears per year, passive use values for grizzlies in a specific road section results in expected passive use costs associated with grizzly bear deaths on the 13.7 mile Ninepipes section of Highway 93 have accounted for from $1.5 million in losses in value per year based on the 15 year average mortality to at least $3.5 million per year based on the recent three year average grizzly bear mortality per year. Using this range of annual values, the present discounted value of mitigation structures that would increase connectivity and fully prevent these deaths over the next 25 years (at, for example, a 7.0 percent real interest rate) is 17.5 million to $40.8 million.

This estimate would apply to mitigation actions that would limit mortality, such as fencing. The per-bear values could also be used to estimate the benefits of connectivity, such as through wildlife crossing structures. For this, one would need to know the wildlife biology basis for how much the NCD grizzly population would increase if bears had increased connectivity (safe access) to the habitat west of Highway 93 in the Mission and Flathead Valleys and perhaps further west into the Ninemile-Reservation divide, the Ninemile Valley, and perhaps into the Bitterroot Mountains.

In an actual application one would use the same financial parameters as the construction cost analysis including the life-time planning horizon for the specific infrastructure, the actual extent of expected level of mitigation of the grizzly mortality in the Ninepipes section of Highway 93, and the same cost of capital (or real discount rate).

Estimating the wildlife-related benefits of mitigation structures for the Ninepipes section of Highway 93 North based only on direct use values for these grizzly bears (viewing and, perhaps in the future, hunting) would badly understate total benefits. This plausible example demonstrates that incorporation of passive use values has the potential to substantially increase the reliability of benefit-cost or other financial analysis of increased connectivity and reduced mortality for high profile keystone species. This certainly seems to be the case for the incorporation of passive use values for wildlife into an analysis of wildlife mitigation infrastructure for grizzly bears and other wildlife on the 13.7-mile Ninepipes section of Highway 93 north between St. Ignatius and Ronan.

The species passive use values reported are based on specific studies and differ in several regards which may impact estimated values. Species studied in protected landscapes (such as Yellowstone NP) likely have a significantly higher value than the same species might have in a less "unique" and high-profile setting. For instance, while passive values for a species in a protected park might be quite high, in another setting where the species is hunted as a game animal, the passive use values for the species might be very low or even zero, and that setting the species' value would be dominated by any "direct use" values (such as for hunting). The methodology of a passive valuation study can also impact estimated values. For instance, use of hypothetical questions on willingness to donate to a conservation trust fund for an animal may lead to higher stated values than asking people about their willingness to pay a tax to protect a species in a particular setting. In the case of values based on stated willingness to donate to a fund, it might be appropriate to calibrate the estimated species value to account for potential over-statement of true willingness to pay for species protection. This was done in the case of wolves and grizzlies in this analysis. Overall, care must be taken to understand the specific settings and methods used to value a species, and to ensure those factors are consistent and appropriate for any benefit-cost analysis application.

Summary Table: Estimated Per-animal Values, by Species.

Species	Setting	Basis of Value Estimate	Original Value per-animal	2019 Value per-animal
Elk-Passive use	1989 survey of Yellowstone visitors (Duffield 1991)	Donation for winter range for 4,000 elk; contingent valuation	$18,325 ($1989)	$36,925
Elk-Viewing	1989-1990 survey of Yellowstone visitors (Duffield 1991)	Increased value per trip (contingent valuation)/per elk in population	$8,802 ($1989-90)	$17,230
Wolves-Passive use in a protected area	1993 national value per household for wolf recovery in Yellowstone (USFWS 1994)	Contingent valuation donation for recovery of 100 wolves	$1,180,500 ($1993) - National net value $13,100 – Regional (ID MT WY) net value	$2,002,700 National; $22,300 Regional
Wolves-value outside Yellowstone	2005 survey of Yellowstone visitors (Duffield et al. 2006)	Contingent valuation donation to compensation fund for livestock depredation (400 wolves)	$42,910 ($2005)	$56,427
Grizzly Bear-Passive use	1996 Regional and National household survey on Grizzly reintroduction (USFWS 2000)	Contingent valuation donation for recovery of 280 grizzly in Bitterroot Ecosystem	$2,578,800 ($1996)	$4,133,000
Desert Tortoise (1)	National value per household (Amuakwa-Mensah et al. 2018)	Meta-analysis model for threatened reptile/passive use value	$7,610 ($2015)	$8,179
Desert Tortoise (2)	ESA project mitigation costs	Costs to protect species at Ivanpah Solar facility/passive use value	$7,282 ($2014)	$7,883

Regional Economic Impacts of Mitigation Structure Spending

A final aspect of the economic impact of collision mitigation spending involves the regional economic impact of construction spending. This road construction spending has indirect and induced benefit to local economies in terms of personal income and associated employment.

There are a number of essential steps involved in conducting any regional economic impact analysis. These steps can be summarized as follows.

The most commonly used predefined economic areas utilized in regional economic analyses are an individual county, groups of counties, or individual states. For the following example, we have chosen two Montana counties that represent a range from a very economically small county to a large one. In the context of regional economic modeling, the size of the county is gauged in terms of the economic diversity and complexity of the county. A larger and more economically complex county will see a larger share of structure spending occur with businesses and employees already located within the county, and accordingly, the add-on indirect and induced multiplier effects of the original direct spending will be larger if the analysis area is larger and more complex . County level models were not readily available for the counties where construction took place, Lake and Missoula. For this example, IMPLAN models (a regional economic modeling tool) were available for Sanders and Yellowstone counties, including indirect and induced output, employment, and income multipliers. Sanders is one of the smallest and least developed Montana counties, while Yellowstone has the largest regional economy of any county in the state.

The two example counties used in this analysis actually represent the likely range of economic complexity and size for counties in the generally rural Western U.S. Sanders County has a population of just over 11,000 and a total Gross Regional Product of goods and services produced of roughly $250 million per year. At the other end of the spectrum is Yellowstone County (the largest county in Montana, including the city of Billings) with a population of 159,000 and a total annual output of goods and services that is roughly 40 times greater than that of Sanders County, at $10 billion. The IMPLAN system utilizes economic data specific to a defined region (such as a county) within its modeling of spending impacts. The larger and more diverse and complex an economic area is, the larger the “spin-off” indirect and induced impacts of spending will be to other nearby areas that have a greater scope of available economic inputs including goods, services, and specialized labor skills.

As an example, the new economic activities being modeled in the IMPLAN analyses are the actual costs associated with construction of wildlife crossing structures in the year 2010 along the Highway 93 corridor near Evaro, MT, Finley Creek, and Schley Creek. The costs were drawn from Table J1, page 143 of the US 93 North Wildlife Mitigation Final Report. The total wildlife mitigation costs in the year 2010 were $4.8 million. The next step is to map estimated direct spending/employment associated with the new economic activity into the most appropriate of the 536 predefined IMPLAN economic sectors. For this example, the economic sector examined within the IMPLAN modeling framework was Sector 56 “Construction of New Highways and Streets.” All mitigation structure spending falls neatly within this pre-defined sector. Next, one defines the time horizon of the activity. In this case, the construction is assumed to be completed in one year and the analysis year is 2010.

The last step is to run the I-O model to estimate the direct, indirect and induced impacts to employment, income, value-added and output, which are the basic financial parameters that define the scale of a given regional economy. In the following report, several detailed output tables are presented with a matrix of location and financial parameters. For purposes of this summary, it is useful to just note a substantial difference in the economic impact of the modeled $4.8 million in construction spending in Sanders versus Yellowstone Counties. With respect to employment, the one-year total impact in Sanders was 38.9 jobs compared to 49.3 in Yellowstone. Sanders and Yellowstone labor income totaled $1.4 million and $2.8 million and the impact on total economic output was $6.0 million and $8.3 million respectively. These results roughly bracket the likely impact across a range of Montana county-level economies for this $4.8 million in direct construction spending.

It is clear from the comparison of the two county models that the larger and more diverse Yellowstone County captures a much larger share of the indirect and induced effects of the original mitigation spending. Additionally, a larger share of income and value added is also captured in the larger county. Overall, total effects on labor income in the larger (Yellowstone) County are two times those in Sanders County. Employment in the Yellowstone County model is roughly 27% greater than in the case of the Sanders County Model. This is basically because Yellowstone County has a larger share of the physical inputs and contractors and workers with the skills to participate in a road construction project relative to the much smaller Sanders County.

While impacts to the local area economy are undeniably larger in larger, more-complex economic areas, it is important to note that in both counties the total regional economic impacts of the original mitigation spending contribute substantially to the area's employment, income and total output.

Regional economic impact modeling (such as with the IMPLAN modeling platform) is commonly used in the context of modeling impacts on employment and income of local area spending, such as in the previous example. A second use of the model, however, is to estimate the local area economic impacts associated with wildlife viewing expenditures (a non-consumptive recreational use of wildlife) or hunter spending (a direct consumptive use).

An example of the substantial benefits associated with one species/population comes from estimates of the direct annual visitor spending by visitors to Yellowstone NP specifically to view and/or hear wolves (Duffield, Neher and Patterson 2006). Duffield et al. conducted a year-long survey of YNP visitors on the issue of wolf viewing (among other issues). Responses from this survey indicated that visitors who would not have visited the park if wolves were not present spend an estimated $35.5 million per year in the 3-state economy (ID, MT, and WY) while on their trips to the park. Incorporating this estimate within an IMPLAN regional impact model of the 3-state economy results in an estimate that the wolf-related tourist spending within the greater Yellowstone ecosystem accounts for over $60 million dollars in total output of goods and services, and 1,460 jobs in the economy annually. While the high-profile nature and setting of the Yellowstone wolf example makes it somewhat unique, these results also clearly demonstrate that protection of a species in a local area through mitigation measures can be directly tied to additional substantial spending and employment spin-off impacts associated with wildlife viewing activities or other direct recreation such as hunting.

CHAPTER 1

Introduction

This report addresses the potential use of passive use economic values for wildlife to inform the mitigation of wildlife-vehicle collisions. Passive use values for wildlife, also known as non-use values, are the values individuals place on the existence of a given animal species or population as well as the bequest value of knowing that future generations will also benefit from preserving the species in future years. This analysis by Bioeconomics, Inc., a Missoula, MT natural resource economics firm, was under a contract to the Western Transportation Institute at Montana State University. The overarching task associated with this contract is defined as to "provide rationale for and provide economic values for large ungulates, carnivores and one or more small animal species (amphibians, reptiles, small mammals (smaller than coyote) that are threatened or endangered" within the context of analyzing the costs and benefits associated with implementing wildlife collision avoidance and mitigation measures.

The core objective of the analysis is to present estimates for the following:

1. Passive use value for elk (value calculated per individual elk)
2. Passive use data for wolves (value calculated per individual wolf).
3. Optional: Passive use data (based on existing data) for grizzly bear (value calculated per individual grizzly bear).
4. Passive use data for one or more small threatened or endangered species such as an endangered turtle species, desert tortoise, or California tiger salamander.
5. Direct economic viewing benefits for elk (value calculated per individual elk).
6. Application of individual passive use value for a species to a setting where mitigation could improve connectivity or otherwise increase a population by one or more animals.
7. Example demonstration of mitigation construction project regional economic impact on employment and income.

Conservation and other advocacy organizations demonstrate that individuals in the economy attach an economic value to such things as preserving endangered species, open space, wild rivers, and wilderness areas. This economic value is demonstrated through the simple fact that individuals are willing to donate money to organizations working toward these goals. Some of this demonstrated value is due to the fact that people want the possibility of "using" the resources they are paying to help preserve through direct use activities such as hiking, hunting, or wildlife viewing. Some people, however, may never intend to make any direct use of a given resource, but still attach a value to the preservation of that resource. They may hold this value for a number of reasons: 1) they may want to preserve the resource for future generations (bequest value); 2) they may want to hold open the option to use the resource in some way in the future (option value); or 3) they may simply feel that preservation of a resource or species is the right thing to do, and thus attach a value to its existence or viability (existence value). The term passive use values as used in this paper includes any or all of these possible motives. The general concept of passive use and these various motives and the possible importance of these values for conservation were described in a seminal paper by Krutilla (1967).

People demonstrate their passive use value in the marketplace by contributing to organizations such as the Nature Conservancy, Ducks Unlimited, or Defenders of Wildlife. When an individual contributes to the

World Wildlife Fund to protect pandas in China, which they themselves almost certainly may never see, it is evidence of passive use values. However, whether people enjoy existence values of resources is not contingent upon whether they donate money to support a cause. The fact that some people are willing to donate money is just the most obvious manifestation of these passive use values.

Given that passive use values exist, the problem facing economists is how to measure these values without actually collecting the monetary equivalent from the relevant human population. The primary technique used in this analysis, contingent valuation (which essentially amounts to conducting surveys and asking people what they are willing to pay for something), is the only method available to economists to measure passive use values directly. This method has been used in hundreds of applications in the last several decades. Contingent valuation is recognized by governmental regulatory agencies such as the Department of Interior, U.S. Fish and Wildlife Service, National Park Service, and National Oceanic and Atmospheric Administration as the appropriate tool for use in measuring passive use values.

The report is organized in three main sections: 1) Discussion of the theory and methods and literature associated with wildlife valuation; 2) Presentation of per animal direct and passive use values for elk, wolves, and other small T&E species; and 3) Discussion of the regional economic impacts on employment and income associated with construction and maintenance of wildlife mitigation structures as well as providing an example of modeling these impacts.

CHAPTER 2

Purpose and Need for Wildlife Valuation Estimates in the Context of Collision Mitigation Research

Wildlife-vehicle collisions and the associated damage and economic costs that result have been increasing in recent years (Huijser et al. 2009). Damage caused by collisions with large ungulates (deer, elk, and moose) represent substantial costs in terms of vehicle damage as well as human injury and death. In ongoing efforts to mitigate these collision-caused damages and costs, there has been significant research aimed at identifying and estimating the extent of these collision costs in recent years (see Huijser et al. 2009 for a review of this literature). Associated with understanding the scale and costs of the wildlife-collision problem has been research on the effectiveness, and specifically the cost-effectiveness of collision mitigation measures. While the costs of adopting or constructing collision mitigation structures are generally easily measured, estimating the benefits of successful mitigation measures is less so. Factors necessary to understand the benefits of collision mitigation include considerations of the type of animal(s) involved in collisions; average costs associated with vehicle damage, human injury and death; as well as any lost value of the animal killed. These benefit-cost estimations have been presented and discussed both in a generalized example (Huijser, et al. 2009) and in relation to specific road sections and mitigation projects (Huijser et al. 2016).

In past studies the values associated with collision avoidance related to the injured/killed animals have been limited to easily identifiable direct use values of the animals, such as the value of the animal as hunting prey. A second component of wildlife value heretofore omitted from the cost-benefit analysis of the cost-effectiveness of mitigation measures is passive use value for the animals.

CHAPTER 3

Preliminary Estimation of Marginal Passive Use Benefits for Select Species

Given the diversity of potential species impacted by wildlife-vehicle collisions, and the relative scarcity of previously conducted passive-use value studies producing valuation estimates for individual terrestrial species, there are obvious challenges to providing passive use values from current data at the species and location level of detail. In general terms, there are five potential sources of wildlife valuation estimates.

1. Use of a previously estimated passive use value for the species in the setting desired.
2. Benefit transfer: use of an estimate from a different setting, location, or even species as an appropriate proxy for an existing location and species-specific estimate.
3. Meta-Analysis: use of a valuation estimate derived from a larger comprehensive meta-analysis of existing species valuation studies.
4. Original valuation study specific to the species/population at issue.
5. Government expenditure decisions that reveal a minimum value for a given resource.

As noted, a range of estimates and methods for deriving estimates relative to the species of interest in this analysis exist. This section discusses the existing data and passive valuation estimates for four specific species (elk, wolves, grizzly bears, and the desert tortoise).

Several researchers have noted the challenges associated with estimating marginal passive use values per animal for a species. In a recent review of studies of non-market valuation of threatened species, Pandit et al. (2015) found that "Many studies found that non-market values were sensitive to population size. Marginal WTP often decreased when populations increased above their minimum viable population sizes, consistent with commonly observed result of diminishing marginal utility with increasing consumption of a good." (p. 9)

A straightforward method of estimating value per-animal from value per-person (or more commonly, per-household) is to multiply the value per-household by the number of households in the relevant geographic area of concern (often national for a nationally-listed or high-profile species), and divide that value by the population (or subpopulation) size of the given animal. Given the result that value per-household tends to increase as the population base of a species becomes (or is) smaller and more tenuous, if we assume the same household base, there will likely be a large range of values between large population-widely distributed species like elk, and very small local population species like wolves in the Rocky Mountains.

In an unpublished proceedings paper, McLennan et al. (2009) attempted to construct a meta-model of per-animal passive use values from 89 species-specific passive value estimates. These authors noted the large variation in the value per animal estimates. The mean value per animal in the data was $2,117,061, while the median was only $12,343. This was explained in part by valuations studies that had a substantial aggregated WTP applied to a rather small animal population to yield the value per animal. The very high per-animal values found in some of the studies in the McLennan data (including values for wolves from Duffield 1992, and Duffield et al. 2006) underscore that at very low population levels species tend to become more valuable on a per-household value and extremely more valuable on a per-animal basis when this straightforward method of calculation of per-animal value is used.

An alternative method of calculating per-animal values might entail employing an understanding of how much each animal of a species that is killed in a collision pushes the species (or sub-population) towards extinction. This population viability methodology could provide more parallel value estimates in terms of how passive use values are often measured (as a willingness to pay to protect a species from extinction). However, the underlying data in the realm of conservation biology related to population viability includes large degrees of uncertainty, and is likely specific to each species and location/setting. Given the currently available data, this method is not feasible to incorporate in the current report. Wildlife biology research would also be needed in evaluating the population impacts of increased connectivity at a given location for a given species.

Marginal Passive Use Value of Elk

An estimate of the passive use value of elk was developed by Duffield (1989) in a social and economic impact assessment of a Montana Department of Fish, Wildlife and Parks (DFWP) proposed purchase of a 2,098 acre property from several ranchers, Allen and Edwin Nelson, for use as an elk winter range near Yellowstone National Park.

The Nelson property consisted of 2,098 acres in the Upper Paradise Valley and was used as summer grazing for the nearby cattle ranch. The property was bounded on the west by the existing Dome Mountain Wildlife Management Area (WMA) and on the south and east by the Gallatin National Forest. Increasing elk populations in Yellowstone National Park and changes in the late season elk hunt north of the park in the late 1980s had led to increased migration of the Northern Yellowstone elk herd to historical elk winter range. In the winter of 1988-1989 many elk were wintering in the Dome Mountain area which is heavily used because of its location near the park and because the range is windblown and therefore accessible even in severe winters. In this severe winter, which followed a summer of drought and the 1988 fires, it was estimated that 4400 to 5500 elk, or about 30% of the Northern Yellowstone herd died as a result of winter kill. This spectacle of mass starvation received considerable media attention. At the same time, this increased use of the range by elk in the winter heavily impacted the productivity of the summer range for cattle. As part of a response to these issues, DFWP proposed adding the 2,098 acre Nelson property to the Dome Mountain Wildlife Management Area. To evaluate the proposed purchase, an economic analysis was undertaken to compare the benefits of the property as a dedicated winter range compared to then existing use for summer cattle grazing and some outfitted hunting use.

As winter range, the Nelson property would contribute to the long-term viability of a segment of the Northern Yellowstone herd and associated direct recreational use including hunting and wildlife viewing. Because the elk using the larger Dome Mountain area summer in Yellowstone National Park, it was expected that park visitors would value not only seeing elk on visits but would also be concerned about the long term viability of the Northern Yellowstone herd and that some individuals would value knowing that at least a segment of this migratory herd had adequate winter range. To provide a partial measure of these potential passive use values, Yellowstone Park visitors were surveyed in October,1989. This was a partial estimate because not only Yellowstone visitors but also other residents of Montana or other states may also be concerned about the existence of these elk.

The survey was randomly distributed at park entrance gates with 2,000 distributed in October, and by mid-November 728 or 36.1% of surveys had been returned. A limitation of the study is that it was not possible to sample park visitors in other months. The valuation method used was dichotomous choice contingent valuation. Respondents provide yes/no (dichotomous) responses to whether they would pay/donate a given dollar amount that varies randomly across respondents. The response is contingent on their acceptance of a hypothetical described in the survey in which the individual could be asked to pay/donate for achievement of some change.

In the case at hand, survey participants were told that if approximately 10,000 acres of key winter range north of the park were managed primarily for elk, this would ensure the long-term survival of the Yellowstone herd, and that about 4,000 elk could winter in this area in even the most severe winters. Participants were also told that a private organization, such as the Rocky Mountain Elk Foundation, could establish a trust fund to purchase and improve this critical winter range. Participants were then asked (yes or no) if they had an opportunity to participate in a such a trust fund, would they be willing to purchase a membership for (dollar amount) to buy land for elk winter range. The dollar amount varied randomly across potential respondents in the range of $1 to as high as $500. The mean donation per visitor was $78.09, but the median (amount at least 50% of respondents were willing to donate) was much lower at $17.72. Statistical models that explained the donation responses showed that responses were consistent with economic theory including statistically significant parameters for income, frequency of visits to Yellowstone, whether the individual hunted or liked seeing elk, and their attitudes toward preservation of wildlife.

Visitors were asked the importance of various reasons for visiting Yellowstone. The top three reasons for visiting the park were all related to seeing wildlife: the percent who marked “very important” or “important” for observing a variety of wildlife, observing large numbers of wildlife, and viewing or hearing elk were 95, 90, and 88 percent of all respondents respectively.

The response rate to the survey was 36.1 percent. It was conservatively assumed that all the non-respondents had a zero passive use value, which leads to an estimated weighted average preservation value per respondent for the sample of $28.12. Total passive use values for the increment of 4,000 elk provided by the winter range were computed based on the adjusted mean value per respondent of $28.12 and 2.6 million park Yellowstone recreation visitors per year for a total of $73.3 million. Assuming a simple linear relationship between the viability of this core group of elk and population levels, this implies a marginal passive use value per individual elk of $18,325 per elk.

The 2098-acre Nelson property that motivated the study was estimated to support 1500 of the 4000 wintering elk and therefore provided passive use values of $27.5 million. The benefits of acquiring the winter range substantially exceed costs and the State of Montana did choose to purchase the property to add to the Dome Mountain Wildlife Management Area and has in the last few years also acquired other adjoining properties. The basic finding of the study was that there are very large values associated with protecting winter range for the Northern Yellowstone herd. These values are in part a function of the large numbers of people who visit Yellowstone every year (2.6 million then, more than 4 million now) and the fact that wildlife observation is the number one reason that people travel to the park. The Nelson property is very valuable for largely locational reasons. It happens to be part of the winter range of choice of a segment of one of the largest migrating elk herds in the world. This herd happens to have its summer home in the world’s first, and perhaps best known, national park. These factors combined to indicate that the DFWP purchase of the Nelson property was clearly in the public interest.

Marginal passive use value of Wolves in Yellowstone

Passive use values for wolf were previously estimated (Duffield 1991, 1992, Duffield and Neher 1996, and U.S. Fish and Wildlife Service 1993, 1994) to estimate the benefits of reintroducing endangered gray wolves into the Yellowstone National Park and Central Idaho recovery areas. The discussion here focuses on more extensive Yellowstone work. This discussion provides the rationale and basis for the marginal passive use values presented for wolves and an example of the methods that were applied in this case and others, including grizzly bear and elk.

In January 1995, 29 gray wolves were relocated from Canada into Yellowstone National Park and the wilderness areas of central Idaho. This action was the culmination of an extensive planning effort that began with the listing of the gray wolf as an endangered species in most of the contiguous United States in 1973. In the 1980s the U.S. Fish and Wildlife Service (FWS) approved several wolf recovery plans for the

Northern Rockies that identified central Idaho and Yellowstone National Park as suitable habitat for wolves. In 1991, Congress directed the FWS to prepare an Environmental Impact Statement (EIS) on wolf reintroduction into Yellowstone and central Idaho. The draft EIS (U.S. Fish and Wildlife Service 1993) generated more comments (more than 160,000 were received) than any other previous proposed federal action. The final EIS (U.S. Fish and Wildlife Service 1994) published in April 1994 recommended the reintroduction of nonessential experimental populations in central Idaho and Yellowstone. This action was expected to result in wolf population recovery (10 breeding pairs, about 100 wolves per area for three successive years).

In 1989 our research team was invited by the National Park Service to work on the environmental impact statement stemming from the 1987 Northern Rockies wolf recovery plan. In 1990 and 1991 our team surveyed park visitors in Yellowstone and found that overall they strongly favored wolf reintroduction and that many were willing to donate to efforts to restore wolves (Duffield 1991). Biologists estimated that the number of wolves that could be supported long-term in the recovery area (100 wolves) and also estimated the direct impacts of wolf predation on elk populations and livestock based in part on experience in Alberta and Minnesota where wolves were present. Our study team estimated the costs of a full recovery as averaging $937,000 per year ($31,000 livestock loses, $465,000 foregone value to hunters due to reduced elk populations, and management costs of $441,000 per year). To measure the benefits of wolf reintroduction, in 1993 our study team implemented a random sample of national households as well as a subsample of all listed phone numbers in the three-state region of Idaho, Montana, and Wyoming. A total of 335 completed surveys were obtained from the regional sample with a response rate of 70.0 percent and a total of 313 completed surveys were obtained for the national sample, with a response rate of 48 percent and a sampling error of 5.6 percent.

In designing the survey, because wolf reintroduction was a potentially contentious and divisive issue, it was anticipated that there would be two distinct groups of respondents: those who support wolf recovery and attach a value to the existence of wolves in the Yellowstone area, and those who oppose recovery and may attach a value to being free of wolves. These values were partitioned by first asking respondents if they favored or opposed wolf recovery. Respondents who favored wolf recovery were then asked if they would be willing to buy a lifetime membership (make a one-time donation to) a trust fund established to support. Respondents who opposed wolf recovery were asked a parallel question about donation to a fund to oppose wolf recovery. The survey showed that for the national sample, supporters of wolf recovery outnumbered opponents by 2:1 ratio, but within the three-state region, opinion was more closely divided with 49% favor, 43% oppose, and 8 percent didn’t know.

With regard to economics, Table 1 shows the average willingness to pay to support or oppose wolf recovery into the Yellowstone area for both the three-state residents and the national sample. The standard errors on the valuation estimates were derived using a simulation procedure with 5,000 iterations, a method suggested by Krinsky and Robb (1986). The mean value for supporters in the three-state region was $20.50 (opposed regional group $10.48) and the mean for those favoring reintroduction in the national sample was $8.92 ($1.52 for those opposed). The individual values were aggregated using the number of households with phones regionally and nationally since the survey sample was drawn from all such households in the relevant population (Table 1).

These measures of the net value individuals place on having a recovered gray wolf population in Yellowstone are based on what survey respondents say they would be willing to donate. However, in prior research Duffield and Patterson (1991) found that the actual amounts individuals will contribute may be smaller than the amount they say they will contribute. In order to be conservative, a significant adjustment to the net mean dollar values for wolf recovery was made to adjust for possible overstatement of donation amounts relative to the actual cash donations one might make. In prior research (Duffield and Patterson 1991) on other endangered species (arctic grayling and Yellowstone cutthroat) it was found that respondents to contingent valuation questions using a trust fund payment vehicle tended to overstate their actual willingness to donate. Specifically, in cooperation with The Nature Conservancy an actual trust fund was established. This provided a setting for a controlled experiment where responses to nearly identical surveys were compared that differed only in that the survey version provided to part of the sample population asked for actual cash donations and the other survey version asked the remainder of the total sample for how much they would hypothetically donate if contacted at a future date. Among Montana resident respondents the cash responses averaged 48.1% of the hypothetical promised donation or about 50 cents on the dollar and for nonresidents cash donations were more similar to the stated donations with cash at 72.6% of the stated or about 73 cents on the dollar.

One can also compute donation values per deliverable. In other words, for the cash survey sample the total amount of cash received in donations is divided by the total number of cash surveys actually delivered to get the average cash donation per deliverable. Computing the average donation per deliverable turns out to be equivalent to correcting for the difference of actual and stated donations; it also implicitly assumes that all nonrespondents place a zero value on the proposed action. (This is a quite conservative assumption. Many nonrespondents may in fact have positive values for the action but for one reason or another do not participate in the survey.) Donations per deliverable of readily collectable cash donations averaged 25% to 35% relative to the stated valuation or hypothetical donation. The average ratio from these studies of 0.286 cash to hypothetical was applied as a scaler (Table 1) to the wolf donation estimates. For example, for the national group favoring wolf reintroduction, this has the effect of reducing the estimated mean value for national supporters from $20.50 to $5.86.

As shown in Table 1, the resulting net economic value per year for Yellowstone wolf reintroduction is $8,263,680, as reported in the 1993 and 1994 wolf EIS (U.S. Fish and Wildlife Service 1993, 1994 and Duffield and Neher 1996). Based on sampling error and statistical parameters in the contingent valuation model, the 95% confidence interval for this mean estimate of $8.3 million is $6.7 to $9.9 million.

Table 1. Estimated Mean Passive Use Values for Wolf Reintroduction to Yellowstone NP

Welfare Measure Statistic	MT, WY, Idaho Residents	Out of Region Residents	All
Mean Value for those[a] supporting reintroduction (Standard Error)[b]	20.50 (1.43)	8.92 (0.74)	
Mean Value for those opposing reintroduction (Standard Error)	10.08 (1.48)	1.52[d] (0.55)	
Population supporting wolf reintroduction	391,204	50,152,416	
Population opposing wolf reintroduction	340,522	25,774,280	
Aggregate net economic value/year[c]	321,201	28,572,785	
Calibration[e]	0.286	0.286	
Estimated net economic value/year (Standard Error)	91,863 (9179)	8,171,817 (811,470)	8,263,860 (956,437)

Notes:

[a] The mean values are calculated as a truncated mean with the truncation level at $50 for 3-state residents and at $25 for out of region residents. The truncated mean valuation calculation included both responses from people with directory-listed phone numbers and non-listed numbers, contacted through a random dialing procedure. In the aggregation of mean values an assumption was made of not difference in willingness to pay between those with listed phone and those not listed. This assumption was tested by making a non-parametric comparison of those responses from a small random digit dialing simple with the listed sample. The mean values from the random digit sample were higher than those from the listed sample.

[b] All standard errors on estimates of mean net willingness to pay were estimated using a simulation procedure with 5,000 iterations (Krinsky and Robb 1986)

[c] Values are calculated assuming a perpetual benefit stream from a one-time trust fund deposit amortized at a 7% real interest rate.

[d] The sample size for the out of region respondents opposing wolf reintroduction to the Yellowstone area was not adequate to estimate willingness to pay. A non-parametric comparison of the Yellowstone area and central Idaho, out of region, oppose responses yielded quite similar means, $1.16 for Idaho and $6.67 for Yellowstone area out of region, oppose willingness to pay. Because of the closeness of the estimates, the estimated Idaho mean of $1.52 was also used to estimate the Yellowstone out-of-region oppose willingness to pay.

[e] This factor is an estimate of the ratio of the amount individuals would actually contribute to the amount they state they would contribute, based on Duffield and Patterson (1991) and Ward and Duffield (1992).

Source: USFWS, 1994

To develop a marginal passive value for an individual wolf in the Yellowstone recovery area, it is necessary to compute the total net present value of a long term recovered population of Yellowstone wolves. The total present discounted value of a perpetual benefit stream from the one-time trust fund per year of $8,263,680 for wolf recovery is $118.05 million. As noted earlier, biologists estimated the population goal for recovery in Yellowstone at 10 breeding pairs (a population of around 100) for successive years. Accordingly, under the simplifying assumption of constant marginal passive use values up to the level where the population's existence is judged to be viable, the marginal value per individual wolf is $1,180,500 in 1993 dollars (and $2,002,700 when corrected to the year 2019 dollars using the Consumer Price Index to account for inflation in Table 1). This would be the appropriate value for settings where on average one wolf per year is removed from this population. For example, this would correspond to a section of roadway where wildlife vehicle collisions result in an average of one wolf mortality per year. As it happens, the biologists who helped develop the wolf EIS did a good job of identifying the future population of wolves in Yellowstone National Park, the population is currently around 100 wolves and this has been close to an average population since the early 2000s.

It is interesting to note that the wolf recovery decision was analyzed by the FWS from the perspective that Yellowstone National Park is a national resource and (as shown by public comments) was important to people from across the nation. If the decision had been viewed as only of regional interest, benefits were much lower (Table 1), because of the regional population's more closely divided opinions between favor and oppose. Based only on values for the regional population, the marginal passive use value per wolf is $13,120 in 1993 dollars or $22,270 in current 2019 dollars.

Marginal passive use value of wolves outside Yellowstone

The relatively high values per individual wolf in Yellowstone may be unique to the reintroduction of a keystone species (the only then missing major carnivore from this ecosystem) to a well-known and much visited national park. Possibly similar values may be associated with the wolf populations on Isle Royal and in Algonquin Provincial Park in Ontario, Canada. However, as the response by regional residents (Idaho, Montana, and Wyoming) may indicate, the values associated with wolves outside Yellowstone Park but in the larger recovery area may be somewhat lower.

Data on this question was developed in a study by Duffield, Neher, and Patterson (2006, 2008), which implemented a survey of Yellowstone Park visitors in 2004-2005 and examined the values and attitudes associated with Yellowstone wolves after 10 years of experience with reintroduction. Among other findings the study confirmed several of the EIS economic predictions, particularly the regional economic impact of wolf viewing in the park, and it also examined actual predation impacts and impacts on elk populations and hunters. The study also included a survey question that asked visitors if they would donate to a fund to compensate ranchers for wolf predation that occurs in area ranches that are outside the park. Potential respondents were asked to suppose that a necessary condition for wolves to exist in areas adjoin the park is that ranchers are compensated for their losses and that "By having a larger overall wolf population and range in the Yellowstone recovery area, the long-term viability and genetic health of this population, both inside and outside the park, is improved". The average donation was $32.26 (2005 dollars). When calibrated for likely actual versus stated donations as in the national visitor study in 1993 and assuming visitor non-respondents to have zero values, an estimated donation amount is $6.13 per visitor. In 2005 there were 2.8 million visitors implying one year's worth of visitor donations at $17.164 million.

The recent wolf population in the Yellowstone recovery area has been a little over 500 and the population in the park is around 100. The 400 wolves outside the park might be considered a viable recovered population for the area in that delisting wolves has been proposed by FWS. Accordingly, the marginal passive use value for the population of wolves outside the park is estimated to be $42,910 in 2005 dollars and $56,427 in 2019 dollars.

Marginal passive use value of Grizzly bears

Passive use values for grizzly bear have been previously estimated by Duffield, Neher and Patterson (1997) as part of an EIS on proposed reintroduction of grizzly bears into the Bitterroot Mountains of Idaho and Montana. The methods in this study are similar to those developed for estimating passive use values for wolves in the context of reintroducing wolves to Yellowstone National Park and central Idaho.

In 1997 the U.S. Fish and Wildlife Service (1997) issued a draft EIS proposing the reintroduction of an experimental population of grizzly bears into the Bitterroot Ecosystem. Most of this ecosystem, about 70%, is federal land, and much of this is designated wilderness in an area where grizzlies were historically relatively abundant. The analysis included a benefit-cost comparison of the costs of reintroduction, including the management costs and the impact of bear predation on domestic livestock. The benefits estimated were largely the passive use values, or existence values, associated with reintroduction of bears. It was anticipated that the proposed recovery area could support around 280 bears and, given the typical slow population growth of this species (possibly two to four percent per year), this population might reach that number in 50 to 100 years.

The methodology used in estimating the net economic value associated with a recovered Bitterroot grizzly population follows that of Duffield (1992) and Duffield, Neher, and Patterson (1993). Individuals were asked how much they would be willing to contribute to a fund to support (or oppose) grizzly recovery. Three random samples of potential respondents were drawn: one from the pool of all possible phone numbers in the U.S. (excluding Alaska and Hawaii), a second from all possible numbers in a six state region (Idaho, Montana, Wyoming, Washington, Oregon, and Utah), and a third from all possible numbers in 8 counties in or near the proposed recovery area (Missoula, Mineral, Ravalli, Idaho, Clearwater, Nez Perce, Lewis, and Shoshone). Individuals in these samples were contacted and surveyed as to their understanding of, and attitudes about, grizzly reintroduction in the Bitterroot Ecosystem.

The national and regional populations very strongly favored the reintroduction, at 88.2 percent and 90.0 percent respectively. The local population also strongly favored reintroduction with 70.3 percent favoring and 29.7% opposed. The key survey question used a dichotomous choice contingent valuation framework. After respondents were asked whether they favored or opposed reintroduction, they were asked if they would be willing to buy a lifetime membership (make a one-time donation) in a trust fund established to support (or oppose) efforts to help reintroduce grizzly bears in the Bitterroot Ecosystem. Analysis of the valuation question responses followed the methods of Hanneman (1984, 1989). Table 2 shows the average willingness to pay to support or oppose grizzly reintroduction for the local, regional, and national samples. The standard errors on the valuation estimates used a bootstrap method suggested by Duffield and Patterson (1991). Because relatively few individuals opposed reintroduction, sample sizes for those respondents proved to be too small to allow model estimation and estimation of an average donation. A non-parametric analysis of these responses, however, showed that average willingness to pay was substantially lower for this group than for those supporting reintroduction. This is consistent with the findings of similar studies of another large carnivore, the gray wolf (Duffield 1992 and Duffield, Neher, and Patterson 1993). In order to conservatively estimate the net benefits from grizzly bear reintroduction, the same average donation estimates for those supporting reintroduction were assigned to those opposing reintroduction.

To summarize, net willingness to pay was estimated for the two different groups in the population, those who opposed reintroduction and valued the absence of grizzlies from the Bitterroots and those who valued the prospect of a recovered grizzly population. Once these values were estimated for the three sample populations, the aggregate value for those who opposed reintroduction was subtracted from the aggregate value for those who favored reintroduction to get a final net economic value for grizzly reintroduction. For purposes of the EIS, the estimated net passive use value for reintroduction was reported on a value per year basis. The estimated net passive use value per year associated with the proposed recovered grizzly population is $19,363 for the local population, about $10.2 million for the regional population and about $166.6 million for the national population (Table 2).

Table 2 shows the calculation of the total net economic passive use value per year of grizzly bear reintroduction to the Bitterroot Ecosystem. This total value figure is based on the estimated mean lifetime willingness to support grizzly bear reintroduction times the number of households with phones in the relevant population (local, regional, national supporting or opposing) times an interest rate of 7.0 percent. The individual values were aggregated to the number of households with phones because the sample was randomly drawn from all households with phones in the relevant population. The real interest rate of 7.0 percent is used in order to convert a lump sum donation to a grizzly bear recovery trust fund into a yearly income stream. For a perpetual income stream, the lump sum is converted into an annual value by multiplying by the interest rate. Annual values were estimated for comparison to the cost estimates, such as the cost of management, which are most readily available as annual costs.

The aggregate net economic value per year estimates in Table 2 are conservative in several respects. First, the valuation responses were treated as household responses rather than an individual response. Treating the responses as individual responses would increase estimated net benefits substantially. A second, smaller, source of conservative bias arises from the fact that only households with phones were used in the aggregation. It was estimated that at the time of the survey 95 percent of households owned phones. Third, the approach to converting the lifetime contribution into an annual value is conservative in that it assumes that only the values of the present generation of contributors count. In addition, the amortization is for perpetuity. Finally, as discussed in more detail below, donation averages are based on survey respondents. A common approach is to assume that those who don't respond to the survey, the non-respondents, have the same values as the respondents. A much more conservative approach, which is taken here, is to assume that non-respondents haven't responded because they place zero value on the proposed action.

These measures of the net value individuals place on having recovered grizzly bear populations are based on what survey respondents say they would be willing to donate. However, Duffield and Patterson (1991) found that the actual amount individuals will contribute may be smaller than the amount they say they will contribute. In a study of donations to improve stream flows for endangered fisheries in Montana, Duffield and Patterson found that Montana resident respondents to a request for an actual cash donation had an average donation across their sample that was about half (48.3 percent) of the stated donation respondents. It was also found that the response rate for cash respondents was only about half as high (47.1 percent) as the response rate for those who were asked for a stated or hypothetical donation. Similarly, for the sample of nonresidents (living outside of Montana) the cash donations per respondent were about 72.6 percent of the stated donation amount and again the response rate for the cash survey was about half (47.3 percent) of the stated donation amount. Averaging across both resident and nonresidents with this data and assuming non-respondents place zero value on the proposed action and also correcting for hypothetical bias leads to an overall calibration factor or "scalar" in Table 2 of 0.286 (average of 0.483 times 0.471 for residents and for nonresidents 0.726 and 0.344). (This overall calibration was also used in the gray wolf EIS for reintroduction of wolves to Yellowstone.) This calibration remains preliminary since the relationship between the amount hypothetically and actually paid may vary across resources and the population sample. We do not know the exact relationship between state and actual willingness to contribute for grizzly bear recovery in the Bitterroot Ecosystem, but given the other conservative assumptions made here the estimated passive use values presented are likely a lower bound on the unknown true value.

Even adjusted for an assumed difference between stated and actual willingness to pay, the estimated net annual passive use value of grizzly bear recovery in the Bitterroots is very large, on the order of $50.5 million per year, with a 95 percent confidence interval of $40.5 million to $60.6 million (Table 2). This substantial value reflects the high percentage (90 percent) of the U.S. population that supports the recovery effort and the fact that the grizzly bear is a very high-profile wildlife species.

To compute marginal passive use value for grizzly bear, the total present discounted value of the annual stream of value associated with introduction at $50, 544,105 per year in perpetuity is $722,058,600. For the recovered population of 280 bears, and assuming linear relationship between marginal value and population levels, the marginal passive use value per grizzly bear for this population is $2,578,800 in study year (1993) dollars and $4,133,000 in current 2019 dollars (Table 2).

Table 2. Estimation of Grizzly Reintroduction Annual Passive Value from USFWS Draft Grizzly Reintroduction EIS (1997).

Welfare Measure/Statistic	Local sample Residents	Regional sample Residents	National Sample Respondents
Mean value for those[a] supporting reintroduction (Standard Error)[b]	48.70 (4.15)	45.02 (3.48)	40.17 (3.52)
Mean value for those opposing reintroduction (Standard Error)[c]	48.70 (4.15)	45.02 (3.48)	40.17 (3.52)
Population supporting grizzly bear reintroduction	45,897	3,725,013	66,671,516
Population opposing grizzly bear reintroduction	19,363	496,668	7,439,739
Aggregate net economic value/year[d]	90,454	10,173,806	166,553,834
Scaler[e]	0.286	0.286	0.286
Estimated net economic value/year (Standard Error)	25,870 (4,939)	2,909,709 (296,475)	47,634,396 (5,142,009)

[a] The mean values are calculated as a truncated mean with the truncation level at $100.

[b] All standard errors on estimates of mean net willingness to pay were estimated using a bootstrapping procedure with 200 boostrap iterations (Duffield and Patterson 1991)

[c] The sample size for those opposing reintroduction were not large enough to allow estimation of models of willingness to pay. The assumption was made that willingness to pay to oppose reintroduction per household was equal to willingness to pay to support reintroduction. Analysis of non-parametric means of the contingent valuation responses by those opposing reintroduction showed that this assumption likely overstates the true willingness to pay by those opposing reintroduction.

[d] Values are calculated assuming a perpetual benefit stream from a one-time trust fund deposit amortized at a 7% real interest rate.

[e] This factor is an estimate of the ratio of the amount individuals would actually contribute to the amount they state they would contribute, based on Duffield and Patterson (1992).

Source: USFWS Draft Grizzly Reintroction EIS, 1997

Marginal passive use value of the Desert Tortoise

The Mojave Desert Tortoise is currently listed by the USFWS as Threatened within its range, with a roughly estimated population of 85,000 individuals in 2014 (USFWS at https://www.fws.gov/nevada/desert_tortoise/dt/dt_life.html). Within our literature search of passive use values, we found no directly comparable estimates for tortoises. Estimates for sea turtles are based on a completely different ecosystem and may not provide an appropriate proxy value directly applicable to the terrestrial tortoise. In the following analysis we estimate the passive use value of the Mojave Desert Tortoise using two methods, application of a meta-analysis model, and estimation from evidence of public expenditures.

Use of the estimated meta-analysis valuation model (Amuakwa-Mensah et al. 2018) predicts a 2015 total passive use value for the desert tortoise of $5.19 per household in the US (**Table 3**). The primary covariates used in this prediction are an indicator variable for a threatened species with a low charismatic index, and an indicator for “reptile.” It should be noted that the model only provides generalized group value estimates and would return the same per-household value for any threatened-low charisma reptile. The $5.19 household value was multiplied by the number of households in the US in 2015 and divided by the estimated population of the desert tortoise. The result is an estimated value of $7,610 per tortoise.

In recognition of the generalized nature of the meta-analysis value estimate, a second value estimate was calculated based on actual protection and mitigation expenditures incurred at the Ivanpah Solar project within the tortoise's critical habitat. The total reported spending to protect the species within and near the solar installation ($22 million) was divided by the number of estimated adult and juvenile tortoises potentially impacted by the project from the species-project biological opinion (3,021). The implication of this spending is that society was willing to spend nearly $7,300 per tortoise for protection and mitigation. This second value estimate compares very favorably with that from the meta-analysis. It should be noted that estimates of value from project mitigation costs would not necessarily be expected to directly correspond with value estimates from other methods. Rather, they represent a minimum value society places on the species specific to the specifics of that project and species dynamic.

Table 3. Comparison of Estimates of per-animal value for the desert tortoise from a meta-analysis model prediction, and public expenditures.

Parameter	Meta-analysis model (2015)	Ivanpah Solar Power Project (Mojave Desert)
Passive use value per household	$5.19/hh	--
U.S. households	124,000,000	--
Total species passive use value	$643,560,000	--
Cost of Species protection for project	--	$22,000,000[a]
Species population	85,686[c]	--
Number of Tortoises protected	--	3,021[b]
Value per Tortoise	$7,610/animal	$7,282/animal

[a] https://web.archive.org/web/20120609103146/http://ivanpahsolar.com/desert-tortoise-care-at-the-ivanpah-solar-project

[b] Estimate of 80 adult and 608 juveniles inside the project area and 207 adult and 2055 juvenile outside the area potentially impacted by construction activities.

[c] From "STATUS OF THE DESERT TORTOISE AND ITS CRITICAL HABITAT" at https://www.fws.gov/nevada/desert_tortoise/dt/dt_life.html

Direct Use Values

In contrast to passive use values, direct use values for wildlife are generally more straightforward to compute. In this case the uses in question, such as recreational or subsistence hunting or fishing, or wildlife viewing, can be directly observed. This means that in addition to contingent valuation (in the class of "stated preference" approaches) one can also use observable behavior with "revealed preference" approaches like the travel cost method for recreational use. The latter is based on the response of recreational use at a given site to the travel costs that vary according to mode of travel and distance from the site. This information can be used to construct an economic demand relationship and average use values at a given site. Direct use values may be categorized into both consumptive (such as hunting) and nonconsumptive (such as wildlife viewing).

The following section provides an example of an economic direct use study, in this case a study to estimate the wildlife viewing values associated with elk.

Elk Viewing Values

A prior study of wildlife viewing values for elk is Duffield (1991). This paper examined both existence and nonconsumptive values for wildlife using surveys of visitors to Yellowstone National Park in two samples: a survey in October of 1989 and a survey in the following year, August-September 1990. The main focus of the 1989 survey was on the passive use value for elk winter range for the Northern

Yellowstone herd as previously discussed. The 1990 survey was an initial examination of the attitudes toward and values for potential wolf recovery in Yellowstone. Survey questions in both surveys concerned visitor values for elk, as it was anticipated that the main prey species for wolves in the park would be elk, and so, among other species, some investigations were made into the values visitors have for viewing elk.

The general approach was to use dichotomous choice valuation to value the given visitor's recreational trip to the park.

Nonconsumptive values related to elk viewing were estimated using a current trip payment vehicle. After a question to establish the respondent's actual trip expenditures including gas, lodging, food and so on, she was asked "Suppose that your share of trip expenses to visit Yellowstone National Park increased, would you still have made the trip if your cost had been $ (<u>bid amount</u>) more? The bid amount varied randomly across surveys from $10 to $2000. A model of respondent willingness to pay was estimated that included a variable to measure whether any elk were seen on this trip. The changes in the visitor's experienced conditions on willingness to pay is estimated by computing welfare estimates (value of the trip) at different levels of the covariate of interest (in this case, whether any elk were seen). For the case at hand, the working hypothesis was that the value of park visits would be a function of the respondent's income, the length of the trip, respondent's level of education, an indicator variable for the year of the survey, and whether the respondent saw an elk on their trip.

Both studies utilized a printed questionnaire distributed to park visitors at entrance gates, one in October 1989 and the other in late August and early September of 1990. The 1989 survey was previously described in the elk passive use discussion above. The 1990 surveys were distributed among entrance stations in proportion to historic use levels. By a cutoff date of 1 November, a total of 612 surveys were received for a response rate of 30.6 percent. As noted this study also draws on the survey of park visitors undertaken in October 1989 (Duffield 1989). For the latter, a total of 2000 surveys distributed in mid-October resulted in 728 (36 percent response rate) surveys returned by mid-November. These are typical response rates for simple hand-out mail back surveys. Because both surveys were done on a tight time frame, it was not possible to sample throughout the year. A limitation of the survey data base is that visitors in other seasons were not sampled. This analysis is best viewed as exploratory in that bias may be introduced by not simultaneously examining the effect of other nonconsumptive activities (e.g. viewing bison, moose, bear, etc.) on the visit experience.

Estimated multivariate logistic models for regional resident visitors (Montana, Idaho, Wyoming) and out of region resident visitors based on current trip valuation responses are reported in Table 4. To increase precision through larger sample sizes, the reported estimates are based on combined October 1989 and August-September 1990 samples. The reported models for residents and nonresident visitors are quite similar. In the reported equations, the indicator variable for whether a visitor saw an elk or not (SAWELK) is not statistically significant at even the 80 percent level. However, when the variable lnDAYS is excluded, SAWELK is significant at the 90 percent level for nonresidents and 80 percent level for residents. This may be in part due to the resident sample being about half the size of the nonresident (435 resident respondents versus 791 nonresident). As one might expect, the probability of seeing at least one elk and the length of the trip are multicollinear; in these situations the parameter estimate is unbiased if both variables are included but standard errors are not reliable. Using the parameter estimates with lnDAYS excluded would lead to omitted variable bias. Accordingly, the best models are those shown in Table 4.

The models were used to examine a hypothetical reduction of 20 percent on elk populations, which was thought to be the likely effect of wolves on the Yellowstone northern herd. Most visitors (76 to 77 percent) report seeing elk. If elk populations were reduced by 20 percent the total number seen (which at the time averaged 40 per trip) might be reduced linearly to 30 to 33 elk per trip. Using data from both samples, which differed in number of elk seen and percent who saw elk, the reduction in probability of seeing at least one elk when the elk population declined by 20% was estimated to drop by 3.0 percent from 77 percent for nonresidents to 74 percent and a comparable change for residents. Baseline current trip values in 1989-1990 were estimated from these models to be $95.51 for residents and $663.97 for nonresidents. This is in part due to higher income of nonresidents and typically longer stays. The current trip value when elk are seen for residents was 101.81 and when not seeing elk is $80.1,5 or a difference of $21.66. For nonresidents seeing elk, the trip value is $705.04 and without seeing elk is $559.70 or a difference of $145.34. A three percent change in the probability of seeing elk compared to the baseline leads to a reduction in value of $0.63 for residents and $4.61 for nonresidents (Table 5).

Table 4. Estimated Logistic Regression Model of Willingness to Pay for Current Trip from Duffield (1991).

Variable/Statistic	MT, ID, WY Residents	Out of Region
Constant (t-stat)	3.4384 (7.55)	-.6469 (-.522)
LNBID	-.9664 (-10.1)	-.8612 (-11.6)
LNDAYS	.6917 (2.79)	.4147 (3.14)
LNINC	--	.5859 (5.12)
LNED	--	-.4237 (-2.15)
1990	.7796 (2.70)	--
SAWELK	.2312 (.777)	.1988 (1.0)
Sample Size	435	791
Hosmer-Lemeshow		
Chi-Square	6.451	15.499
D.F.	8	8
P.	.597	.050

Note: Variable Definitions:

LNBID = log of the bid amount

LNDAYS = log of the number of days spent in YNP

LNINC = log of gross family income

LNED = log of educational index (1 to 8)

1990 = dummy for year of survey administration

SAWELK = dummy variable; 1 = saw elk, 0 = did not see elk

Source: Duffield, 1991

Table 5. Effects of reduced Elk Viewing Opportunities for Yellowstone NPS Visitors (Duffield 1991)

Variable/Statistic	MT, ID, WY Residents	Out of Region
(A) Baseline – from October 1989 and August/Sept. 1990 surveys		
Baseline number of Elk seen per visitor	37.7	41.0
Baseline probability of seeing elk	.761	.770
(**B) With 20% reduction in elk population**		
Expected number of elk seen per visitor	30.1	32.8
Expected probability of seeing elk[1]	.733	.740
(C) Typical value of current trip to YNP (median welfare measure). [2]		
Baseline current trip (1990 dollars)	96.15	668.58
With reduced probability of seeing elk	95.51	663.97
Reduction in value	.63	4.61
(D) Value of current trip with and without seeing elk (median).		
Current trip value if see elk	101.81	705.04
Current trip value if don't see elk	80.15	559.70
Value difference	21.66	145.34

[1] Based on relationship of number of elk seen and probability of elk seen from 1989 and 1990 samples.

[2] Based on multivariate model, Table 6 (of source document)

Source: Duffield, 1991

These values are aggregated on the number of total trips over a year from each population (123,273 in 1990 were residents and 2,120,092 were nonresidents) times the respective dollar reduction in trip value, which leads to an annual loss of $2,243,400. At the time of the study, the northern Yellowstone elk population was near an historical high with 15,000 elk in 1989-90 and 12,000 elk in 1990-91. The average is 13,500 and a 20 percent long-term decline in elk would amount to a reduction of 2,700 elk.

The present discounted value of an annual loss of $2,243,400 in Yellowstone visitor net trip values over, for example, a 20-year time horizon can be computed. Assuming constant visitor populations and constant dollars at 7.0 percent real discount rate (present net worth factor of 10.594) yields a present value cost of $23,766,240 in total foregone elk viewing value. This reduction in elk would presumably be sustained by ongoing wolf predation through the 20-year period. This level of more or less sustained impact on a population (though likely not at the level of 2,700 elk every year) could also occur from a given rate of wildlife vehicle collisions in a given section of roadway.

In any case, for the assumed sustained 2,700 elk population reduction in Yellowstone National Park with its 2.6 million visitors per year in 1990, the marginal viewing value foregone per individual elk in 1990 dollars is estimated to be $8,802.

Ancillary Benefits of Wildlife Mitigation

Mitigation structures and associated actions on a particular road section are designed to reduce collisions and the deaths to animals and damage/injury to drivers that these collisions cause. As discussed above, there is value associated with protecting animals from road-based mortality beyond the potential damages associated with collisions. These passive use values are tied to preserving the viability of the species/population. A second, and associated, benefit of mitigation structures relates to reducing fragmentation of a species' range, and facilitating safe passage between portions of that range. These ancillary benefits help to strengthen the species and support its continued existence in the range and, hopefully, increase populations for ESA-listed species. This type of benefit is directly related to the existence/passive use value for a species. The values associated with facilitating passage for a species/population are uncertain and extremely species/location specific. However, in all cases where the species has a positive passive use value, these values would also be positive and would be additive to any estimated passive use values per animal death avoided.

Application of Passive Use Value Estimate in Mitigation Benefit-Cost Decisions

Each potential application of using wildlife passive use values within a collision mitigation benefit-cost analysis presents unique settings and challenges. The following presents a generalized discussion of how a specific passive use wildlife value could help inform the benefit-cost calculation of mitigation spending for a specific road segment.

US Highway 93 North in Montana has seen significant collision mitigation spending in recent years on selected highway segments. One section where no wildlife mitigation effort has been applied is a 13-mile segment from St Ignatius north to Ronan. This road section is a particularly active crossing area for grizzly bears in the Northern Continental Divide recovery zone. Between 2004 and 2017 ten grizzlies were killed in collisions on this road stretch. Most of these mortalities are in wetlands or stream crossings including the Ninepipes/Kicking Horse area and the Crow Creek and Post Creek crossings. In the most recent year, 2018, a record nine grizzlies were killed on the stretch of road. Over the 15 years from 2004 to 2018, an average of 1.26 grizzly bears a year have been killed on this 13-mile stretch of road, but in the last three years there have been more than 3 per year.

An estimate of per-animal passive use value for grizzly bears from the previously discussed EIS study of recovery of 280 bears to the Bitterroot Mountains found a passive use value of approximately $4.13 million per grizzly. The Bitterroot Ecosystem is one of six grizzly bear recovery areas in the lower 48 states; the others are Yellowstone, the Northern Continental Divide or NCD (including Glacier National Park and the Bob Marshall Wilderness complex), the Cabinet-Yaak, Selkirk, and North Cascades. The grizzly bears being killed on Highway 93 are part of the NCD and come down out of the Mission Mountains east of the highway to cross to the west. These mountains are largely in the federally designated Mission Mountain Wilderness and the Mission Mountains Tribal Wilderness, designated by the Confederated Salish and Kootenai in 1979. This is the first and only tribally-designated wilderness in the United States.

The total recovery area has a grizzly population of 1,000 bears, though one might consider the population in the somewhat isolated Mission Mountains to be more relevant here. In any case, employing benefit transfer to use the Bitterroot recovery area value to conservatively value an individual bear in the NCD would imply a passive use value per bear of $1.16 million, all other factors being equal. Because the NCD grizzly population has increased over the last fifteen years, a shorter-term averaging period might be more appropriate to current population levels and for projecting expected mortality into the future.

This simple application of existing passive use values for grizzlies in a specific road section results in expected passive use costs associated with grizzly bear deaths on the 13.7 mile Ninepipes section of Highway 93 have accounted for from $1.5 million in losses in value per year based on the 15 year average mortality to at least $3.5 million per year based on the recent three year average grizzly bear mortality per year. Using this range of annual values the present discounted value of mitigation structures that would prevent these deaths over the next 25 years (at, for example, a 7.0 percent real interest rate) is 17.5 million to $40.8 million.

This estimate would apply to mitigation actions that would limit mortality, such as fencing. The per-bear values could also be used to estimate the benefits of connectivity, such as through wildlife crossing structures. For this, one would need to know the wildlife biology basis for how much the NCD grizzly population would increase if bears had increased connectivity (safe access) to the habitat west of Highway

93 in the Mission and Flathead Valleys and perhaps further west into the Ninemile-Reservation divide, the Ninemile Valley, and perhaps into the Bitterroot Mountains.

In an actual application one would use the same financial parameters as the construction cost analysis including the life-time planning horizon for the specific infrastructure, the actual extent of expected mitigation of the grizzly mortality, and the same cost of capital (or real discount rate).

Estimating the wildlife-related benefits of mitigation structures for the Ninepipes section of Highway 93 North based only on direct use values for these bears (viewing and, perhaps in the future, hunting) badly understates total benefits. Incorporation of passive use values into a benefit-cost analysis of collision mitigation spending on the road has the potential to improve the benefit-cost analysis or other financial analysis for mitigation infrastructure in this 13.7 mile Ninepipes section of Highway 93 north between St. Ignatius and Ronan.

CHAPTER 4

Regional Economic Impact Associated with Mitigation Structure Spending

Regional economic impact analysis is a different accounting framework that is generally more of a measure of the distributive impacts of a given project on a local area or region. This method addresses the question: how will this activity affect the local or regional economy in terms of jobs and income? Often a given project just moves economic activity to one area at a cost to another. For example, a given road project in Wyoming funded from a fixed transportation budget just displaces a project somewhere else, like Minnesota. This framework is distinct from benefit-cost analysis which answers the question: is society as a whole better or worse off as a result of the project? For mitigation projects, there are possibly two major areas of potentially significant regional economic impacts: those impacts associated with construction expenditures, and those with direct use impacts on wildlife-related recreation, including wildlife viewing and hunting.

Collision avoidance mitigation actions entail costs associated with construction of mitigation structures such as culverts, overpasses, and fencing. An important impact of any proposed substantial economic activity in a defined economic region (e.g., a county or county group, or a state), is the additional "spin-off" economic activity, such as employment and income, that the original expenditures create within the specified economic region.

While the costs associated with mitigation measures are often detailed, a more comprehensive analysis of the regional economic impact takes these estimates of direct construction costs as a starting point in estimating the total economic impacts of that original direct economic activity on the local economy. There are a number of regional economic impact models used to describe the additional impacts of spending on an economic area, with the most commonly used being the IMPLAN modeling platform. IMPLAN is a widely used and relied on regional economic impact model in the U.S. with decades of history and thousands of applications throughout the economy.

When new expenditures are made within a local, county, or state economy, that spending results in income for employees and business owners. This is referred to as a direct impact of the economic activity. In addition to the direct impacts on employment and income however, the businesses involved (whether construction, engineering, technical, etc.) also purchase items and supplies for their businesses within the local economy, thus supporting the employment and income of another group of people. These are called indirect impacts. A third impact is related to the economic activity that occurs when individuals employed either directly in the affected businesses or indirectly spend a portion of their earnings within the defined economic area. This round of spending supports what are called induced impacts on income and employment. The sum of direct, indirect, and induced impacts are the total impacts associated with economic activity (Figure 1).

The estimation of indirect and induced impacts is done with the use of an input-output model. The model uses comprehensive data on the structure and size of a defined economic region for a certain year to estimate the indirect and induced effects on the economic regional economy (measured in employment and income) associated with a specified level of direct spending within the economic region.

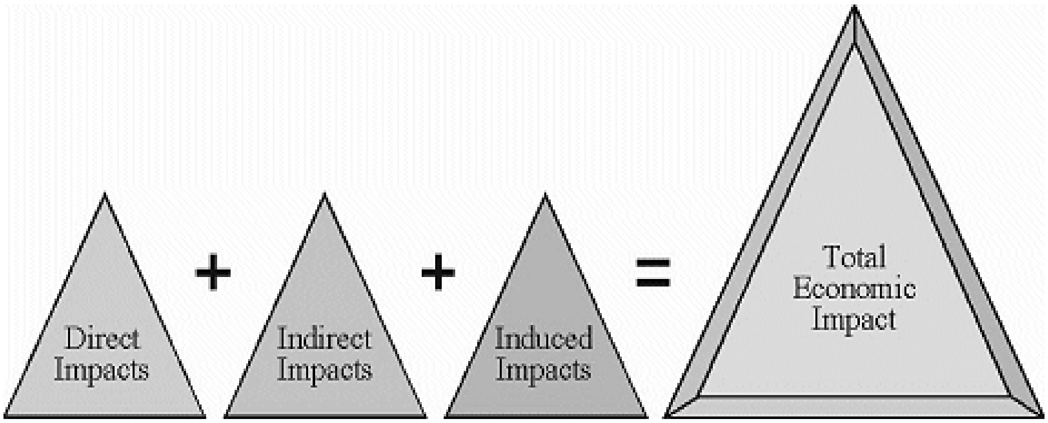


Figure 1. Relationship of Direct, Indirect, and Induced Economic Effects or Impacts.

Regional Economic Impact Analysis using an Input-Output Modeling Framework for Mitigation Construction Spending

There are a number of essential steps involved in conducting any regional economic impact analysis. These steps can be summarized as follows.

Define the regional economic area of interest

The most commonly used predefined economic areas utilized in regional economic analyses are an individual county, groups of counties, or individual states. For the following example, we have chosen two Montana counties that represent a range from a very economically small county to a large one. In the context of regional economic modeling, the size of the county is gauged in terms of the economic diversity and complexity of the county. A larger and more economically complex county will see a larger share of structure spending occur with businesses and employees already located within the county, and accordingly, the add-on indirect and induced multiplier effects of the original direct spending will be larger if the analysis area is larger and more complex For this example, IMPLAN indirect and induced output, employment, and income multipliers are used for Sanders County, Montana, and Yellowstone County, Montana.

Specify the new economic activity being modeled

The new economic activities being modeled in the IMPLAN analyses are costs associated with construction of wildlife crossing structures in the year 2010 along the Highway 93 corridor near Evaro, MT, Finey Creek, and Schley Creek. The following table (Table 6) is a portion of Table J1, page 143 of the US 93 North Wildlife Mitigation Final Report.

Table 6. 2010 Wildlife Mitigation Spending for Construction on US 93 North.

Structure	Structure Type	Dimensions width x height, length (meters) (from animal's perspective	Construction year	Construction Costs (US $)	Construction Costs (US $)	Construction Costs (US $)
				Total	**Minimum for Hydrology**	**Additional for wildlife**
North Evaro	Corr metal culvert	7.75 x 5.1 x 25.8	2010	$385,923	$0	$385,923
Railroad Bridge	Multi span bridge	103.5 x 9.7 x 12.0	2010	$3,134,633	$3,134,633	$0
Finely Creek 1	Corr metal culvert	7.95 x 5.55 x 32.0	2010	$478,467	$13,917	$464,550
Finely Creek 2	Corr metal culvert	7.95 x 5.55 x 21.9	2010	$438,157	$42,719	$395,438
Overpass	Wildlife overpass	60 x n/a x 63	2010	$1,884,650	$0	$1,884,650
Finely Creek 3	Corr metal culvert	7.75 x 5.1 x 24.7	2010	$354,126	$8,647	$345,479
Finely Creek 4	Corr metal culvert	7.95 x 5.55 x 25.3	2010	$410,398	$11,308	$399,090
Schley Creek	Corr metal culvert	7.75 x 5.1 x 30	2010	$601,796	$48,519	$553,277
East Fork Finley Creek	Corr metal culvert	7.75 x 5.1 x 24.3	2010	$462,109	$83,795	$378,314

Source: US 93 North Wildlife Mitigation Final Report.

The total wildlife mitigation costs in the year 2010 were $4.8 million.

Map the estimated direct spending/employment associated with the new economic activity into the most appropriate of the 536 predefined IMPLAN economic sectors

For the example provided, the economic sector examined within the IMPLAN modeling framework was Sector 56 "Construction of New Highways and Streets." All mitigation structure spending falls neatly within this pre-defined sector.

Determine the temporal scope of the impact analysis

For the example, the construction is assumed to be completed in one year. The analysis year was 2010.

Run the I-O model to estimate the direct, indirect, and induced impacts to employment and income in the predefined economic analysis area.

The final step in the IMPLAN modeling was to estimate the IMPLAN models, and to examine and discuss the results.

IMPLAN Modeling Results

The regional economic impact example presented uses the total road construction and modification costs incurred to mitigate traffic-wildlife collisions and enhance wildlife movement along a section of US Highway 93 North. As noted, the total construction cost for the year 2010 was $4.8 million for wildlife mitigation activities. County-level models were not readily available for the counties where the mitigation primarily took place (Missoula and Lake Counties). For purposes of illustration, the following example uses the IMPLAN regional economic impact platform and data for two different Montana counties (Sanders and Yellowstone) to demonstrate the impact of mitigation measure spending on local county economic activity in terms of employment and labor income.

The two example counties used in this analysis represent the likely range of economic complexity and size for counties in the generally rural Western U.S. Sanders County has a population of just over 11,000 and a total Gross Regional Product of goods and services of roughly $250 million per year. At the other end of the spectrum is Yellowstone County, MT (the largest county in Montana, including the city of Billings) with a population of 159,000 and a total annual output of goods and services that is roughly 40 times greater than that of Sanders County, at $10 billion. The IMPLAN system utilizes economic data specific to a defined region (such as a county) within its modeling of spending impacts. The larger and more diverse and complex an economic area is, the larger the “spin-off” indirect and induced impacts of spending will be to other nearby areas that have a greater scope of available economic inputs including goods, services, and specialized labor skills.

The following tables (Table 7, Table 8) show the IMPLAN modeled impacts of $4.8 million in mitigation spending in the two example Montana counties. It is clear from the comparison of the two county models that the larger and more diverse Yellowstone County captures a much larger share of the indirect and induced effects of the original mitigation spending. Additionally, a larger share of income and value added is also captured in the larger county. Overall, total effects on labor income in the larger (Yellowstone) County are two times those in Sanders County. Employment in the Yellowstone County model is roughly 27% greater than in the case of the Sanders County Model. This is basically because Yellowstone County has a larger share of the physical inputs and contractors and workers with the skills to participate in a road construction project relative to the much smaller Sanders County.

Table 7. Example of Regional Impact of Wildlife Mitigation Spending in Sanders County, MT.

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	27.7	$1,131,304	$1,371,505	$4,806,721
Indirect Effect	6.3	$162,422	$251,857	$654,780
Induced Effect	4.9	$123,880	$248,592	$510,014
Total Effect	38.9	$1,417,606	$1,871,953	$5,971,515

Table 8. Example of Regional Impact of Wildlife Mitigation Spending in Yellowstone County, MT.

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	27.1	$1,660,656	$2,080,066	$4,806,721
Indirect Effect	9.2	$600,025	$938,756	$1,777,830
Induced Effect	13.1	$588,953	$967,924	$1,687,222
Total Effect	49.3	$2,849,635	$3,986,747	$8,271,773

Figure 2 shows a side-by-side comparison of county-level personal labor income impacts for the same sized mitigation structure investment in the example counties, the small Sanders and the large Yellowstone Counties.

While impacts to the local area economy are undeniably larger in larger, more-complex economic areas, it is important to note that in both counties the total regional economic impacts of the original mitigation spending contribute substantially to the area's employment, income and total output.

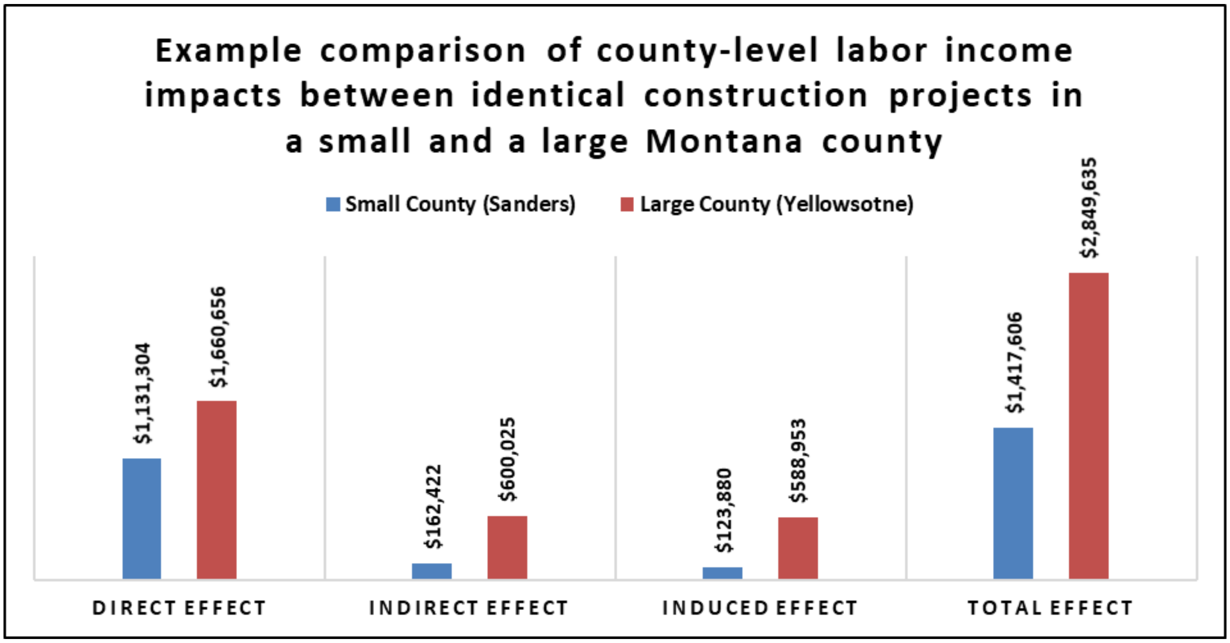


Figure 2. Example comparison of county-level labor income impacts between identical construction projects in a small and a large Montana county. (For each type of effect, the left (blue) bar represents the small county, and the right (red) bar represents the large county.)

Regional Economic Impacts associated with Wildlife Viewing

Regional economic impact modeling (such as with the IMPLAN modeling platform) is commonly used in the context of modeling impacts on employment and income of local area spending, such as in the previous example. A second use of the model, however, is to estimate the local area economic impacts associated with wildlife viewing expenditures (a non-consumptive recreational use of wildlife) or hunter spending (a direct consumptive use).

An example of the substantial benefits associated with one species/population comes from estimates of the direct annual visitor spending by visitors to Yellowstone NP specifically to view and/or hear wolves (Duffield, Neher and Patterson 2006). Duffield et al. conducted a year-long survey of YNP visitors on the issue of wolf viewing (among other issues). Responses from this survey indicated that visitors who would not have visited the park if wolves were not present spent an estimated $35.5 million in the 3-state economy (ID, MT, and WY) while on their trip to the park. Incorporating this estimate within an IMPLAN regional impact model of the 3-state economy results in an estimate that the wolf-related tourist spending within the greater Yellowstone ecosystem accounts for over $60 million dollars in total output of goods and services, and 1,460 jobs in the economy annually. While the high-profile nature and setting of the Yellowstone wolf example makes it somewhat unique, these results also clearly demonstrate that protection of a species in a local area through mitigation measures can be directly tied to additional substantial spending and employment spin-off impacts associated with wildlife viewing activities or other direct recreation such as hunting.

References

Amuakwa-Mensah F, R Bärenbold, and O Riemer. 2018. 'Deriving a Benefit Transfer Function for Threatened and Endangered Species in Interaction with Their Level of Charisma.' Environments 5:31.

Clawson, M. 1959. Methods of Measuring the Demand for and the Value of Outdoor Recreation, reprint no. 10, Washington DC: Resources for the Future.

Clawson, M. and J. Knetsch. 1966. Economics of Outdoor Recreation, Baltimore: John Hopkins Press

Davis, R. 1963. 'Big game hunting in the Maine woods', Natural Resources Journal, 3, 329–49.

Duffield, J. 1988. The net economic value of elk hunting in Montana. Montana Dept. Fish, Wildl. and Parks, Helena. 54 pp.

Duffield, J. 1991. Existence and non-consumptive values for wildlife: Application to wolf recovery in Yellowstone National Park. Pages 1-1-1-39 in C. L. Kling, ed., Benefits and costs in natural resource planning, Fourth Interim Rept., Univ. California, Davis. 380 pp.

Duffield, J. 1992. An economic analysis of wolf recovery in Yellowstone: Park visitor attitudes and values. Pages 2-35-2-87 in J. D. Varley and W.G. Brewster, e.• Wolves for Yellowstone? A report to the U.S. Congress. Vol. 4, Research and analysis. Nat. Park Serv., Yellowstone Nat Park, WY. 739 pp.

Duffield, J, and C. Neher. 1996. "Economics of Wolf Recovery in Yellowstone National Park". Trans. 61st No. Am. Wildl. and Natur. Resour. Conf. (1996): 285-292.

Duffield, J, Neher, C, and D Patterson. 2006. "Wolves and People in Yellowstone: Impacts on the Regional Economy." Report for the Yellowstone Park Foundation. Bozeman, MT. 67 pp.

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

Duffield J, C Neher, and D Patterson. 2016. "Colorado River Total Value Study." Report for the National Park Service. August 2016. Fort Collins, CO.

Duffield, John W., Chris J. Neher, David A. Patterson, and Patricia A. Champ. 2006. "Do Fishermen Lie: Measuring Hypothetical Bias across Response Formats". Pp 86-114 in Klaus Moeltner, comp. Benefits and Costs of Resource Policies Affecting Public and Private Lands. Proceedings from the W1133 Annual Meeting, San Antonio, Texas, February 22-25, 2006. Nineteenth Interim Report. University of Nevada, Reno, Department of Resource Economics.

Duffield, J. W. and D. A. Patterson. 1991. Inference and optimal design for a welfare measure in dichotomous choice contingent valuation. Land Econ. 67(2): 225-239.

Duffield, J. W. and D. A. Patterson. 1992. "Field Testing Existence Values: Comparison of Hypothetical and Cash Transaction Values" in R. Bruce Rettig, ed., Benefits and Costs in Natural Resource Planning Corvallis: Department of Agricultural and Resource Economics, Oregon State University.

Federal Energy Regulatory Commission (FERC). 1984. initial decision, Northern Lights, Inc. Project no. 2752–000, 23 April.

Federal Energy Regulatory Commission (FERC). 1987. "Opinion no. 276, Northern Lights, Inc. Project No. 2752-000, order and opinion affirming initial decision denying license for Kootenai Falls development."

Glass GV. 1976. Primary, secondary, and meta-analysis of research. Education Resources 5(10): 3-8.

Harpman, D.A., M.P. Welsh and R.C. Bishop. 1995. "Non-use economic value: emerging policy analysis tool." Rivers, 4(4), 280–91.

Hoehn, J., and A. Randall. 1989. "Too Many Proposals Pass the Benefit Cost Test." American Economic Review. Pp.544-551.

Huijser M, J Duffield, A Clevenger, R Ament, and P McGowen. 2009. "Cost–Benefit Analyses of Mitigation Measures Aimed at Reducing Collisions with Large Ungulates in the United States and Canada: A Decision Support Tool." Ecology and Society 14(2).

Huijser, M.P., W. Camel-Means, E.R. Fairbank, J.P. Purdum, T.D.H. Allen, A.R. Hardy, J. Graham, J.S. Begley, P. Basting & D. Becker. 2016. US 93 North post-construction wildlife-vehicle collision and wildlife crossing monitoring on the Flathead Indian Reservation between Evaro and Polson, Montana. FHWA/MT-16-009/8208. Western Transportation Institute – Montana State University, Bozeman, Montana, USA

Knetsch, J. and R. Davis. 1966. “Comparison of methods for recreation evaluation” in Allen V. Kneese and Stephen C. Smith (eds), Water Research, Baltimore: Johns Hopkins Press for Resources for the Future, pp. 125–42.

Krinsky, I. and A. L. Robb. 1986. On approximating statistical properties of elasticities. Rev. Econ. and Stats. 68: 715-719.

Krutilla, J. 1967. “Conservation reconsidered.” American Economic Review, 57(4), 777–86.

Loomis, J. B., & White, D. S. 1996. Economic benefits of rare and endangered species: summary and meta-analysis. Ecological Economics, 18(3), 197-206.

McFadden, D. 1998. Measuring willingness-to-pay for transportation improvements. Theoretical foundations of travel choice modeling, 339, 364.

Mclennan D, P van Beukering, M Schaafsma, and Nieuwenhuis.2009. “The economic value of wildlife: a meta-analysis” unpublished draft proceedings paper.

National Research Council. 1996. River Resource Management in the Grand Canyon, Washington, DC: National Academy Press.

Neher C, J Duffield, and D Patterson. 2013. “Valuation of National Park System Visitation: The Efficient Use of Count Data Models, Meta-Analysis, and Secondary Visitor Survey Data.” Environmental Management (2013) 52:683-698.

Nelson JP and Kennedy PE. 2008. The use (and abuse) of meta-analysis in environmental and resource economics: an assessment. Working paper. Department of Economics, Penn State University, University Park.

Pandit, R., Subroy, V., Garnett, S.T., Zander, K.K. and Pannell, D. 2015. A review of non-market valuation studies of threatened species and ecological communities. Report to the National Environmental Science Programme, Department of the Environment, Canberra. 18 December 2015.

Preusch, M. 2008. “Rogue River dams to come down.” The Oregonian, 8 June.

Randall, A. and J. Stoll. 1983. “Existence Value in a Total Valuation Framework.” IN Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas. (Rowe and Chestnut, Eds. 1983).

Richardson, L., & Loomis, J. 2009. The total economic value of threatened, endangered and rare species: an updated meta-analysis. Ecological Economics, 68(5), 1535-1548.

Smith VK and Kaoru Y. 1990. Signals or noise? Explaining the variation in recreation benefit estimates. American Journal of Agricultural Economics 72(2):419-433.

U.S. Fish and Wildlife Service. 1993. The reintroduction of gray wolves to Yellowstone National Park and central Idaho. Draft environmental impact statement, U.S. Fish and Wtldl. Serv., Helena, Mr. 601 pp.

U.S. Fish and Wildlife Service. 1994. The reintroduction of gray wolves to Yellowstone National Park and central Idaho. Final environmental impact statement, U.S. Fish and Wildt. Serv., Helena, Mr.414 pp.

U.S. Fish and Wildlife Service. 2000. Grizzly bear recovery in the Bitterroot Ecosystem. Final Environmental Impact Statement. Missoula, MT.

Walsh R, Johnson D, McKean J. 1988. Review of Outdoor Recreation Demand Studies with Nonmarket Benefit Estimates, 1968-1988. Technical Report 54, Colorado Water Resources Research Institute, Colorado State University, Fort Collins.

Ward, K. M. and J. W. Duffield. 1992. Natural resource damages: Law and economics. John Wiley and Sons, Inc., New York, NY.684 pp.

Weisbrod, B. 1964. “Collective Consumption Services of Individual Consumption Goods.” Quarterly Journal of Economics. 78 pp. 471-477.

Welsh, M., R. Bishop, M. Phillips and R. Baumgartner. 1995. Glen Canyon Dam, Colorado River Storage Project, Arizona-nonuse value study final report, Madison.

Wood, S. and A. Trice. 1958. “Measurement of recreation benefits.” Land Economics, 34(3), 195–207.

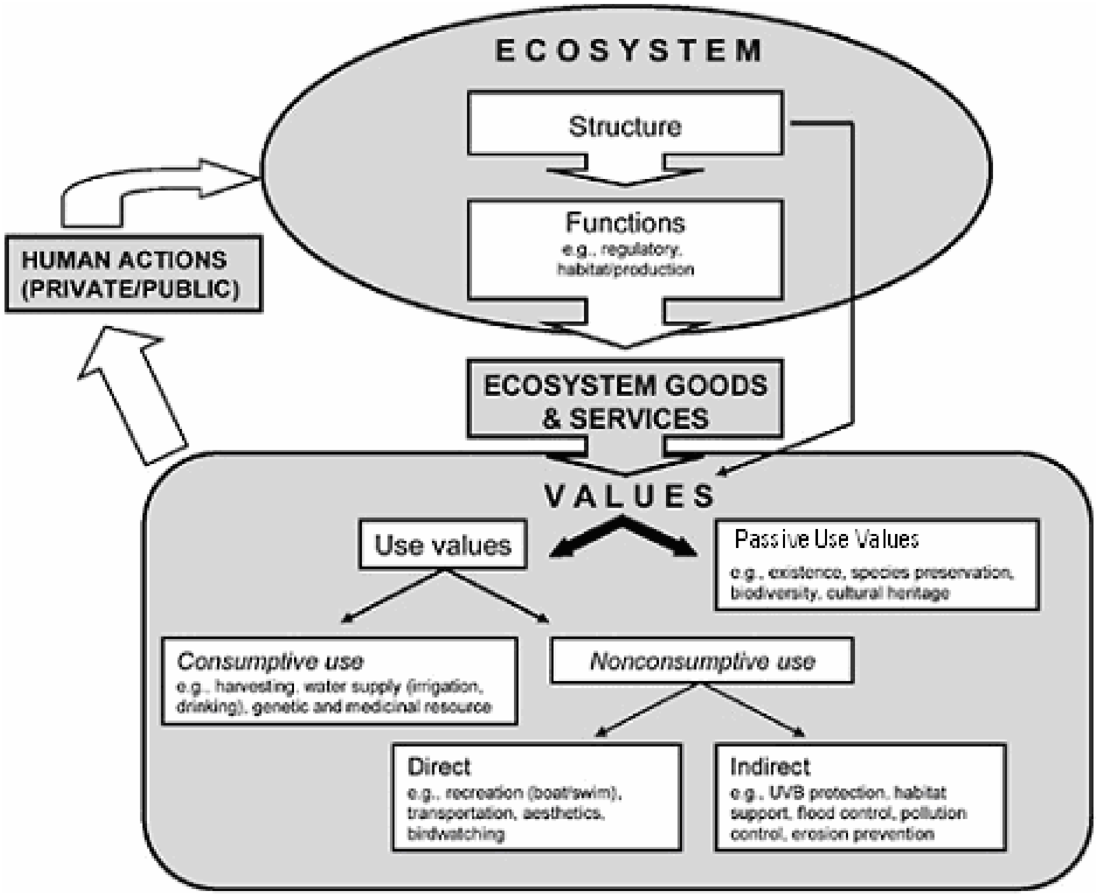
Appendix A: Methods Associated with Passive Use Value Estimation

Wildlife Valuation Concepts and Methods

There is a deep and rich literature in the natural resource economics field related to valuation of wildlife. Estimated values associated with wildlife species fall into several classifications. The National Research Council in its 2004 publication "Valuing Ecosystem Services: Toward Better Environmental Decision Making" provided a general overview of the benefits that derive from ecosystem services. Figure 3 diagrams this generic flow of ecosystem services (including those associated with wildlife species).

As can be seen in Figure 3, several kinds of services, or uses, derive from natural systems. One dichotomy is between direct use and passive use. Direct use includes viewing or hunting a wildlife species. However, individuals who have no expectation to ever see or hunt may still place a value on knowing certain species are present in the ecosystem. This has been demonstrated in numerous studies and is exemplified by the donations that support wildlife conservation organizations, such as the World Wildlife Fund, for the protection of species, such as pandas in China that the donor will likely never see. Such values are termed passive use values and are not dependent on direct on-site use. Several of the possible motives for nonuse values were first described by Weisbrod (1964) and Krutilla (1967), and include existence and bequest values. Existence values can derive from merely knowing that a given natural environment or population exists in a viable condition. These values would be expected to be greatest for species and populations that are in danger of extinction. Bequest values derive from the interest in protecting wildlife species and associated natural environments for use and enjoyment by future generations.

While direct use services may or may not have associated developed markets for them, passive use services are exclusively non-market services. When passive use and direct use values are estimated together, the estimate is referred to as total valuation. This concept was first introduced by Randall and Stoll (1983) and has been further developed by Hoehn and Randall (1989).



Source: NRC, 2004

Figure 3. Flows of Ecosystem Services (adapted from NRC 2004)

Consideration of Passive Use Values in Public Policy Decisions

In the past several decades the concept of passive use value has played an ever-increasing role in decision-making on a broad range of public policy decisions and plans for use and operation of public infrastructure.

Benefit-cost analysis as a field of economics was first developed in the context of water resource development. The Flood Control Act of 1916 was the first instance of a requirement that a proposed federal project must pass a benefit-cost test. The earliest examples where passive use values played a clear and decisive role in benefit-cost decision making for a court or government agency are found in the context of proposed construction of, operation of, or removal of dams on western rivers. Benefit-cost analysis has a long history and many applications, and a positive benefit-cost ratio is still a required value for the Federal Energy Regulatory Act (formerly the Federal Power Act). Beginning in the 1950s recreation values were beginning to be utilized in benefit-cost decision making (Clawson 1959; Krutilla 1968). Passive use values began to be incorporated in this context in the early 1980s. Huijsier et al. (2009) introduced the use of this tool to the application in road ecology.

While the benefits of hydropower are principally the provision of a marketed commodity at a cost lower than the next best alternative source of power, the potential foregone values provided by flooding riparian and whitewater rivers and unblocked fish passage and other impacts on wildlife and natural environments are often not priced and must be evaluated through other means. This is aside from some natural resource industries like commercial fishing. These values include both direct on-site use, such as sportfishing, boating and wildlife observation, but also passive use, which, as noted previously, includes the value associated with the existence of natural environments and related biota and the desire to bequest these resources to future generations, independent of one's own direct use (Krutilla, 1967). Dams such as Grand Coulee on the Columbia River led to the extinction of the huge "June hogs" salmon on the Columbia. As noted, the fact that individuals will donate money for the protection of species such as pandas or tigers, which they have no expectation of ever even seeing, is evidence of these values. The methods for measuring these values have come to be known as non- market valuation and had their origin in the development of the travel cost model (Wood and Trice, 1958; Clawson, 1959; Clawson and Knetsch, 1966) and the contingent valuation method (Davis, 1963; Knetsch and Davis, 1966). The travel cost model is a type of revealed preference model where estimates are derived from observed behavior; contingent value is a type of stated preference and relies on survey research. Passive use values can only be estimated through stated preference methods.

One of the first instances of the use of passive use values to inform public policy decisions on approval of a proposed hydroelectric dam was in the case of the proposed Kootenai Falls hydroelectric project in northwest Montana in 1978. This case is of interest in that: (1) it was a legal case decided initially by an administrative law judge, (2) a site-specific total valuation study (including direct recreation and passive use values) was undertaken, (3) contingent valuation estimates were accepted into evidence, (4) a subset of the contingent valuation estimates of direct recreational values (but not indirect or 'passive use' values) in this case were introduced and were deemed credible despite opposing testimony, and (5) the license application was denied both by the Administrative Law Judge (ALJ) in the initial decision (FERC, 1984) and by Commission order (FERC, 1987) pursuant to the 1986 amendments to the Federal Power Act.

In preparation for the Kootenai Falls case a contingent valuation survey was implemented designed to measure both recreational use value as well as non-use, or passive use values of preservation of the falls in an un-dammed state. The estimates of forgone direct and indirect uses of the falls bracketed the estimated direct net benefits of the proposed hydroelectric facility. The ALJ hearing the case for the FERC issued his initial decision in April, 1984 and chose to reject the utility's license application (FERC, 1984); the ALJ's decision turned on the esthetic and recreation values:

> The conflicting interests instrumental in the denial of the application are the changes in the sensual and recreational values that would be caused to the Kootenai Falls by the proposed Project, and the adverse effect the Project would have on the Kootenai Indians to whom the Kootenai Falls have a special meaning. Even if there were no adverse effect on the Kootenais, the undesirable changes in sensual and recreational values under these circumstances would result in a denial of the license. (Ibid., p. 6)

In its decision, the ALJ did not rely on specific dollar estimates of indirect (passive use) values presented in the proceedings, but stated, "these indirect values are an important aspect of the decision that no license should issue." (Ibid.)

Within the context of informing public decisions on operation of existing dams, passive use values are an indication of the national significance of resources like the river and river corridor through the Grand Canyon (Harpman et al., 1995). These values are associated with knowing that these resources are in a viable condition and with wanting future generations to also be able to enjoy this heritage. Welsh et al. (1995) applied dichotomous choice contingent valuation methods to estimate willingness-to-pay to improve native vegetation, native fishes, game fish (such as trout), river recreation and cultural sites in Glen Canyon National Recreation Area downstream of Glen Canyon Dam and in Grand Canyon National Park.

This social cost–benefit analysis shows a significant net benefit of modifying Glen Canyon Dam water releases from the procedures used since the dam was constructed to a more moderate fluctuating flows scenario. While the non-use study for the Colorado River corridor in Grand Canyon National Park (Welsh et al., 1995) was completed too late to be fully utilized in the 1995 EIS, the study findings did have an influence on the EIS outcome and were favorably reviewed by a National Research Council panel:

> The GCES [Glen Canyon Environmental Studies] nonuse value studies are one of the most comprehensive efforts to date to measure nonuse values and apply the results to policy decisions. . .. While not completed in time to be reported in the final EIS, the nonuse value results are an important contribution of GCES and deserve full attention as decisions are made regarding dam operations (National Research Council, 1996, p. 135).

When certain guidelines are followed, such studies as the Welsh et al. (1995) study are recommended for use in natural resource damage. Willingness-to-pay analyses have also been upheld in court and specifically endorsed by a NOAA-appointed blue-ribbon panel (led by several Nobel laureates in economics). These methods are widely used in determining economic losses in the context of natural resource damage assessment (CERCLA, NOAA). They are also used in regulatory settings (EPA guidelines) and, as noted, benefit-cost analyses are required for all significant Federal actions by Executive Order 12866.

U.S. Governmental agencies also recognize the importance of including accounting for changes in passive use values in agency decision-making. In 1996, then Secretary of the Interior, Bruce Babbitt signed the Record of Decision on operations of Glen Canyon Dam. Included in this decision was an explicit recognition that the non-use (passive use) values of one alternative outweighed the predicted financial benefits of another alternative. The ROD noted:

> [The] Alternative was selected as the preferred alternative because it would provide the most benefits with respect to the original selection criteria, given existing information. This alternative would create conditions that promote the protection and improvement of downstream resources while maintaining some flexibility in hydropower production. Although there would be a significant loss of hydropower benefits due to the selection of the preferred alternative (between $5.1 and $44.2 million annually) a recently completed non-use value study conducted under the Glen Canyon Environmental Studies indicates that the American people are willing to pay much more than this loss to maintain a healthy ecosystem in the Grand Canyon. The results of this nonuse value study are summarized in Attachment 3 of the ROD. (Record of Decision, Operation of Glen Canyon Dam Final EIS, October 1996. Signed by Bruce Babbitt, Secretary of the Interior [emphasis added])

In 2016, the operation of Glen Canyon Dam was once again examined in the Long-Term Environmental Management Plan (LTEMP) FEIS. This large NEPA analysis included results of a replication study of the original Welsh et al. (1995) passive use value study (Duffield et al. 2016). The estimates of passive use values associated with expectations for improvements or stabilization in beach size and number, and in humpback chub populations (an ESA-listed species), played a significant role in informing the economic costs and benefits associated with the seven FEIS alternatives considered for water release from the dam.

Final dam-related examples of the use of passive use values in public policy decisions is in recent dam removal decisions. Two dams have been removed on the Elwah River to restore historic anadromous fisheries; this is a case where passive use values were estimated and appear to have influenced the decision (Loomis, 1996). Another significant restoration effort is also underway on the Rogue River, where four major federal dams, Gold Ray, Elk Creek, Savage Rapids and Gold Hill Dam, have been or are in the process of being removed (Preusch, 2008). On the Klamath River in Northern California and Southern Oregon four dams are under consideration for removal (J.C. Boyle, Irongate, and Copco 1 and 2). A large agency-sponsored passive use survey was undertaken to estimate the values residents and the public at large attribute to restoring and supporting traditional anadromous fish runs in the river through dam removal.

The examples given of passive use values informing public investment decisions have largely been driven by ESA considerations—listed fish species in the case of operation of Glen Canyon Dam, and listed salmon and steelhead in the case of the Oregon and California dams. Given that ESA listed species are also at risk for wildlife-vehicle collisions, the passive use values associated with protection of these species should play a role in the cost-benefit calculations associated with evaluating proposed collision mitigation projects.

Types of Wildlife Economic Values

In the context of incorporating direct use and passive use values associated with wildlife into the benefit cost analysis of wildlife collision mitigation spending, it is important to recognize that different species have different measures of economic value associated with their protection. This distinction is based, at least partially, in differences in "accounting frameworks" used to measure the values. One distinct framework is regional economic impact. This accounting framework measures distribution changes in income and employment across the larger economy resulting from changes in spending. An associated value (within the context of the regional economic impact framework) might be hunter spending associated with hunting the species in the local area. In this framework, increases in spending by hunters or wildlife watchers in one area are likely largely offset by decreases in another area of the economy. A second accounting framework (which is not generally zero-sum), which has its basis in applied welfare economics, is benefit-cost accounting. Some species, such as ESA-listed small mammals, reptiles, or amphibians might have little to no identifiable direct use value, but may nonetheless have passive use value associated with "existence" or "bequest" value to people living far removed from the species. Table 9 provides a general taxonomy of different likely characteristics and associated values for a number of potentially impacted wildlife species.

Table 9. Characteristics and Economic Values Associated with Selected Wildlife Species

Species	Population size/distribution	Listed as T&E or special management?	Direct Use Values	Passive Use Values
Elk and Deer	Large/widespread	Generally, no	Hunting Wildlife viewing	Possible Existence & Bequest
Wolves	Localized to regional	Threatened/endangered	Hunting/trapping Wildlife viewing	Existence & Bequest
Grizzly Bear	Localized to regional	Threatened/endangered	Wildlife viewing, hunting	Existence & Bequest
Desert Tortoise	Small/ localized	Threatened/endangered	Limited viewing	Existence & Bequest

Incorporation of wildlife direct and passive use values within mitigation structure benefit-cost calculations requires a measure of wildlife value not generally measured and reported in the literature. Most studies of passive use values of wildlife denominate estimates of value in terms of dollars per household per year, or an aggregated value associated with protecting a specific wildlife population. In terms of mitigation spending benefit-cost analysis, the most useful measure of wildlife value is in terms of per-animal that is, per animal life saved by collision avoidance.

Value per household or total species valuation could be converted to value per individual animal through simple use of total species value divided by species population. The obvious result of this type of conversion is that species with very small populations, such as localized endangered species, could have very large per individual values while some species with widespread populations, such as elk, might have comparatively small values. It is important to recognize that passive use values are not only found for existence of a given species, but may also be associated with given populations. This parallels the recognition of “distinct population segments” in the Endangered Species Act. This is important for wildlife mitigation applications since a given road segment may have an impact on a local distinct population segment but a much more modest impact on the entire species. Valuation of some sub-populations (such as Northern Rockies wolves, or Grizzly bears) may be associated with relatively high per animal values in the context of that sub-population, but less so in the context of the greater world-wide population.

Methods: Potential Sources for Wildlife Passive Use Values

Given the diversity of potential species impacted by wildlife-vehicle collisions, and the relative scarcity of previously conducted passive-use value studies producing valuation estimates for individual terrestrial species, there are obvious challenges to providing passive use values from current data at the species and location level of detail. In general terms, there are five potential sources of wildlife valuation estimates.

1. Use of a previously estimated passive use value for the species in the setting desired.
2. Benefit Transfer: use of an estimate from a different setting, location, or even species as an appropriate proxy for an existing location and species-specific estimate.
3. Meta-Analysis: use of a valuation estimate derived from a larger comprehensive meta-analysis of existing species valuation studies.
4. Original valuation study specific to the species/population at issue.
5. Government expenditure decisions that reveal a minimum value for a given resource.

These methods are discussed in turn.

Use of an available passive use value for a species

In the context of evaluating the benefit-cost equation for a specific collision mitigation measure at a specific location, and relative to a specific species, having available and off-the-shelf appropriate wildlife passive use value is the least likely source of value data. An example of this might be use of an existing estimate of passive use values for wolves or grizzlies that was originally estimated for the same geographic region in which mitigation structure is being considered. This method will generally, at a minimum, require updating of value estimates to current dollar values using the CPI or other such appropriate index.

Benefit Transfer of available passive use values

A second method frequently used in the economics literature is that of benefit transfer. This method finds an estimate of value from another setting (the original study) and applies it to the current setting. For example, this might use a value for the desired species but from a study conducted for a different geophysical/cultural setting, and with a different human sample population. Less straightforward, benefit transfer may also be considered for a different, but related species. The ability to find an appropriate existing value estimate to transfer can provide an efficient and cost-effective alternative to conducting original economic valuation research. However, care must be taken to ensure the value to be transferred is a valid proxy for the current setting.

Benefit transfer can be applied in a number of ways to use existing passive use values in a similar but distinct setting. A common method is called “point estimate transfer” and entails identifying an existing study and associated value estimate that can be applied (or transferred) to the current case. Benefit transfer is likely to be more precise when:

- The animals valued are almost identical,
- The same human population is involved (same country, for instance),

- The extent of the change being considered is the same in both original and current cases, and
- The initial valuation study has been performed rigorously and accurately.

While the conditions above are the goal in point estimate transfer, in practice most applications of benefit transfer involve greater differences between original and current studies. The process of benefit transfer involves a number of distinct steps.

- Assessing the current case: This includes an assessment of the site characteristics, the animal population being analyzed, and the human population likely to be affected.
- Identifying Source Studies: The criteria for selecting suitable source studies might include factors such as similarities between original and current settings, the type of source study available, the age of the source study, the type of statistical modeling performed in a source study, and the rigor of the source study (including sample size, validity tests performed and the strength of statistical relationships observed).
- Assess Site Differences: Key characteristics of a study site might include the physical characteristics; the type of policy or development changes being considered; the types of impacts being generated, including physical, environmental, social and economic impacts; and the size of the changes involved.
- Assess Population Differences: Different populations may hold different preferences for the benefits involved in a case study situation. This is particularly the case where passive use values are involved, and different populations have different levels of involvement with, or use of a particular resource. For example, tribal uses are unique to Tribes and unique among Tribes.

In addition to these considerations, in applying benefits transfer attention should be paid to understanding the "framing issues" of the original study and any unique statistical modeling issues relative to the original study that might not be appropriate for the setting to which the value is being transferred.

When care is taken to understand the similarities and differences between the original and current settings, benefit transfer can offer an efficient method of finding and utilizing passive use values in a new, but comparable setting.

Beyond the method of point-estimate benefit transfer, there are more complex methods such as "function transfer" where the covariates in a valuation function from the original study are modified to the extent possible to match the setting and characteristics of the current site and setting. This type of transfer can be used to, at least somewhat, correct for obvious differences between the original study and the current case.

Use of meta-analysis for passive use value estimation

In terms of complexity, as well as potential flexibility, meta-analysis provides a special case of benefit transfer where a predictive model of species valuation is estimated, including a range of species-specific and modeling-specific variables which allow the resulting model to be used to predict values for a broad range of species in a range of settings.

Meta-regression analysis modeling studies have seen a dramatic increase in the literature in recent years. First described by Glass (1976), the method is currently applied across a wide spectrum of disciplines, including the social and health sciences, business, and education. Early applications of meta-analysis within the field of resource economics include Smith and Kaoru (1990) and Walsh, Johnson and McKean (1990). Nelson and Kennedy (2008) identified 140 meta-analysis studies, of which one-half focused on environmental issues.

The structure of a meta-analysis is to gather a set of valuation estimates, describe key characteristics of each estimate within the dataset, and use the site characteristics to "explain" observed variation across WTP estimates from the primary studies.

Loomis and White (1996) provided the first aggregation of the literature on wildlife passive use values and associated meta-analysis. They standardized and reported the economic value of threatened and endangered species to citizens of the U.S. based on 20 contingent valuation studies for 18 different wildlife species. Loomis and White found that changes in species population size, if the respondent was a visitor or non-user, and if the species was a marine mammal or bird, explained a majority of the variation in willingness to pay. Richardson and Loomis (2008) updated the earlier meta-analysis study to include studies conducted through 2001. The study detail reported by Richardson and Loomis as well as average species values are included in Appendix B to this report. As noted, all values reported in the Richardson and Loomis meta-analysis are presented in terms of dollars per household per year. Construction of a meta-analysis data set requires assumptions related to the comparability of the valuation estimates included. Examples include how non-response to the underlying surveys is treated (as zero values or as mean values), assumptions related to the extent of the market, or comparability of valuation methodology. Some of these issues are modeled explicitly in the structure of the meta-regression model, while others are less obvious.

Given a broad enough set of underlying valuation studies and a comprehensive set of descriptor variables for the species included, the valuation methods employed, and the settings of the studies, the use of meta-analysis can be a very cost-effective method of leveraging previously collected data into a modeling framework that can be used to provide economic valuation estimates to a wide range of settings. For example, Neher, Duffield, and Patterson (2013) utilized park visitor valuation estimates from 58 original National Park Service visitor surveys to construct a meta-analysis model of park visitor willingness to pay (non-market value per park visit) that has been employed by the NPS to estimate visitation values across the 400-plus individual NPS park units.

The concern with applying currently available meta-analysis models to the issue of providing species-level passive use values for collision mitigation benefit-cost analysis is that when ocean-dwelling animals, freshwater fish, and birds are removed from the underlying Richardson and Loomis passive use data set, only three terrestrial species remain. It should be noted that this 2008 (data through 2001) listing of passive use values could be supplemented currently with additional passive use values for some T&E species (such as grizzly bears) and other non-listed species (such as elk). A thorough literature search of all wildlife passive use values (not just for T&E species) may well expand the Richardson and Loomis data significantly. Accordingly, meta-analysis may provide a promising avenue with which to model and derive a wide range of terrestrial wildlife passive use values for future use in wildlife mitigation benefit-cost analysis.

A 2018 meta-analysis of the economic values associated with protection of threatened and endangered species expanded the set of passive use value estimates used by Richardson and Loomis (2008) by including estimates from the literature from after 2001, estimates from countries other than the U.S., and estimates including rare domestic livestock species (Amuakwa-Mensah et al. 2018). This analysis used 81 unique estimates, and included explanatory indicator variables for U.S. vs. foreign studies, fish, reptiles, and terrestrial mammals, as well as standard methodology, sample and response rate variables. The study also dichotomized species into “charismatic” and non-charismatic species and models interaction terms between threatened and endangered status and charismatic status. The model provides an analytic path for estimating passive use values for classes of animals (reptiles, birds, terrestrial mammals, etc.) using sample means and assumed best practices for study covariates. It, however, does not address the underlying challenge in the current analysis of providing “per-animal” passive use values. At best, it helps inform differences between the passive use values of different classes of T&E species on the value-per-household level. Finally, the meta-model includes some variables that on the surface seem counter-intuitive. For instance, the model implies that an endangered species with “high charisma” is worth substantially less than an endangered species with “low charisma.” This result is likely a statistically significant artifact of the underlying studies used in the regression, but still raises questions about how robust the model predictions might be to new species and settings.

Original Valuation Studies

Of course, it is always possible to undertake original valuation studies specific to the population or species of interest. This may be the best course of action in a given case where wildlife mitigation is considered, but it does require funding and time to implement, but possibly no more than the time frame for mitigation design and costing. Design and implementation of an original valuation study may require one to several years to implement and require from $100,000 to several million dollars, depending on the legal and policy setting. Generally, the process involves holding focus groups, designing survey instruments and sampling plans, implementing a pre-test, administering the final survey, analysis and report writing. A confounding issue with original survey research funded through federal appropriations is they require a lengthy review of all survey design and instruments by the Office of Management and Budget. These types of original passive use value studies have been conducted in the case of the Exxon Valdez oil spill (Carson et al. 1989), operation of Glen Canyon Dam (Welsh et al. 1995; Duffield et al. 2016), removal of dams on the Klamath river to restore salmon and steelhead runs (Mansfield et al. 2012), and estimating national level losses due to the BP Deepwater Horizon oil spill (Bishop et al. 2016).

Government Expenditure Decisions

A final method of estimating a per-animal value for a species that can be specifically appropriate for listed species is to examine public expenditures to protect and preserve the species and rely on this spending as a direct reflection of the minimum value society places on the species and individuals within it. This approach was suggested by McFadden (1998) as an alternative to other methods of economic valuation. In an application, McFadden used data on the increased costs of routing transportation corridors around a park as a measure of the value of a given park. Similarly, for a specific species one could use the mitigation costs for a different already completed project within the species habitat divided by the number of assumed individuals from the species in the project area to arrive at the implied minimum existence (passive use) value for the species in the case of that project. This type of analysis is likely to be project-specific. One could also total preservation and protection costs spent specifically for preservation of given species across the species' range and divide this by the species population. The attractiveness of this cost-based approach lies in the fact that it is based in actual observed economic transactions rather than surveys of willingness to pay.

Appendix B: Richardson and Loomis (2008) Threatened and Endangered Species Passive Use Values

Table 10. Willingness to Pay (WTP) per household ($2006) for threatened and endangered species

Reference	Survey Date	Species	Gain or loss	Size of change	Lump Sum	Annual	CVM method	Survey region	Sample size	Response rate	Payment vehicle
Bell et al. (2003)	2000	Salmon	Gain	100%		$138.64	DC	Grays Harbor, WA households	357	49.1%	Annual tax – high income
						$91.55					Annual tax – low income
			Gain	100%		$141.27		Willapa Bay, WA households	386	61.7%	Annual tax – high income
						$90.64					Annual tax – low income
			Avoid loss	100%		$57.99		Coos Bay, OR households	424	58.4%	Annual tax – high income
						$47.70					Annual tax – low income
			Avoid loss	100%		$91.99		Tillamook Bay, OR households	347	53.2%	Annual tax – high income
						$28.39					Annual tax – low income
			Avoid loss	100%		$134.00		Yaquina Bay, OR households	357	59.7%	Annual tax – high income
						$87.84					
Berrens et al. (1996)	1995	Silvery minnow	Avoid loss	100%		$37.77	DC	NM residents	726	64.0%	Trust fund
Bowker and Stoll (1988)	1983	Whooping Crane	Avoid loss	100%		$43.69	DC	TX and US households	316	36.0%	Foundation
		Whooping Crane	Avoid loss	100%		$68.55	DC	Visitors	254	67%	Foundation
Boyle and Bishop (1987)	1984	Bald Eagle	Avoid loss	100%		$21.21	DC	WI households	365	73%	Foundation
		Striped Shiner	Avoid loss	100%		$8.32	DC				

Chambers and Whitehead (2003)	2001	Gray wolf	Avoid loss	100%	$22.64		DC	Ely and St. Cloud, MN households	352	56.1%	One-time tax
Cummings et al. (1994)	1994	Squawfish	Avoid loss	100%		$11.65	OE	NM	723	42%	Increase state taxes
Duffield (1991)	1990	Gray wolf	Re-introduction		$93.92		DC	Yellowstone National Park visitors	158	30.6%	Lifetime member-ship
Duffield (1992)	1991	Gray wolf	Re-introduction		$162.10		DC	Yellowstone National Park visitors	121	86%	Lifetime member-ship
Duffield et al. (1993)	1992	Gray wolf	Re-introduction		$37.43		DC	ID, MT, WY household	189	46.6%	Lifetime member-ship
USDOI (1994)	1993	Gray wolf	Re-introduction		$28.37		DC	ID, MT, WY household	335	69.6%	Lifetime member-ship
USDOI (1994)	1993	Gray wolf	Re-introduction		$21.59		DC	ID, MT, WY household	345	69.6%	
Duffield and Patterson (1992)	1991	Artic grayling	Improve 1 of 3 rivers	33%	$26.47		PC	US visitors	157	27.3%	Trust fund
		Artic grayling		33%	$19.84		PC	US visitors		77.1%	Trust fund
Giraud et. al. (1999)	1996	Mexican spotted owl	Avoid loss			$68.84	DC	US households	688	54.4%	Trust fund
Giraud et al. (2002)	2000	Stellar sea lion	Avoid loss	100%		$70.90	DC	AK and US households	1653	63.6%	Increase federal tax
Hageman (1985)	1984	Bottlenose dolphin	Avoid loss	100%		$36.41	PC	CA households	180	21.0%	Increase federal tax
		Northern elephant seal	Avoid loss	100%		$34.50	PC		174		
Hageman (1985)	1984	Gray-blue whale	Avoid loss	100%		$45.94	PC	CA households	180	21.0%	Increase federal tax
		Sea otter	Avoid loss	100%		$39.80	PC		174		

Hagen et al. (1992)	1990	No. spotted owl	Avoid loss	100%		$130.19	DC	US households	409	46.0%	Taxes and wood prices
King et al. (1988)	1985	Bighorn sheep	Avoid loss	100%		$16.99	OE	AZ households	550	59.0%	Foundation
Kotchen and Reiling (2000)	1997	Peregrine falcon	Gain	87.5%	$32.27		DC	ME residents	206	63.1%	One-time tax
Layton et al. (2001)	1998	Eastern WA and Columbia River Freshwater Fish	Gain	50%		$210.84	CE	WA households	801	68.0%	Monthly payment
		Eastern WA and Columbia River Migratory Fish	Gain	50%		$146.57					(converted to annual)
		Western WA & Puget Sound Freshwater Fish	Gain	50%		$229.31					
		Western WA & Puget Sound Migratory Fish	Gain	50%		$307.76					
		Western WA & Puget Sound Saltwater Fish	Gain	50%		$311.31					
Loomis (1996)	1994	Salmon and steelhead	Gain	600%		$79.53	DC	Challam County, WA households	284	77.0%	Increase federal tax
		Salmon and steelhead	Gain	600%		$98.41	DC	WA households	467	68.0%	
		Salmon and steelhead	Gain	600%		$91.67	DC	US households	423	55.0%	
Loomis and Ekstrand (1997)	1996	Mexican spotted owl	Avoid loss			$51.52	MB	US households	218	56%	

Loomis and Larson (1994)	1991	Gray whale	Gain	50%		$23.65	OE	CA households	890	54.0%	Protection fund
		Gray whale	Gain	100%		$26.53	OE	CA households	890	54.0%	
		Gray whale	Gain	50%		$36.56	OE	CA visitors	1003	71.3%	Protection fund
		Gray whale	Gain	100%		$43.46	OE	CA visitors	1003	71.3%	
Olsen et al. (1991)	1989	Salmon and steelhead	Gain	100%		$42.97	OE	Pac. NW households	695	72.0%	Electric bill
			Gain	100%		$95.86	OE	Pac. NW HH option		72.0%	
			Gain	100%		$121.40	OE	Pac. NW anglers	482	72.0%	
Reaves et al. (1994)	1992	Red-cockaded woodpecker	% chance of survival	99%		$14.69	OE	SC and US households	225	53.0%	Recovery fund
				99%		$20.46	DC		223	52.0%	
				99%		$13.14	PC		234	53.0%	Un-specified
Rubin et al. (1991)	1987	No. Spotted owl	% chance of survival	50%		$38.61	OE	WA households	249	23%	
				75%		$39.99	OE				
				100%		$60.84	OE				
Samples and Hollyer (1989)	1986	Monk seal	Avoid loss	100%	$165.80		DC	HI households	165	40.0%	Preservation fund
		Humpback whale	Avoid loss	100%	$239.53		DC				Money and time
Stanley (2005)	2001	Riverside fairy shrimp	Avoid loss	100%		$28.38	PC	Orange County, CA households	242	32.1%	Annual tax
Stevens et al. (1991)	1989	Wild Turkey	Avoid loss	100%		$11.38	DC	New England households	339	37.0%	Trust fund
			Avoid loss	100%		$15.36	OE	New England households			
		Atlantic salmon	Avoid loss	100%		$10.00	DC	MA households	169	30.0%	Trust fund
		Atlantic salmon	Avoid loss	100%		$11.12	OE				

		Bald eagle	Avoid loss	100%		$45.21	DC	New England households	339	37.0%	Trust fund
		Bald eagle	Avoid loss	100%		$31.85	OE				
Swanson (1993)	1989	Bald eagle	Increase in populations	300%	$349.69		DC	WA visitors	747	57.0%	Membership fund
				300%	$244.94		OE	WA visitors			
Whitehead (1991, 1992)	1991	Sea turtle	Avoid loss	100%		$19.01	DC	NC households	207	35.0%	Preservation fund

Source: Richardson and Loomis (2008)

Table 11. Summary of economic value of threatened, endangered and rare species ($2006)

	Low value	High value	Average of all studies
Studies reporting annual WTP			
Bald eagle	$21	$45	$39
Bighorn sheep			$17
Dolphin			$36
Gray whale	$24	$46	$35
Owl	$39	$130	$65
Salmon/Steelhead	$10	$139	$81
Sea lion			$71
Sea otter			$40
Sea turtle			$19
Seal			$35
Silvery Minnow			$38
Squawfish			$12
Striped Shiner			$8
Turkey	$11	$15	$13
Washington State anadromous fish populations	$147	$311	$241
Whooping crane	$44	$69	$56
Woodpecker	$13	$20	$16
Studies reporting lump sum WTP			
Artic grayling	$20	$26	$23
Bald eagle	$245	$350	$297
Falcon			$32
Humpback whale			$240
Monk seal			$166
Wolf	$22	$162	$61

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