Economic Values of Protecting Roadless Areas in the United States

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Our opinions also do not necessarily represent those of Colorado State University.

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Contents

In a 1997 letter to President Clinton, 136 scientists and experts from across the United States stated: "A substantial amount of scientific information collected from both aquatic and terrestrial environments has demonstrated the importance of roadless areas in protecting the nation's wildlife, fisheries, and water resources.... [T]hey act as *de facto* refuges for numerous sensitive plant and animal species, reservoirs of genetic material, and benchmarks for experimental restoration efforts in intensively managed landscapes. Streams flowing out of roadless areas typically provide supplies of the purest water, untainted by chemical pollutants.... The ecological risks associated with developing these areas are extremely high, and may jeopardize the flow of goods and services that the national forests currently provide to human society."

In October 1999, President Clinton directed the U.S. Forest Service to assess future management options for approximately 54 million acres of roadless lands on national forests in this country. The assessment is part of an overall evaluation of the environmental consequences stemming from the current 380,000-plus miles of roads on the national forests, particularly in relation to the budgets for maintaining those roads.

The purpose of this report is to present an analysis of the values associated with roadless lands in their current condition, that is, relatively free of permanent human influence. Our study covers the 42 million acres of roadless lands on national forests in the 48 conterminous states.

Roadless areas share many of the same ecological and economic values as legislatively designated Wilderness and other wildland areas. Drawing on the literature related to wilderness preservation, we grouped the values into eight categories: recreation, community, passive use, scientific, biodiversity, off-site, ecological services, and education. Where possible, we estimated dollar values.

We found that in their current condition, the 42 million acres of roadless lands can be expected to provide almost $600 million in recreation benefits each year, more than $280 million in passive use values, and nearly 24,000 jobs (Table E-1). As for environmental benefits, we estimate these lands annually provide between $490 million and $1 billion in carbon sequestration services and $490 million in waste treatment services (Table E-2).

The following discussion summarizes our findings and analysis for each of the eight categories of benefits. The benefits described result from protection of natural systems, whether by administrative designations such as roadless and primitive areas or through legislative designations such as Wilderness.

Table E-1. Estimated annual recreation benefits, passive use values, and jobs from preserving 42 million acres of national forest roadless areas

	Northeast	Southeast	Intermountain	Pacific Coast	Total
Recreation benefits	$21,491,000	$43,530,500	$397,531,500	$137,012,000	$599,265,000
Passive use values	$1,942,720	$4,376,300	$221,471,000	$52,731,800	$280,521,820
Total jobs	849	1,720	15,721	5,415	23,705

Table E-2. Estimated annual carbon sequestration, waste treatment benefits, and off-site benefits from preserving 42 million acres of national forest roadless areas

Category of Benefits	Estimate
Carbon sequestration	$490 million - $1 billion
Waste treatment	$490 million
Gain in local property values	13%

Recreation Benefits

Roadless areas provide opportunities for non-motorized recreation such as hiking, backpacking, camping, wildlife observation, hunting, and fishing. In the literature, the average value per recreation day was nearly $42. Our analysis indicated that protection of a 10,000-acre roadless area in the West provides an estimated 3,875 visitor days per year, for an estimated annual $162,750 in recreation value to visitors in the western United States. Protecting 10,000 acres in the eastern portion of the country yields approximately 11,000 visitor days per year, with an annual recreation value to visitors of $462,000.

Maintaining 42 million acres of national forest roadless areas in the conterminous United States would support 14.6 million visitor days of non-motorized recreation, worth about $600 million in annual recreation benefits to the visitors (Table E-1).

Community Effects

Expenditures by recreation visitors in towns surrounding roadless areas support thousands of jobs throughout the national economy. From the literature, the average expenditure per person per day of primitive, roadless, and designated Wilderness recreation is about $30. Given the visitor use estimates described above, protecting 10,000 acres of roadless lands translates into $443,740 of personal income and 18 jobs from visitor spending in the eastern United States and $156,318 in income and six jobs in the western United States.

Protecting all 42 million roadless acres under study by the Forest Service would support an estimated 23,700 direct, indirect, and induced jobs nationwide (Table E-1). Thus, while development is restricted within roadless areas, visitor spending on gasoline, hotels, restaurant meals, and similar services supports economic activity outside roadless areas. Surveys report that 45% of current residents and 60% of recent migrants to counties containing designated Wilderness indicate that the Wilderness resource is an important reason for living in those counties.

Passive Use Values

Many people who do not regularly visit primitive, roadless, or designated Wilderness areas still value protection of such areas to maintain the opportunity for visits in the future (option value). People also gain benefits simply from knowing that natural areas exist (existence value) and that their protection today sustains them for future generations (bequest value). The option, existence, and bequest values, when combined, are known as passive use values.

Generalizing from the two studies of passive use values in the western United States, we estimate annual values outside Alaska to be $6.72 per acre, yielding annual passive use values of $274 million from protection of 40.8 million roadless acres on national forests in the West. Using the one study of passive use values for the East, we estimate a passive use value of $4.16 per acre, or about $6 million from the 1.5 million roadless acres on national forests in the East (Table E-1).

Scientific Values

Primitive, roadless, and designated Wilderness areas provide a natural benchmark or control to judge the effects of human development on natural systems and to understand unfettered ecological processes. As evidence of their scientific contributions, more than 400 scientific journal articles have been published about such areas during the past 30 years.

Biodiversity Values

Roadless areas contain a variety of plants and animals that are part of Earth's storehouse of biodiversity. In some cases, roadless areas contain elements of biodiversity that are not well represented in current protective designations such as Wilderness or national parks. Current Wilderness designations, for example, of a million acres or more protect only about one-third of the 35 ecoregions in the conterminous United States. Preserving roadless areas has the potential to conserve biodiversity by protecting ecoregions that are currently not adequately represented in the National Wilderness Preservation System.

Off-site Benefits

Protecting natural environments such as roadless areas can increase the property values of adjacent private lands, sometimes significantly. One case study indicated an increase of 13% in the value of private property adjacent to the Green Mountains in Vermont. Off-site benefits also include the value of fish and wildlife that are harvested outside roadless areas but that depend on roadless areas for a portion of their habitat needs.

Ecological Services

Naturally functioning ecosystems such as those often found in roadless areas provide many valuable services. These include watershed protection, carbon storage, nutrient cycling, and fish and wildlife habitat. Watershed protection yields cost savings for water treatment plants in numerous small towns and to highway departments by avoiding sedimentation associated with logging.

This benefit is estimated to range from a minimum of $130,000 to as much as $260,000 annually from just one 631,000-acre national forest. For Salem, Oregon, the cost savings accrued by protecting municipal watersheds from the turbidity associated with logging roads and logging-induced erosion is estimated at $2.1 million.

Forests also play an important role in moderating climate. For example, they capture and store carbon that would otherwise contribute to global climate change. It is estimated that an acre of forest has a value of $65 per ton for storing carbon. Another study estimated the value of climate regulation from temperate zone forests at $35 per acre per year and an additional $35 per acre for waste treatment services (recovering mobile nutrients and cleansing the environment) performed by these forests.

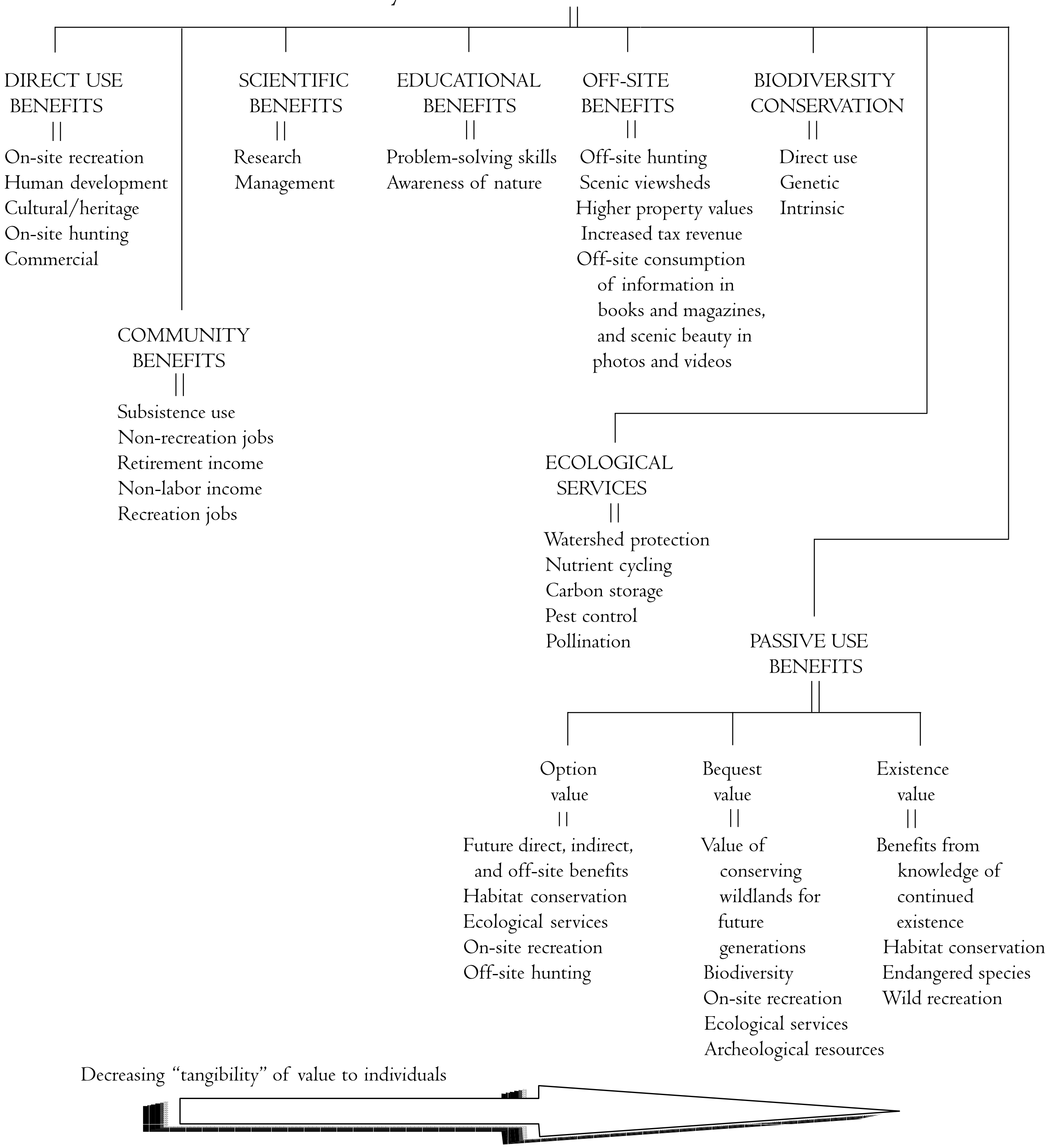
To estimate carbon sequestration benefits, we used the ratio of forest-related ecoregions found in designated Wilderness to the total designated Wilderness acreage and conservatively accounted for reduced forest density in many roadless areas. Our rough estimate placed carbon sequestration benefits from the 42 million acres of national forest roadless areas between $490 million and $1 billion annually. Applying the figure for waste treatment benefits to our conservative estimate yielded $490 million annually for this ecosystem service (Table E-2). Note that this estimate does not take into account the carbon sequestration value of soil in roadless areas. It is estimated that between 40% and 75% of global carbon is in the soil (Morton 1999).

Educational Values

Wilderness and wildlands such as roadless areas provide a natural laboratory for many high school and college courses. Wilderness is also used by various organizations to help teenagers and adults develop self-reliance, teamwork, and coping skills that can be transferred to everyday life. Some outdoor education programs focus on the development of leadership, navigational, and survival skills; others offer service-based experiences such as trail construction or cleanup. The value to society from such educational programs includes the direct benefits of improvements resulting from service trips and the indirect benefits of enhanced physical, emotional, and intellectual development as they contribute to overall social well-being.

In conclusion, we note that in this report, the estimates of values from protection of roadless areas are conservative. This is in part because we did not include all of the benefits and services that roadless areas provide. The diagram on the following page presents a more complete list of those benefits and services.

Summary of the Economic Values of Roadless Areas



Adapted from Morton 1999.

VALUES OF PROTECTING ROADLESS AREAS

Preserving natural environments provides a wide array of benefits to society (Krutilla and Fisher 1975). Those benefits include on-site non-motorized recreation use, scientific research, biological diversity, and habitat for fish and wildlife (U.S. Forest Service 2000). Although lands need not be formally preserved to provide these values, some form of land protection is needed to ensure that these values continue into the future.

Roadless lands share many of the same natural resource values as designated Wilderness. In fact, to be eligible for designation as Wilderness, an area must be roadless. The Wilderness Act of 1964 stated that designated Wilderness provides opportunities for primitive and unconfined recreation. And the Act stated that Wilderness areas "may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value." If the Wilderness Act were under consideration today, additional values such as protection of biodiversity and endangered species might well be recognized.

Many benefits that people derive from the preservation of natural environments can be quantified. Some can be measured in monetary or economic values. Economic factors should never be the driving force in preservation decisions. However, protecting some roadless areas may preclude management agencies from economically inefficient actions such as taxpayer-supported below-cost timber sales (Stewart et al. 1992). In those cases, national economic efficiency is enhanced even if visitation to the area in question is minimal. On the other hand, preservation of under-represented ecosystem types may carry costs of forgone development. In those cases, economics provides a way to communicate the natural and social values of wildlands to public officials, who must ultimately decide whether or not an area is preserved.

Categories of Economic Benefits from Preserving Natural Environments

Preservation of natural environments provides both intrinsic values and economic benefits. Morton (1999) divided nearly 30 distinct economic benefits of designated Wilderness into seven categories that are also applicable to roadless areas, as follows.

1. Recreation use benefits. These include on-site non-motorized recreation such as hiking, backpacking, camping, hunting, fishing, canoeing, rafting, and commercially guided recreation trips.

2. Community benefits. Included are direct and indirect jobs supported by non-motorized recreation and natural environments as a draw for job-creating entrepreneurs and for retirees who bring their incomes into the community.

3. Passive use benefits. These include three kinds of values: (1) option values obtained from being able to visit pristine areas in the future, (2) existence values obtained from simply knowing that natural environments exist, and (3) bequest values obtained from knowing that preservation today will ensure natural environments for future generations.

4. Scientific benefits. Scientists recognize the value of roadless areas as a benchmark or control for evaluating the impacts of development elsewhere and as a living laboratory to increase knowledge of natural forces. This value is reflected in the many scientific journal articles that use designated Wilderness areas and primitive and roadless areas as their subject. Natural areas can also be a source of medicines and of raw materials used as the genetic base for improved agricultural crops.

5. Off-site benefits. These include the value of fish and wildlife that are harvested outside of roadless areas but that depend on roadless areas for a portion of their habitat needs. Other off-site benefits are the scenic vistas provided by natural environments and enhanced values of private property near such environments.

6. Biodiversity conservation. Around the world, people are paying increased attention to the need to conserve biodiversity. Protecting roadless areas will help preserve genetic, species, and ecosystem diversity.

7. Ecological services. These include provision of high-quality water and nutrient cycling as well as carbon storage, which helps combat global climate change.

8. Educational benefits. Morton (1999) included education as part of scientific benefits. We treat it as a separate category. Natural environments provide a living laboratory for many high school and college courses, not just for scientists. In addition, designated Wilderness and primitive and roadless areas are used to teach teenagers and adults self-reliance, teamwork, and coping skills that they can transfer to everyday life.

Conceptual Basis of Economic Values and Effects of Natural Environments

The eight categories of benefits meet two necessary conditions for producing economic value. First, they are relatively scarce. Second, they contribute to human well-being. Logically, the lands that provide these services also have economic value. To evaluate the benefits of natural environments consistently and commensurate with market goods and the costs of preservation, economists measure what users of natural environments would pay over and above the actual cost of use. This is the conceptually correct measure of the value of gains (Sassone and Schaffer 1978; Stokey and Zeckhauser 1978) as well as the federally accepted measure of benefits (U.S. Department of the Interior 1986, 1994; U.S. Water Resources Council 1983). The net willingness to pay for recreation visitation and passive use is sometimes called consumer surplus. The net benefit to businesses such as commercial outfitters, sporting goods stores, and commercial fisheries dependent on natural environments is called producer surplus. Cost savings to municipal water treatment plants and to the federal government from carbon storage arising from natural environments can be thought of as a gain in producer surplus.

Economic effects in local communities are measured using the jobs or personal income (wages and proprietor income) realized in those communities as a result of continued preservation of natural environments.

This is consistent with how the local economic effects of logging or mining are calculated. From this viewpoint, a portion of visitors' expenditures becomes direct income to business owners and workers in recreation-related industries (e.g., gas stations, grocery stores, outfitters). Those individuals spend a portion of that income in the local area to replenish inventories or to purchase consumer services (i.e., retail spending). Such indirect and induced effects also generate income to other individuals in the community, who may not appear to have an obvious direct connection to the natural area.

METHODS FOR QUANTIFYING THE ECONOMIC VALUES OF ROADLESS AREAS

Estimating On-site Recreation Use Values to Visitors

There are two federally approved methods for measuring the value of recreation to visitors—the travel cost method (TCM) and the contingent valuation method (CVM). The CVM is also capable of measuring the passive use values of preserving roadless areas.

Travel Cost Method. This method uses variation in travel costs of visitors living at different distances from roadless areas as prices. It then measures quantities based on the associated number of trips taken to statistically trace a demand curve for recreation in a given roadless area. From the demand curve, the consumer surplus—or net willingness to pay—for non-motorized recreation is calculated (Loomis and Walsh 1997). TCM is quite capable of measuring the value of all types of non-motorized recreation, including hunting, fishing, wildlife viewing, canoeing, backpacking, and so forth.

Contingent Valuation Method. This method is a survey technique that constructs a hypothetical market to quantify willingness to pay for protection of non-market natural and environmental resources. The method involves face-to-face, telephone, or mail surveys. CVM is capable of quantifying the economic value of non-motorized recreation, and it is also the only method currently available to quantify passive use values such as existence values.

CVM develops a realistic but hypothetical market for "buying" use or preservation of natural environments. Then the individual is told to use the market to express his or her valuation of the natural environment. Key features of the market include: (1) description of the natural features being preserved, (2) means of payment (often called payment vehicle), and (3) type of willingness to pay question (open-ended or close-ended). For a more complete discussion of CVM, see Loomis and Walsh 1997.

Both methods are accepted by government agencies for valuing recreation. They have been recommended twice by the U.S. Water Resources Council (1983) under two different administrations as the preferred methods for valuing outdoor recreation in federal benefit-cost analyses. The U.S. Department of the Interior (1986, 1994) endorsed both as methods for estimating the value of non-market natural resources damaged by oil spills and other toxic events. Existing studies using TCM and CVM are applied in this paper to value recreation use of roadless areas.

Quantifying Community Effects

Spending by recreation visitors has a direct economic effect on local businesses that provide supplies and services used by visitors. For example, expenditures may include the purchase of gasoline for travel to the roadless area, purchase of restaurant meals along the way, specialized supplies such as freeze-dried food, and payment of any public fees. These initial expenditures also cause a ripple or multiplier effect on the overall economy because other businesses must expand production to meet the additional demand from those businesses directly serving the visitor. This inter-industry linkage and its resulting multipliers are commonly calculated using input/output models such as IMPLAN (MIG 1997).

IMPLAN was developed by the U.S. Forest Service and is used by that agency and others to estimate the economic effects of agency actions on income and employment. In such calculations, visitor expenditures are disaggregated by distinct economic sectors such as gasoline, hotels, food in restaurants, food in grocery stores, and miscellaneous retail spending on supplies. Given the visitor use levels and the expenditures per day, the resulting total expenditures in each category are entered into the IMPLAN model. The model calculates the direct and indirect effects of the spending and translates them into resulting income (e.g., wages and business profits) and jobs supported by the expenditures of visitors to roadless areas. In addition, there are both direct and indirect effects from visitor spending on commercial outfitters, who lead visitors into primitive, roadless, and designated Wilderness areas.

Another potential effect of protecting natural environments in rural areas is the impact on population. Historically, many rural areas had trouble maintaining their populations, sometimes following boom-and-bust cycles tied to extractive industries. Surveys show that the existence of nearby natural environments is an important reason people move to "wilderness counties" (Rudzitis and Johansen 1991) and may enhance the attractiveness of a region as a place in which to work and do business (Power 1996).

Estimating Passive Use Benefits

Passive use values such as option, existence, and bequest values are typically measured by using the contingent valuation method. Specifically, a survey of the general public ascertains what households would pay just to know that a particular natural environment will continue to exist and that it is protected for future generations (i.e., bequest values). Such studies are summarized in Chapter Three of this report.

Indicators of Scientific Benefits

There are at least two types of scientific benefits that stem from natural environments. First is the value of new discoveries and knowledge that arises from the opportunity to study natural processes. Generating new knowledge has the potential to avoid costly natural resource management mistakes as well as expensive endangered species recovery efforts and environmental restoration activities. Second, new knowledge can sometimes have positive spillover benefits to the rest of the economy (Romer 1990). Denison (1962) was one of the first economists to make the empirical link between economic growth and advances in knowledge and application of that knowledge. After accounting for changes in the amount of other inputs such as labor, land, and capital, he attributed the residual growth in the economy partly to the advances in knowledge. These arise from scientific discoveries and dissemination of such discoveries through academic journal articles (Black 1996).

Natural environments such as roadless areas and designated Wilderness are often referred to as living laboratories. They serve as benchmarks of relatively unmodified natural conditions in which to observe unfettered ecological processes at work (U.S. Forest Service 2000). As such, natural environments are often the subject of scientific research and publications. In some cases, these areas are used as controls. In others, they are studied to improve understanding of the influence of natural conditions on flora, fauna, and physical attributes of the environment. As an indicator of the extent of scientific benefits of natural environments, we use the number of articles in scientific journals related to Wilderness, primitive, and roadless areas.

Natural environments also serve as a genetic reservoir or "factory" for producing the raw ingredients used in medicines and for food crop biotechnology. As one example, the bark of the Pacific yew tree was recently found to contain a substance effective in treating ovarian cancer. For years, the Pacific yew was considered a "weed" species and was routinely cut down during commercial logging operations in the Pacific Northwest. In addition, pharmaceutical companies, recognizing the importance of natural environments in their "bio-prospecting" efforts, are paying host countries for rights to native flora. In principle, these benefits can approach millions of dollars. But it is extremely difficult to predict discovery of useful substances. Therefore, quantification of such benefits—even to an order of magnitude—is uncertain at best.

Valuing Off-site Benefits

Economists have repeatedly demonstrated that environmental amenities increase nearby land values. Because a given parcel of land can be viewed as a bundle of characteristics, land prices are expected to vary with the associated characteristics. The characteristics that influence property prices may include physical attributes (e.g., size, improvements), economic (e.g., regional population density, income levels), public policy (e.g., tax rates, zoning restrictions), and proximity to certain land uses (which may represent a nuisance or an amenity to a potential landowner). Economists assess the value of particular characteristics through a hedonic pricing model (Rosen 1974), which uses multiple regression statistical analysis to disaggregate the price of the land into the value contributed by each characteristic. The characteristics of interest in this context are those that reflect the degree to which a landowner might value the amenities associated with nearby natural areas. The value of land adjacent to natural area boundaries is expected to be higher because of the amenity value, thereby providing off-site benefits to nearby landowners.

Measuring Biodiversity Conservation

As with scientific benefits, biodiversity conservation provides society with a greater understanding of ecological interactions among species. It also provides the ecological structure necessary to protect species from extinction. Primitive, roadless, and designated Wilderness areas contain much of the critical habitat for many listed endangered species such as the northern spotted owl and grizzly bear.

Protecting natural areas can also result in millions of dollars in cost savings to society by avoiding the need to add species to the endangered species list and undertake expensive recovery efforts. Further, protecting biodiversity improves the resiliency and stability of many ecosystems, enhancing their ability to recover from natural variations (e.g., drought) and adapt to human-induced variations (e.g., air pollution and climate change).

Economic techniques such as the contingent valuation method could be used to value the benefits of biodiversity. To date, however, few such evaluations have occurred. Therefore, we used Geographic Information Systems to document the extent to which Wilderness designation has protected various ecosystems and to identify underprotected ecoregions that might benefit from protection of roadless areas.

Valuing Ecological Services

The net willingness to pay for the ecological services provided by natural environments can be computed in one of several ways. First, people who benefit from ecosystem services can be asked what they would pay for these services (contingent valuation). Second, and more commonly, economists calculate the cost savings to municipal water treatment agencies and water users such as aquaculture producers (e.g., fish hatcheries). Purer source water lowers costs of treatment in the form of settling basins, sediment precipitators, and so forth (Moore and McCarl 1987). The cost savings approach also can be applied to the nutrient cycling and carbon storage properties of natural forests. In the case of storing carbon in trees, the benefits can be calculated as the cost savings over the next least expensive method for capturing or sequestering carbon.

Quantifying Educational Benefits

Many outdoor programs recognize the educational benefits to society that accrue from primitive, roadless, and designated Wilderness areas. But there is no standard methodology for measuring these benefits. Indicators include the number of students who use natural areas as a laboratory or participate in outdoor courses (e.g., skills, leadership, or team building). Surveys of participants are sometimes used to gauge the effect that exposure to and participation in nature-oriented courses have had on their lives.

EMPIRICAL RESULTS

Recreation Use Values

Estimating the economic benefits from non-motorized recreation requires data on both the economic benefits per visitor and the number of visitors. We are not aware of any data on visits to national forest roadless areas. Therefore, we used visits to national forest designated Wilderness areas to statistically estimate visitor use of roadless areas. Cole (1996) compiled much of what is known about visitation to designated Wilderness. These data, consistently compiled by the U.S. Forest Service, are the best available.

Recreation visitor days (RVDs) at national forest Wilderness areas for selected years between 1965 and 1996 are shown in Table 1. (The Forest Service defines an RVD as 12 hours of recreation use, which can be one person for 12 hours, two people for six hours, and so forth.)

As the table shows, recreational use of designated Wilderness has increased substantially over time, and this may imply a continuing strong demand for the types of non-motorized recreation opportunities provided by roadless areas.

Using the data in Table 1 and acres of designated Wilderness, we note that over the 30 years studied, visitor days per acre fluctuated. Generally, visitation was much higher in the eastern United States than in the western part of the country, although visitor days per acre rose consistently in the Rocky Mountain region.

Table 1. National forest Wilderness visitation (recreation visitor days) for the United States and regions (selected years, not including Alaska)

Year	U.S. Total	North	South	Rocky Mountains	Pacific Coast
1965	2,951,500	717,200	13,700	996,500	1,224,100
1970	4,646,000	1,171,500	15,300	1,054,500	2,404,700
1975	6,465,000	1,205,200	169,900	1,635,900	3,454,000
1980	9,079,360	1,421,300	422,600	3,751,460	3,484,000
1985	10,954,170	1,352,920	527,850	4,917,400	4,156,000
1990	11,569,821	1,821,800	519,783	5,136,700	4,091,538
1993	12,028,873	1,837,800	507,716	5,959,575	3,723,782
1995	13,467,000	1,852,000	804,000	6,327,000	4,484,000
1996	13,930,000	1,880,000	849,000	6,413,000	4,788,000

Sources: 1965 to 1993, Cole (1996); 1995-1996, personal communication Gerald Stokes, Wilderness Coordinator, U.S. Forest Service, Washington, D.C., and Peggy Hernandez, USDA Forest Service, Washington, D.C.

Relationship of Roadless Acreage and Visitation. Protecting natural areas may support significant amounts of non-motorized recreation. However, federal agencies generally collect recreation use data only for designated Wilderness areas and not for roadless or primitive and semi-primitive non-motorized recreation classifications. Thus, we relied on a model to estimate visitor use of unprotected roadless areas.

We used the available annual national forest Wilderness visitation data and Wilderness acreage to statistically estimate the visitation relationship with acres (Loomis 1999). In this regression model, acreage had a statistically significant effect on visitor use in each of four regions of the country. Visitor use elasticity with respect to acreage was estimated at 0.89, which means that a 10% increase in national forest Wilderness acreage would result in an 8.9% increase in visitor use. It is reasonable to apply this same relationship to estimate the use of roadless areas for two reasons. First, wildlands must be roadless to qualify for Wilderness designation. Second, roadless areas generally provide the same type of non-motorized recreation as do designated Wilderness areas. We believe that using the Wilderness coefficients in the regression model provides a reasonable estimate of roadless recreation that would be supported if these areas were protected in their current state.

We increment roadless acreage as an addition to the existing Wilderness acreage in each region to account for the influence of these existing Wilderness areas on visitor use of the roadless areas (i.e., we account for the diminishing marginal effect of preserving roadless areas). Using the regression equation, we calculated that protecting an acre of a national forest roadless area would provide 1.1 visitor days annually of non-motorized recreation in the eastern United States and 0.35 more visitor days in the western part of the country. Thus, protecting a 10,000-acre roadless area in the East would provide 11,000 RVDs annually. The same acreage in the West would provide 3,500 RVDs.

Table 2 shows estimated recreation visitor days by region from protecting the 42 million roadless acres under study by the Forest Service. In total, about 14.6 million visitor days of non-motorized recreation would be provided.

Table 2. Annual recreation use from preserving 42 million acres of national forest roadless areas

	Northeast	Southeast	Intermountain	Pacific Coast
Roadless acres	467,000	1,052,000	32,957,000	7,847,000
Estimated recreation visitor days	511,692	1,036,440	9,465,035	3,262,189

Table 3. Wilderness, primitive, and roadless recreation values per day (1999 dollars)

Authors	Year	Location	Method*	Value/Day
Brown and Plummer	1979	WA and OR	TCM	$149
Loomis	1979	UT	TCM	$ 32
Smith and Kopp	1980	CA	TCM	$ 37
Walsh et al.	1981	CO	TCM	$ 26
Walsh and Gilliam	1982	CO	CVM	$ 30
Walsh et al.	1985	CO	CVM	$ 35
Walsh et al.	1985	CO	TCM	$ 38
Barrick	1986	WY	CVM	$ 16
Peterson and Rosenthal	1986	MN	TCM	$ 25
Rosenthal and Walsh	1986	CO	CVM	$ 18
Leuschner et al.	1987	NC	TCM	$ 14
Prince	1988	VA	CVM	$ 18
Peterson et al.	1988	MN	TCM	$ 13
Peterson et al.	1988	MN	TCM	$ 38
Hellerstein	1991	MN	TCM	$ 31
Halstead et al.	1991	NH	CVM	$ 2
Englin and Shonkwiler	1994	WA	TCM	$ 23
Englin and Shonkwiler	1994	WA	TCM	$ 36
Casey et al.	1995	NC	TCM	$230
Baker	1996	CA	TCM	$ 26
Overall average				$41.87

* TCM is travel cost method; CVM is contingent valuation method.

According to Loomis et al. (1999), Wilderness recreation use in the northeastern United States and Rocky Mountain region is forecasted to increase by 0.5% per year over the next 50 years. Wilderness recreation use in the southeastern United States and Pacific Coast states is forecasted to increase by about 1.0% per year over the next 50 years. These forecasts formed the basis of the U.S. Forest Service Resource Planning Act (RPA) Assessment of future Wilderness recreation use (Cordell 1999).

Results of Recreation Values per Day. There are about two dozen empirical studies of the economic value of recreation in primitive, roadless, and designated Wilderness areas. Activities include hiking, backpacking, and backcountry canoeing. The studies were originally compiled by Sorg and Loomis (1984), added to by Walsh et al. (1992), and recently updated by Loomis et al. (1998). Table 3 presents the summary of values, which averaged $41.87 per day in 1999 dollars. This means that each visitor would pay nearly $42 more than actual travel costs rather than give up a day of non-motorized recreation. Multiplied by the estimated 14.6 million days of recreation in roadless areas, the aggregate value is about $600 million annually. When the regression estimate of use per acre and the $41.87 average value per visitor day are combined, the designation of an additional 10,000-acre roadless area as Wilderness would yield some $162,750 in recreation value to visitors each year in the western United States and $462,000 in annual recreation value to visitors for an area of the same size in the East.

Community Effects

Results of Income and Jobs Supported by Recreation Use. Table 4 presents a summary of existing studies of spending per visitor in designated Wilderness, Wilderness Study Areas, and other wildlands. As can be seen, numerous sectors are directly stimulated by visitor spending, especially transportation/gasoline and general merchandise. The average visitor to a wildland area spends about $30 per day. This includes $3 to $7 per person for gas to travel to the area, $5 to $7 to purchase food in stores for each day of the trip, and another $6 to buy food in restaurants at the start or end of a trip. About $7 to $15 per day is spent on general merchandise such as stove fuel, film, and other supplies.

The average of the expenditures in Table 4 along with the estimated visitor days of roadless area recreation were used in the IMPLAN input/output model to calculate personal income, total value added to the economy, and employment by sector and in total (Table 5).

Table 5 shows that personal income (wages and proprietors' income) supported by estimated visitor spending for recreation in roadless areas is $576 million annually. Total value added,

Table 4. Expenditures per day in Wilderness, primitive, or wildland areas

Study	Data Year	State	Gas	Food Store	Food Restaurant	Car	Public Fees	Supplies/ Misc.	Hotel	Total*
Keith and Fawson	1993	UT	$7.18	$5.17	$5.74	$1.68	$0.72	$ 6.92	$4.40	$31.82
Moisey and Yuan	1989	MT	$7.11	$5.85	$7.32	$0.93	$1.23	$15.11	$6.39	$49.35
Walsh et al.	1981	CO								$29.52
Casey et al.	1993	NC					$7.45			$24.40
Clonts	1988	AL	$2.96	$6.81						$16.45

* Total expenditures may differ from the sum of the individual categories because not all studies provided individual industry detail. However, all reported a total.

Table 5. Personal income and employment from estimated recreation in roadless areas	Personal income (millions)	Total value added (millions)	Jobs
Direct, indirect, and induced	$576	$916	23,700

which includes personal income plus rental income and indirect business taxes, is $916 million each year across the national economy. In relation to employment, 23,700 jobs are directly or indirectly supported by visitor spending for recreation in roadless areas.

Detailed, disaggregated results from the IMPLAN analysis show that retail/wholesale trade and service sectors receive the majority of economic activity from spending of visitors to roadless areas, although there are indirect and induced effects on many other sectors in the economy. Thus, although development is restricted within roadless areas, visitor spending on gasoline, hotels, restaurant meals, and other services supports economic development outside roadless areas.

These are conservative estimates because only the variable expenses associated with a recreation trip are included. The figures do not take into account the economic effects associated with purchase of durable equipment items such as backpacks, specialized clothing, binoculars, and tents. Further, the multipliers relating total economic effect to the initial direct effect as calculated by IMPLAN appear quite reasonable because the personal income multiplier is 2.07 and the employment multiplier is 1.72.

To aid in applying these impact figures to the evaluation of roadless areas, Table 6 presents the figures as per visitor day, per dollar of visitor spending, and per acre. The table shows that each visitor day of non-motorized roadless recreation provides $40 of personal income (wages and proprietor income) to those working in economic sectors such as transportation, retail/wholesale trade, and services. Every dollar spent by non-motorized recreation visitors generates a direct personal income of $0.65 when leakages and exports are deducted. Multiplying the $0.65 of direct income by the personal income multiplier of 2.07 yields the $1.34 of personal income shown in the table.

The jobs per acre effect may seem small at 0.000568. However, it means that protecting a 10,000-acre roadless area would support, on average, 5.68 jobs in the national economy. Use of the visitor estimation model indicates that protecting 10,000 acres in the eastern United States would result in 11,000 visitor days and support 18 jobs.

Table 6. Personal income, total value added, and jobs per unit

Economic impact	Personal income	Total value added	Jobs
Per visitor day	$40.34	$64.20	0.00166
Per $1 visitor expenditure	$ 1.34	$ 2.12	0.000055
Per acre	$13.84	$22.00	0.000568

Effects on Community Population. Communities near natural areas derive positive economic effects by virtue of their proximity to the environmental amenities that the areas contain. These effects are often reflected in terms of people "voting with their feet" and moving themselves and sometimes their businesses to rural areas near wildlands.

In 1991, Rudzitis and Johansen published the results of a survey of 2,670 residents in 11 "Wilderness counties" in 10 states where significant population growth—ranging from 29% to 104%—had occurred between 1970 and 1980. The sample was almost evenly divided between recent immigrants (moved into area in the last 10 years) and longer term residents.

The study found that 53% of the respondents felt that the presence of Wilderness was (is) an important reason they moved to (stay in) the area. Forty-five percent of residents said that Wilderness is why they stay in the area, and 60% of recent immigrants cited wilderness as an important reason they moved.

Most models of migration assume people move in pursuit of higher income, but many migrant respondents in this survey did not give that reason (Rudzitis and Johansen 1989a, b). A survey of residents of and migrants to 15 fast-growing Wilderness counties showed that only 25% of the migrants increased their income, whereas almost 50% accepted income losses when they moved (von Reichert and Rudzitis 1992). This demonstrates a strong willingness to pay for proximity to natural areas. Moreover, roughly 80% of the respondents were young (21 to 35 years of age) or middle-aged (36 to 65 years of age), which excluded retirement migration as the primary factor. Eighty-one percent of all respondents agreed that nearby wildlands are important to their county (Rudzitis and Johansen 1991). The results of this survey research support the notion that natural environments influence nearby communities in relation to population growth.

To further dispel the notion that preserving wildlands "locks up" potentially useful resources and limits economic growth, Lorah (2000) studied 113 rural counties in the western United States and found that the presence of wildlands was positively correlated with growth in population, income, and employment. For the period 1969 to 1996, he found positive and significant

(99% confidence level) correlation among the percentage of land designated as Wilderness and employment, per capita income, total income, and population growth rates. When the land designation was expanded to include land devoted to designated Wilderness, national parks and monuments, and Wilderness Study Areas, the correlation between amenities and measures of growth was stronger yet.

Lorah cautioned that his analysis demonstrated a positive association between land preservation and economic growth, not a causal relationship. He also focused on the role wildlands play in transforming extractive-based economies to amenity-based economies by mapping the diffusion of amenity economies (and the retreat of extractive economies). Lorah noted that because of this rapid transition in many western counties, many communities face an array of challenges to address the inevitable cultural change, but suggested that the transition offers western economies many opportunities for sustainable development.

Lorah noted also that his findings do not mean that extractive industries are becoming irrelevant. In fact, they may represent a lure to some communities. However, his findings suggest that the amenity-driven economic transition in the West has increased economic diversity in counties that might otherwise suffer from the boom-and-bust cycles that typically characterize extractive-based economies.

Estimates of Passive Use Values

Undeveloped, pristine environments cannot be created by people. They can, however, be damaged or destroyed by people. This led Weisbrod (1964) to suggest that natural environments might be a source of option value, that is, maintaining the opportunity to visit them in the future. Krutilla (1967) added the categories of existence and bequest values to the concept of passive value. The Wilderness Act itself emphasized many societal benefits of wilderness preservation that go well beyond recreation. For many non-visiting members of the general public, natural environments represent the last vestiges of what North America was before Europeans arrived.

Walsh et al. (1984) represented the first attempt to use the contingent valuation method to measure option, existence, bequest, and recreation values of roadless and designated Wilderness areas. They conducted a mail survey of Colorado residents in 1980, asking households about their willingness to pay annually into a fund to continue preservation of the 1.2 million acres of designated Wilderness in Colorado at the time of the study. They also asked about residents' willingness to pay to preserve 2.6 million acres, 5 million acres, and finally all roadless acres in Colorado (10 million acres) as Wilderness. They then asked what percentage of willingness to pay was for recreation use that year, for maintaining the option to visit in the future, for knowing that wilderness areas exist as a natural habitat for plants, fish, and wildlife, and, finally, for knowing that future generations would have Wilderness areas.

The survey had a 41% response rate after two mailings. The results are summarized in Table 7 on both a per household basis and for total Colorado households. The calculation for all Colorado households illustrates the public-good nature of the option, existence, and bequest values. Assuming that households outside of Colorado receive existence and bequest values as well, we used the rough approximations of Walsh et al. (1984) to estimate such values across the country. Our results, also shown in Table 7, likely represent a conservative estimate of what non-Colorado residents would pay for wilderness because Colorado residents had more than a million acres of designated Wilderness in their state at the time of the survey. The majority of U.S. residents in the East and Midwest have little designated Wilderness within their state borders. Thus, an additional acre of Wilderness may be worth more to them than to Colorado residents.

Walsh et al. (1984) also concluded that willingness to pay exceeded the opportunity costs of designating nine of the 10 million acres of roadless areas as Wilderness in Colorado. The present value per acre of Wilderness to Colorado and the rest of U.S. households ranged from a high of $1,246 per acre for protection of 1.2 million acres to $220 per acre for protecting five to 10 million acres.

A second study of the total economic value of wilderness preservation, the results of which are also presented in Table 7, was undertaken by Pope and Jones (1990) in Utah. Their telephone interviews of Utah households addressed designation of alternative quantities of Bureau of Land Management land as Wilderness. They obtained a 62% participation rate of households contacted. The results illustrate a similar pattern of willingness to pay, with the present value for all U.S. households decreasing as the number of acres proposed for protection rose.

Gilbert et al. (1992) conducted the only study of total economic value of eastern U.S. Wilderness. Two versions of a written questionnaire were mailed to separate samples of Vermont residents, resulting in an overall response rate of 30% after two mailings. The total economic value of protecting all eastern wilderness areas was $14.28 per household.

Table 8 presents results from Gilbert et al. (1992), who used a new category related to altruism (i.e., protecting natural environments for current use by others). The table also presents the apportionment of total value into the recreation use and passive use components for Colorado households. As shown, the majority of the total economic value to a general public household is a combination of option, existence, and bequest values.

Barrick (1986) provided estimates for the option value of one wilderness area, the Washakie in Wyoming. On-site users'

Table 7. Recreation and passive use values of Wilderness in Colorado and Utah

COLORADO

	Amount of Roadless Land Protected			
Walsh et al. (1984)	1.2	2.6	5.0	10.0
		(millions of acres)		
Passive use				
Per household	$13.92	$18.75	$25.30	$31.83
Total for Colorado	$15.3	$20.6	$27.8	$35.0
		(millions $)		
Recreation	$13.2	$21.0	$33.1	$58.2
		(millions $)		
Total economic value for Colorado	$28.5	$41.6	$60.9	$93.2
		(millions $)		
% passive use	54%	50%	46%	38%
Marginal present value* per acre to Colorado and U.S. residents	$1,246	$320	$220	$220

UTAH

	Amount of Roadless Land Protected			
Pope and Jones (1990)	2.7	5.4	8.1	16.2
		(millions of acres)		
Total economic value				
Per household	$52.72	$64.30	$75.15	$92.21
Total for Utah	$26.7	$32.5	$38.0	$46.7
		(millions $)		
Marginal present value* per acre to Utah and U.S. residents	$402	$245	$190	$117

* To calculate a land value comparable to a stumpage value for timber or the value of a mineral deposit, the annual values of wilderness benefits are summed over time. Specifically, the annual benefits of wilderness in perpetuity are discounted back to the present using the interest rate. The resulting sum is referred to as the present value of this future stream of wilderness benefits. An important pattern is that option, existence, and bequest values (i.e., passive use values) represent about half the total economic value of wilderness.

Table 8. Distribution of total economic value per household

	Personal recreation	Passive Use Values: Option value	Existence value	Bequest value	Altruistic value
Walsh et al. (1984) Colorado	$14.00	$5.44	$6.56	$6.75	not asked
Gilbert et al. (1992) all eastern Wilderness	$ 2.26	$2.41	$3.03	$4.14	$2.44

option value for future visits was $46 in 1983, or $77 in 1999 dollars. For urban and rural non-visiting households living throughout the United States, the option value for the Washakie Wilderness Area was $15.40 and $13.45 (1999 dollars), respectively.

Applying Passive Use Values to National Forest Roadless Areas. Table 9 provides a rough estimate of the annual passive use value per acre for preserving roadless lands in the West (applying Walsh et al. 1984 and Pope and Jones 1990) and in the East (applying Gilbert et al. 1992). As explained, we used the conservative assumption of Walsh et al. (1984) to estimate what U.S. households would pay to preserve these lands in the West. Accordingly, we calculated the annualized passive use value per acre in the western states outside of Alaska at $6.72 per acre. When applied to 40.8 million acres of roadless land on national forests in the western United States, the estimated total is $274 million annually. We multiplied the annualized value per eastern acre ($4.16) times 1.5 million acres of eastern roadless lands on national forests

Table 9. Annual passive use values of preserving national forest roadless acres

	Roadless Acres (millions)	**$ per Acre**	**Total Value** (millions)
Western United States (excluding Alaska)	40.8	$6.72	$274
Eastern United States	1.5	$4.16	$6.24

for an estimated $6.24 million in passive use value. The estimated total of passive use values across the country was $280 million. We note that this rough approximation should be refined as additional studies of passive use values of natural environments are completed.

Scientific Benefits

Scientific benefits from natural areas were calculated by using the number of academic journal articles published that studied or relied upon these natural environments. To obtain a conservative estimate of the number of journal articles related to primitive, roadless, and designated Wilderness areas, we searched five electronic databases, including ecological abstracts (1960-1991), water resources abstracts (1960-1991), economic literature (EconLit 1969-1999), sociological abstracts (SocioAbs 1963-1999), and biological abstracts (1991-1996). The search of ecological and water resources abstracts was limited to articles with the word "wilderness" in the title.

We found a total of 368 articles during the 30-year time period for the first four abstracts. The biological abstract search on wilderness in the United States yielded nine articles, five of which had wilderness in the title and four of which had wilderness in the abstract or as a keyword. Because the electronically searchable time period for this category was only five years, we multiplied by six to yield a comparable 30-year time period; thus, 54 articles would be expected. In all, our small sample of five databases suggests that at least 422 articles in natural and social science journals were associated with primitive, roadless, and designated Wilderness areas. This number is used as an indicator of the scientific contribution that primitive, roadless, and Wilderness areas provide to scientific research and discovery.

The economic contribution of a journal article is difficult to estimate, and we are not aware of a standard approach. Black (1996) provided some indicator of the economic value. He incorporated earth scientists' allocation of time among competing tasks, journal article production, and their willingness to pay someone else to reduce time spent on data entry to increase journal article production. He then calculated an economic value to society of approximately $300,000 per journal article.

This appears to be a present value. Annualizing this amount yielded a value of $12,000 per journal article per year in relation to the advancement of knowledge that leads to additional economic growth, as measured by national income.

The estimate of $12,000 per article gives a very conservative value of about $5 million annually but provides some indication of the extent of scientific benefits attributable to protecting natural environments for scientific research.

Off-site Benefits

Economists assess the value that proximity to natural amenities might add to land prices by using the hedonic pricing model (Rosen 1974). The value of private land near primitive, roadless, and designated Wilderness areas is expected to be higher because of the amenity values of the natural environments, thereby providing off-site benefits to nearby landowners.

Phillips (1999) used a hedonic pricing model to assess the value of land parcels in the Green Mountains area of Vermont, with particular attention to the value of attributes associated with national forest Wilderness areas. Using a data set of 6,148 land-transfer transactions in Vermont, he found that the existence of designated Wilderness enhanced nearby land values. Parcels of land in towns near designated Wilderness sold at prices 13% higher than in towns not located near designated Wilderness.

The analysis further demonstrated that land prices decreased by 0.8% per acre with each kilometer of distance away from the nearest Wilderness area boundary. One would expect a similar relationship to hold with regard to other natural areas such as primitive and roadless areas.

Conserving Biodiversity

In recent years, scientists and policy makers have become more aware of the importance of preserving natural diversity in plants and animals and physical environments. In general, two methods of land management are targeted at preserving diversity—manipulative management and preservation management. Davis' (1989) analysis of designated Wilderness addressed preservation management, specifically the inclusion of representative samples of naturally occurring ecosystems in the National Wilderness Preservation System. But preservation as Wilderness is only one mechanism for protecting selected portions of the natural landscape. For example, administrative protection of roadless areas also could contribute to protection of biodiversity.

To illustrate the ecoregion types currently under-represented in the National Wilderness Preservation System that could contribute to maintenance of biodiversity, we analyzed designated Wilderness areas in relation to the ecoregions they contain. As background, in its second Roadless Area Review and Evaluation (RARE II) in 1977, the U.S. Forest Service gave preference to adding areas that would increase the diversity of the National Wilderness Preservation System. The agency adopted the Bailey-Kuchler ecosystem classification regime that considers physical (climate and soil) and biological (vegetation) factors. The number of ecosystems identified under the Bailey-Kuchler system totaled 261. The Forest Service defined adequate representation of an ecosystem to include two or more distinct examples at least 1,000 acres in size that epitomize the ecosystem in question.

As a result of RARE II and subsequent Wilderness designations by Congress, 157 of the country's 261 ecosystems were represented in the National Wilderness Preservation System by 1989. The Bureau of Land Management also adopted the Bailey-Kuchler system for its wilderness studies, and addition of the Bureau's land has the potential to increase diversity within the system. Davis (1989) anticipated that up to 200 ecosystems would be represented by the year 2000.

To quantify the extent of biodiversity protection provided by designated Wilderness, Loomis and Echohawk (1999) used the Bailey-Kuchler ecoregions at the province level and data from the federal agency Wilderness Geographic Information System (GIS). The data were collected from several sources, including GIS coordinators with the Forest Service, Bureau of Land Management, and National Park Service. The GIS analysis was conducted using Arc/Info, Arc View, and Atlas GIS software.

The results of the GIS work are summarized in Table 10 (next two pages), which organizes the data around several key types of information in the conterminous United States: (1) percent of each ecoregion protected as designated Wilderness, (2) percent of designated Wilderness in each ecoregion, and (3) percent of total Wilderness by ecoregion.

These categories show that only about 2% of the land area in the conterminous United States is protected as Wilderness. At the higher end, about 26% of the Everglades ecoregion and 16.4% of the American Desert ecoregion are designated Wilderness (the latter includes recent additions to the National Wilderness Preservation System through California National Parks Wilderness legislation). Relatively high proportions of alpine ecoregions in the Cascade Mountains, Rocky Mountains, and Sierra Nevada Mountains are also protected.

To provide perspective on relative representation, we calculated the ratio of designated Wilderness to ecoregion. A ratio of 1 means that an ecoregion has equal percentages of the National Wilderness Preservation System and conterminous U.S. land area. For example, Ecocode M331, with a ratio of 5.10, means that this ecoregion has five times more representation in the National Wilderness Preservation System as it has in the land area of the conterminous United States. Thus, this ecoregion is well protected by the National Wilderness Preservation System. Conversely, Ecocode 341 (Intermountain Desert) represents 3.6% of the U.S. land area but only 1.4% of the National Wilderness Preservation System. Its ratio of 0.39 indicates that it is under-represented in the National Wilderness Preservation System and not well protected. This is striking in light of the large proportion of federal ownership within the ecoregion.

It would take a huge effort to conduct the CVM survey needed to provide even a rough estimate of the dollar value attached to biodiversity resources protected in designated Wilderness. Montgomery et al. (1999) attempted to estimate what they called "management prices" for biodiversity. That study's implicit values are specific to a local case study and cannot be generalized. Still, their approach illustrates a potential method to calculate dollar values of biodiversity.

Table 10. Ecoregions in the 48 conterminous United States

Eco-code	Province	% of Total U.S. Lower 48 Wilderness	% of U.S. in Province
322	American Semi-Desert and Desert Province	21.0%	2.9%
M331	Southern Rocky Mountain Steppe-Open Woodland-Coniferous Forest-Alpine Meadow Province	17.4%	3.4%
M332	Middle Rocky Mountain Steppe-Coniferous Forest-Alpine Meadow Province	13.7%	2.7%
M261	Sierran Steppe-Mixed Forest-Coniferous Forest-Alpine Meadow Province	11.8%	2.3%
M242	Cascade Mixed Forest-Coniferous Forest-Alpine Meadow Province	11.4%	1.8%
411	Everglades Province	3.0%	0.3%
M313	Arizona-New Mexico Mountains Semi-Desert-Open Woodland-Coniferous Forest-Alpine Meadow Province	2.9%	1.7%
212	Laurentian Mixed Forest Province	2.8%	4.9%
313	Colorado Plateau Semi-Desert Province	2.5%	2.5%
M262	California Coastal Range Open Woodland-Shrub-Coniferous Forest-Meadow Province	2.5%	0.8%
M333	Northern Rocky Mountain Forest-Steppe-Coniferous Forest-Alpine Meadow Province	2.3%	1.3%
341	Intermountain Semi-Desert and Desert Province	1.4%	3.6%
331	Great Plains-Palouse Dry Steppe Province	1.2%	9.7%
232	Outer Coastal Plain Mixed Forest Province	1.2%	5.8%
M341	Nevada-Utah Mountains-Semi-Desert-Coniferous Forest-Alpine Meadow Province	1.1%	1.5%
321	Chihuahuan Semi-Desert Province	0.8%	2.8%
342	Intermountain Semi-Desert Province	0.7%	5.3%
M221	Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province	0.6%	2.3%
261	California Coastal Chaparral Forest and Shrub Province	0.5%	0.3%
M212	Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province	0.3%	1.5%
222	Eastern Broadleaf Forest (Continental) Province	0.2%	9.0%
242	Pacific Lowland Mixed Forest Province	0.1%	0.5%
315	Southwest Plateau and Plains Dry Steppe and Shrub Province	0.1%	5.4%
221	Eastern Broadleaf Forest (Oceanic) Province	0.1%	3.5%
263	California Coastal Steppe-Mixed Forest-Redwood Forest Province	0.1%	0.2%
M222	Ozark Broadleaf Forest - Meadow Province	0.1%	0.2%
231	Southeastern Mixed Forest Province	0.1%	6.4%
M231	Ouachita Mixed Forest - Meadow Province	0.0%	0.3%
332	Great Plains Steppe Province	0.0%	4.5%
311	Great Plains Steppe and Shrub Province	0.0%	0.6%
234	Lower Mississippi Riverine Forest Province	0.0%	1.5%
251	Prairie Parkland (Temperate) Province	0.0%	7.3%
255	Prairie Parkland (Subtropical) Province	0.0%	2.7%
262	California Dry Steppe Province	0.0%	0.6%
M334	Black Hills Coniferous Forest Province	0.0%	0.1%
	Totals	100.0%	100.0%

Wilderness to Province Area Ratio	Ratio over 1?*	% Province as Wilderness	Total Wilderness (acres)	Province Area (acres)
7.17	Yes	16.4%	9,197,580	56,238,396
5.10	Yes	11.6%	7,635,330	65,613,296
5.04	Yes	11.5%	6,021,600	52,324,240
5.17	Yes	11.8%	5,164,810	43,748,392
6.40	Yes	14.6%	5,001,910	34,242,360
11.35	Yes	25.9%	1,299,350	5,014,900
1.75	Yes	4.0%	1,287,300	32,182,260
0.57	No	1.3%	1,226,870	94,418,672
1.01	Yes	2.3%	1,115,840	48,280,396
3.00	Yes	6.9%	1,094,610	15,966,126
1.84	Yes	4.2%	1,022,580	24,375,970
0.39	No	0.9%	616,502	68,719,944
0.12	No	0.3%	529,926	186,315,184
0.21	No	0.5%	527,653	111,395,924
0.77	No	1.8%	492,072	27,947,022
0.28	No	0.6%	354,299	54,607,684
0.13	No	0.3%	304,501	101,961,848
0.26	No	0.6%	259,940	43,615,616
1.35	Yes	3.1%	202,972	6,608,040
0.23	No	0.5%	147,172	27,986,370
0.02	No	0.1%	97,687	172,911,328
0.26	No	0.6%	57,497	9,534,571
0.02	No	0.0%	39,815	103,129,536
0.03	No	0.1%	38,808	66,889,328
0.52	No	1.2%	34,481	2,918,990
0.28	No	0.6%	26,369	4,100,165
0.01	No	0.0%	26,353	123,644,224
0.09	No	0.2%	11,908	5,644,113
0.01	No	0.0%	10,148	85,891,360
0.03	No	0.1%	8,504	11,252,168
0.01	No	0.0%	4,122	28,361,032
0.00	No	0.0%	0	139,783,520
0.00	No	0.0%	0	51,247,280
0.00	No	0.0%	0	12,323,812
0.00	No	0.0%	0	2,353,896
Median				
0.26		2.3%	43,858,509	1,921,547,962

*A ratio of 1 means that an ecoregion has equal percentages of the National Wilderness Preservation System and conterminous U.S. land area.

Ecological Services

Natural areas provide ecological services that have direct economic value to people and indirect life-support values to human and non-human species (DeGrood 1999). Ecosystem services from intact natural environments such as roadless areas are likely to include watershed protection, carbon storage, nutrient cycling, waste treatment, and fish and wildlife habitat (Costanza et al. 1997). Watershed protection is a particularly valuable service performed by roadless lands. Roads, even when not built to support logging operations, can increase erosion rates by a factor of 100 over undisturbed lands and contribute to more than half of the landslides on such lands (Amaranthus et al. 1985). Logging further increases the erosion rates.

Thus, protecting roadless lands would yield cost savings to water treatment plants and highway departments in numerous small towns from avoiding sedimentation associated with logging and roads. This benefit was estimated to range from at least $130,000 to as much as $260,000 annually for one town located adjacent to a relatively small national forest of 631,000 acres (Loomis 1988). For Salem, Oregon, protection of municipal watersheds from the turbidity associated with logging roads and logging-induced erosion and landslides was estimated to result in cost savings of at least $2.1 million (Schwickert and Mauldin 1997). In the long run, the construction costs of new facilities to treat low-quality water can be as high as $50 million, with annual operating costs as high as $3 million (Schwickert and Mauldin 1997).

An important ecosystem service of many natural forested areas is the sequestration, or capturing, of carbon that would otherwise end up in the atmosphere and add to global climate change (Meyers 1997; Morton 1999). U.S. Forest Service estimates for the Interior Columbia Basin suggest a value of $65 per ton of carbon sequestered as a value to society. This can be thought of as either avoided damages from climate change or as cost savings from sequestering carbon rather than reducing fossil fuel emissions. Turner et al. (1995) indicated that carbon sequestration continues to grow at a substantial annual rate over a 100-year time period in Douglas fir forests in the Pacific Northwest.

Birdsey and Heath (1995) estimated that an average acre of public forest land sequesters about 31.45 tons of carbon per acre just in the trees. Currently, about 29.5 million acres (67%) of the 43.8 million acres in Bailey-Kuchler's ecoregions that contain forests as a dominant vegetation type have been designated as Wilderness (Loomis and Echohawk 1999).

Given that these ecoregion types include not only coniferous forests and mixed forest but also alpine meadows, we conservatively estimated that about half the acreage may actually contain tree densities similar to Birdsey and Heath's estimate for all public land forests. To estimate carbon storage in national forest roadless areas, we took the 42 million acres of roadless lands in the conterminous United States and applied the 67% ratio noted above, then multiplied by 0.5. The latter step was needed to adjust for lower tree density in roadless areas than on typical public lands or, alternatively, to account for the possibility that only half of the high-elevation ecoregions are forested. The result was an estimated 14 million acres of equivalent forest land in roadless areas. Applying the 31.45 tons of carbon per acre from Birdsey and Heath yielded 445 million tons of sequestered carbon.

Using the Forest Service's estimated value of $65 per ton resulted in a total value of $26.7 billion. When we annualized that figure at the 4% discount rate used by the Forest Service, we arrived at an estimated value of $1 billion annually for the carbon sequestration service performed by the 42 million acres of roadless areas on national forests in the conterminous United States.

Costanza et al. (1997) estimated that annual climate regulation benefits from temperate forests could be valued at $35 per acre per year. This yields a value of about $490 million annually in climate regulation benefits from roadless area forests. The authors indicated that temperate forests also provide waste treatment services by recovering mobile nutrients and cleansing the environment and estimated an additional $35 per acre from temperate forests for waste treatment benefits. Thus, roadless area forests would provide another $490 million in benefits per year from this ecosystem service.

In total, the two ecosystem services of carbon sequestration and waste treatment yielded between $980 million and $1.5 billion in annual benefits from roadless areas. Note that this estimate does not take into account the carbon sequestration value of soil in roadless areas. It is estimated that between 40% and 75% of global carbon is in the soil (Morton 1999).

Educational Benefits

We were unable to locate any quantitative indicators of the use of primitive, roadless, and designated Wilderness areas as part of school courses or formal programs. However, Kellert (1998) studied the impact of wilderness education on participants of courses offered by three national organizations: National Outdoor Leadership School (NOLS), Outward Bound (OB), and the Student Conservation Association (SCA). Kellert found that such programs foster improved physical fitness, effective coping and adaptation skills, problem-solving abilities, intellectual capacity, emotional development, and a greater awareness of and concern for the natural environment.

The study had two components. A retrospective component examined the effects perceived by participants over longer periods of time after their participation in a course. A longitudinal component examined the effects perceived by recent alumni just prior to and immediately following their completion of a course. Both surveys and face-to-face interviews were used.

The connection of participants' benefits to overall social benefits is intuitive. However, the methodology for estimating social value is not fully developed. Walker et al. (1998) examined the quantity of optimal experiences during the on-site phase of outdoor recreation, the quantity of benefits realized off-site during the recollection phase, and the relationship between the two. They found that high quantities of optimal experience produced higher quantities of several benefit categories.

There are many economic values provided by protection of unroaded natural environments. These values, grouped in eight categories, can be substantial as indicated by the literature review and analyses we conducted for this report. Our results show that roadless lands on national forests in the conterminous United States provide U.S. citizens with millions of dollars in economic benefits from on-site visitation and off-site use of these natural environments each year. In addition, the carbon sequestration and waste treatment services alone provided by these lands could avoid billions of dollars in costs associated with climate change and with providing clean water for domestic consumption.

We trust that the information in this report will prove useful as the U.S. Forest Service examines its options for future management of roadless lands under study on national forests.

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Thus, roadless areas far exceed roaded areas in the ecological benefits they provide. Europe has been fragmented by transportation infrastructure for a long time. Accordingly, preserving the continentâ€™s last remaining roadless areas will significantly contribute to prevent further loss of biodiversity. Preserving roadless areas is hence necessary for reaching the UN Aichi strategic goals and EU biodiversity targets. Therefore we, the participants of the IENE 2014 International Conference, call for a pan-European strategy to protect roadless areas. We urge that such areas are given a stronger c The Roadless Area Conservation Rule, established nearly 20 years ago to conserve almost 60 million acres of our national forests in 39 states and territories, has provided a balanced and flexible approach that scientists and lawmakers from both sides of the aisle have praised as an effective way to protect extraordinary lands.Â Roadless areas, such as parts of the Manti-La Sal National Forest in Utah, make up just 2 percent of all the land in the United States. Tim Peterson.