Soda Mountains. Photo by John Dittli

THE ECONOMIC BENEFITS OF CALIFORNIA DESERT WILDLANDS

10 Years Since the California Desert Protection Act of 1994

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THE ECONOMIC BENEFITS OF CALIFORNIA DESERT WILDLANDS: 10 Years Since The California Desert Protection Act of 1994

Robert B. Richardson, Ph.D.

EXECUTIVE SUMMARY

Desert wildlands in southeastern California provide numerous direct and indirect economic benefits to humans. Relatively undisturbed landscapes such as wilderness areas provide a natural laboratory for scientific research, serve as a storehouse for biological diversity, and provide space for recreation activities. Many of these values were recognized by the California Desert Protection Act of 1994 (The Act), which designated several national parks and wilderness areas in the California desert area for "the people of this and future generations." The Act stated that "these desert wildlands display scenic, historical, archaeological, environmental, ecological, wildlife, cultural, scientific, educational, and recreational values used and enjoyed by millions of Americans." (CDPA, 1994) These places also generate economic benefits and support local communities. Policy makers must often make choices between alternative uses of natural resources. Efficient policy decisions require information about the total economic value associated with each policy alternative. However, many of the values of natural resources such as wildlands are ignored by economic markets and are frequently overlooked in public policy.

The purpose of this report is to estimate the total value of the economic benefits of wildlands in the California desert region. The analysis found that wildlands in the California desert generate economic values of approximately $1.4 billion per year and support nearly 3,700 jobs in the four counties of the region (Inyo, San Bernardino, Riverside, and Imperial Counties). Economic valuation of desert wildlands is important for a variety of reasons. The Act specifies that "the wilderness values of desert lands are increasingly threatened by and especially vulnerable to…incompatible use and development," and states that preservation "requires the highest forms of protective designation and management." (CDPA, 1994) In the ten years since the passage of the Act, the pressures of urban expansion, pollution, and heavy

vehicle traffic have increased the threats to desert ecosystems. Studies such as this one can help communicate to policy makers the range of economic values provided by desert wildlands to aid in effective and sustainable decisions about the future of the California desert.

The geographic scope of the study is limited to wilderness areas in Inyo, San Bernardino, Riverside, and Imperial Counties that were designated by the California Desert Protection Act of 1994 and managed by the National Park Service (NPS) and the Bureau of Land Management (BLM). In addition, nearly one million acres of unprotected desert land that possess many of the same characteristics as wilderness areas have been included in the analysis, in order to demonstrate their potential economic value if protected as wilderness. Most of the data used in this analysis were collected from federal agency reports, regional planning documents, and government databases.

The wildlands under review in this analysis comprise over 8.5 million acres in the California desert region (over 255,000 acres in Imperial County, over four million acres in Inyo County, over 1.1 million acres in Riverside County and nearly 3.1 million acres in San Bernardino County). Table E-1 provides a summary of the Imperial County lands considered in this study; Inyo County lands are summarized in Table E-2; Riverside County lands are summarized in Table E-3; and San Bernardino County lands under review are summarized in Table E-4.

Table E-1: Wildlands in Imperial County, California

IMPERIAL COUNTY	LAND DESIGNATION	TOTAL ACRES
Bureau of Land Management	Wilderness	204,082
	Other wildlands	51,375
TOTAL		**255,457**

Source: Bureau of Land Management.

Table E-2: Wildlands in Inyo County, California

INYO COUNTY	LAND DESIGNATION	TOTAL ACRES
National Park Service	Death Valley National Park Wilderness	3,128,000
Bureau of Land Management	Wilderness	764,004
	Other wildlands	157,454
TOTAL, INYO COUNTY		**4,049,458**

Source: National Park Service, Bureau of Land Management.

Table E-3: Wildlands in Riverside County, California

RIVERSIDE COUNTY	LAND DESIGNATION	TOTAL ACRES
National Park Service	Joshua Tree National Park Wilderness	471,733
	Joshua Tree Additions	86,914
Bureau of Land Management	Wilderness	563,343
TOTAL		**1,121,990**

Source: National Park Service, Bureau of Land Management.

Table E-4: Wildlands in San Bernardino County, California

SAN BERNARDINO COUNTY	LAND DESIGNATION	TOTAL ACRES
National Park Service	Joshua Tree National Park Wilderness	86,069
	Mojave National Preserve Wilderness	695,200
Bureau of Land Management	Wilderness	1,651,990
	Other wildlands	663,648
TOTAL		**3,096,907**

Source: National Park Service, Bureau of Land Management.

Nearly thirty distinct economic benefits of wilderness and natural areas have been categorized into broad categories, which are described in this report. These benefit categories include recreation values, off-site benefits, scientific research values, educational benefits, ecosystem service benefits, and passive use values. These benefits have an estimated value of more than $1.3 billion per year in the California desert region ($126 million per year associated with wildlands in Imperial County; $366 million per year in Inyo County; $278.1 million per year in Riverside County, $556.7 million per year in San Bernardino County). The results of the study and the values for each category of benefits are summarized below in Table E-5. These estimates were derived by applying several standard valuation methods and the results of peer-reviewed academic journal articles to publicly-available data and published studies of wilderness in California as well as in other regions of the U.S.

Table E-5: Economic benefits of wildlands in the California desert region

Category of Economic Benefits ($ millions/year)	Imperial County	Inyo County	Riverside County	San Bernardino County	Total – Desert Region ($ millions/year)
Direct Use Benefits	$ 1.3	$ 50.3	$ 35.6	$ 71.8	$ 159.0
Off-site Benefits	111.8	105.5	157.5	314.2	689.0
Scientific Benefits	n.a.	0.1	0.4	0.5	1.0
Educational Benefits	n.a.	n.a.	0.3	0.5	0.8
Ecosystem Services	0.7	17.4	30.9	22.4	71.4
Passive Use Benefits	12.2	192.7	53.4	147.3	405.6
TOTAL	**$ 126.0**	**$ 366.0**	**$ 278.1**	**$ 556.7**	**$ 1,326.8**

n.a. – not available

Other economic benefits that cannot easily be added to the above estimates include the community impact of visitor spending, which supports local jobs and income. This study has found that wildland visitors in the California desert generate $120 million annually in local income and nearly $190 million in annual output, and support 3,674 jobs in nearby communities. A summary of the community impacts of California desert wildlands is provided below in Table E-6.

Table E-6: Community impacts of wildlands in the California desert region

Community Impact	Imperial County	Inyo County	Riverside County	San Bernardino County	Total – Desert Region
Employment (# jobs)	38	914	882	1,840	3,674
Total income ($ millions)	$ 1.0	$ 28.2	$ 29.7	$ 61.1	$120.0
Output ($ millions)	$ 1.6	$ 44.2	$ 46.7	$ 96.8	$ 189.4

Other benefits of wildlands cannot be easily quantified or measured in dollars, such as the benefits of biological diversity. One indicator of biodiversity is the number of special status species (such as endangered or threatened species), which is presented by county below in Table E-7.

Table E-7: Other benefits of wildlands in the California desert region

Biological Diversity Benefits	Imperial County	Inyo County	Riverside County	San Bernandino County	Total-Desert Region
Special status species [1]:					
Plants	4	11	20	24	48
Fish	3	4	4	5	13
Amphibians	0	2	5	3	6
Birds	8	8	12	12	17
Mammals	1	4	4	3	8
Reptiles	2	1	3	2	4
Invertebrates	0	0	4	1	4

[1] County totals do not sum to region total because of common listings between counties.

INTRODUCTION

Ten years ago, the U.S. Congress declared in the California Desert Protection Act of 1994 (The Act) that the deserts of southern California "constitute a public wildland resource of extraordinary and inestimable value for this and future generations" (CDPA, 1994). The Act, a landmark legislative decision and an enduring environmental legacy, designated several national parks in the California desert along with dozens of wilderness areas. While many of the ecological values of the California deserts may be seen as intrinsic and "inestimable," human uses of desert wildlands generate economic values that can be measured or estimated using a variety of valuation techniques. Communication of these economic values to policy makers can help improve the information upon which land management decisions are based. The biological diversity and integrity of desert ecosystems in the region are increasingly threatened by the forces of urban development, population growth, road construction, and intensive pressures from motorized recreation. Wilderness designation offers the highest level of protection of both the ecological and economic values generated by lands in the California desert.

The California desert region is comprised of the Mojave, Great Basin, and Sonoran Desert ecosystems, and is one of the largest wild and undeveloped areas in the conterminous United States. The Mojave Desert is the smallest of the four North American deserts, but it is dominant in southeastern California. Its arid mountains and basins are surrounded by large urban centers with populations in the millions (Mettermeier *et al*., 2002). Annual precipitation is highly variable—ranging from less than 10 inches over most of the area to as high as around 65 inches—and the landscape is characterized by rough, unsettled terrain. The predominant vegetation is creosote shrub habitat, which supports a great diversity of plants and animals (Bury *et al*., 1977).

Exclusive of urban centers, the population of the region is about 490,000, which translates to a density of about 6.1 people per square mile (USGS-SDMT, 1998). Total population of the four-county region that includes Inyo, San Bernardino, Riverside, and Imperial Counties is approximately 3.8 million (U.S. Census, 2000). The metropolitan areas of Los Angeles and Las Vegas are within a short drive of most of the area, and urban and suburban sprawl from these areas have increased development pressures

both within desert cities and on surrounding public lands. Regional population growth between 1990 and 2000 was 30%, 32%, and 21% for Imperial, Riverside, and San Bernardino Counties respectively, and exceeded the statewide average of 14%. The pressures of a rapidly-growing human population, increased recreation demand, several large military bases, mines, and toxic waste disposal sites threaten the ecosystem of the area along with its natural resources—including wildlife, vegetation, air quality, and water availability. Since the 1800s, the region has been acutely affected by mining and grazing, and more recently by military activities and extensive off-road vehicle use. Wilderness designation protects areas of the California desert against many of these threats. Since wilderness areas are managed only for non-mechanized human uses, they provide the highest level of protection of many important ecological, social, and economic values.

The objective of this report is to estimate the value of economic benefits provided by wildlands in the California desert. Desert wildlands provide numerous economic benefits to society, including recreation uses (which support jobs and local income in nearby communities), educational values, scientific benefits, and the value of ecosystem services. Many of these values were recognized by the California Desert Protection Act of 1994, which designated several national parks and dozens of wilderness areas in the California desert (CDPA, 1994). The Act indicated that "these desert wildlands display scenic, historical, archaeological, environmental, ecological, wildlife, cultural, scientific, educational, and recreational values used and enjoyed by millions of Americans." These places also generate economic value and support local communities. Ten years since the passage of the California Desert Protection Act, there are 7.5 million acres of designated wilderness in the California desert, yet nearly one million acres of primarily roadless federal desert remains unprotected and threatened by the forces of sprawling urban and suburban development, population growth, and motorized recreation. These influences have degraded air quality and impaired biodiversity throughout the region.

Many factors influence the decisions involved in designating and managing wilderness areas. While economic values should not be the only consideration in wilderness designations or wilderness management (Loomis, 2000), the decision to designate wilderness or to protect natural areas certainly

involves economic trade-offs between wilderness uses and commodity uses (or, in many cases, other recreation uses). Many economic benefits of desert wildlands areas are frequently overlooked in management and policy decisions, and some have implications for society as a whole. All of the wildlands investigated in this analysis are on federal land and are managed by federal agencies using federal tax revenues. The public lands of the nation are held in trust for the American people. The concept of public trust establishes that certain public goods are so important that they should not be managed for the benefit of the few over the interests of many (Sax, 1970). This notion is supported by language in the National Environmental Policy Act (NEPA, 1969), with which federal land management agencies must comply. Thus, federal agencies have a responsibility to the interests of the *national* society, including the recognition of the values of biodiversity, research, and education, as well as a responsibility to future generations. Still, public land decisions may affect *regional* economies regarding recreation management and impacts on the natural environment; therefore, the value of wilderness recreation and the economy of local communities should also be recognized.

The study area is limited to the four-county region of Inyo, San Bernardino, Riverside, and Imperial Counties, and includes all desert wilderness areas managed by the Bureau of Land Management (BLM) and the National Park Service (NPS) in the region, as well as several BLM wilderness study areas (WSA), which possess the same characteristics of designated wilderness areas (*i.e.*, the areas are roadless, retain their natural character, and provide opportunities for solitude and primitive recreation), and are managed as such by their respective agencies. For purposes of simplicity, the term "wildlands" is used throughout the study to refer to these areas, and is assumed here to be defined as areas that are primarily roadless, minimally developed, and managed for non-motorized recreation and the protection of unique natural values and resources.

The entire study area in this analysis comprises 8,523,812 acres in the four-county region. Designated wilderness areas and their respective acreage in each county are presented in Tables 1 through 4. There are over 200,000 acres of designated wilderness in Imperial County, nearly four million acres of designated wilderness in Inyo County (including portions of Death Valley National Park), over one

million acres of wilderness in Riverside County (including portions of Joshua Tree National Park), and more than 2.4 million acres of wilderness in San Bernardino County (including portions of Joshua Tree National Park and Mojave National Preserve).

Table 1: Desert Wilderness Areas in Imperial County, California

AGENCY/ORGANIZATION	AREA	ACRES
Bureau of Land Management	Coyote Mountains Wilderness	18,574
	Fish Creek Wilderness	20,575
	Indian Pass Wilderness	31,922
	Jacumba Wilderness	31,171
	Little Picacho Wilderness	38,052
	North Algodones Dunes Wilderness	25,811
	Palo Verde Mountains Wilderness	29,149
	Picacho Peak Wilderness	8,828
TOTAL, Imperial County		**204,082**

Source: Bureau of Land Management.

Table 2: Desert Wilderness Areas in Inyo County, California

AGENCY/ORGANIZATION	AREA	ACRES
National Park Service	Death Valley Wilderness	3,128,000
Bureau of Land Management	Argus Range Wilderness	74,890
	Coso Range Wilderness	50,520
	Darwin Falls Wilderness	8,600
	Funeral Mountains Wilderness	25,696
	Ibex Wilderness	28,804
	Inyo Mountains Wilderness	132,442
	Malpais Mesa Wilderness	32,360
	Manly Peak Wilderness	16,105
	Nopah Range Wilderness	106,571
	Pahrump Valley Wilderness	72,528
	Piper Mountain Wilderness	72,575
	Resting Spring Range	78,868
	South Nopah Range Wilderness	17,036
	Surprise Canyon Wilderness	29,180
	Sylvania Mountains Wilderness	17,829
TOTAL, Inyo County		**3,892,004**

Source: National Park Service, Bureau of Land Management.

Table 3: Desert Wilderness Areas in Riverside County, California

AGENCY / ORGANIZATION	AREA	ACRES
National Park Service	Joshua Tree Wilderness	471,733
Bureau of Land Management	Big Maria Mountains Wilderness	45,272
	Chuckawalla Mountains Wilderness	84,473
	Little Chuckawalla Mountains Wilderness	27,331
	Mecca Hills Wilderness	26,016
	Orocopia Mountains Wilderness	45,878
	Pallen/McCoy Wilderness	212,533
	Rice Valley Wilderness	41,536
	Riverside Mountains Wilderness	23,959
	Santa Rosa Wilderness	56,345
TOTAL, Riverside County		**1,035,076**

Source: National Park Service, Bureau of Land Management.

Table 4: Desert Wilderness Areas in San Bernardino County, California

AGENCY / ORGANIZATION	AREA	ACRES
National Park Service	Joshua Tree Wilderness	86,069
	Mojave Wilderness	695,200
Bureau of Land Management	Bigelow Cholla Garden Wilderness	13,517
	Black Mountain Wilderness	20,550
	Bristol Mountains Wilderness	69,976
	Cadiz Dunes Wilderness	19,278
	Chemehuevi Mountains Wilderness	85,556
	Cleghorn Lakes Wilderness	32,860
	Clipper Mountain Wilderness	33,855
	Dead Mountains Wilderness	46,640
	Golden Valley Wilderness	37,700
	Grass Valley Wilderness	31,695
	Hollow Hills Wilderness	22,024
	Kelso Dunes Wilderness	144,173
	Kingston Range Wilderness	199,310
	Mesquite Wilderness	44,815
	Newberry Mountains Wilderness	20,308
	North Mesquite Mountains Wilderness	28,915
	Old Woman Mountains Wilderness	162,688
	Piute Mountains Wilderness	47,952
	Rodman Mountains Wilderness	29,793
	Saddle Peak Hills Wilderness	1,528
	Sheephole Valley Wilderness	186,432
	Stateline Wilderness	7,003
	Stepladder Mountains Wilderness	83,337
	Trilobite Wilderness	29,588
	Turtle Mountains Wilderness	176,712
	Whipple Mountains Wilderness	75,785

TOTAL, San Bernardino County		**2,433,259**

Source: National Park Service, Bureau of Land Management.

Wilderness study areas and other wildlands in the California desert region are presented in Table 5, and they comprise nearly one million additional acres.

Table 5: Other Wildlands in the California Desert Region

AGENCY / ORGANIZATION	COUNTY	AREA	ACRES
National Park Service	Riverside	Joshua Tree (addition)	86,914
Bureau of Land Management	Imperial	Algodones Dunes	51,375
	Inyo	Great Falls Basin	7,900
	Inyo	Inyo Mountains (addition)	3,600
	Inyo	Malpais Mesa (addition)	43,152
	Inyo	Slate Range	102,802
	San Bernardino	Amboy Crater	14,895
	San Bernardino	Avawatz Mountains WSA	83,880
	San Bernardino	Cady Mountains WSA	108,238
	San Bernardino	Denning Springs/Death Valley	57,680
	San Bernardino	Iron Mountains	128,096
	San Bernardino	Kingston Range Addition	90,941
	San Bernardino	Ship Mountains	36,008
	San Bernardino	Sleeping Beauty	33,110
	San Bernardino	Soda Mountains WSA	110,800
TOTAL, Other Wildlands			**959,391**

Source: Henson, R. and P. Spitler, 2001.

ECONOMIC BENEFITS PROVIDED BY WILDLANDS

Societies must often choose between alternative uses of the natural environment (Goulder and Kennedy, 1997). In order to make rational choices, it is essential to understand the total economic value that each alternative provides. Many benefits of natural resources are ignored by economic markets, and their values are frequently overlooked in policy decisions. Such market failures are the root of many environmental problems, and they have motivated economists to develop methods for valuing non-market benefits. Environmental policy decisions regarding the alternative uses of public lands must consider the total economic value of these lands—including their non-market values—in order to be economically efficient. Ignoring these values has historically led to irrational and inefficient land allocation and management decisions.

The stock of natural resources—especially undeveloped or roadless landscapes—is finite. Since we live in a world of limited resources, satisfying all human demands is impossible, from an economic point of view (di Castri *et al*., 2002); unregulated use of limited public resources leads to exploitation and cannot be sustained. Consequently, the importance of sustainable development has been emphasized by scientists and policymakers in recent years. The Brundtland Commission determined that economic development is sustainable if it satisfies the needs of the current generation without impairing the ability of future generations to satisfy their necessities (WCED, 1987). The protection of natural environments provides a wide array of economic benefits to society (Krutilla and Fisher, 1975); the designation of wilderness areas ensures that these economic benefits will be available for use by future human generations.

There are many values associated with the designation of wilderness areas, and they are emphasized in the Congressional legislation that created the National Wilderness Preservation System. According to the Wilderness Act of 1964, wilderness areas provide opportunities for a “primitive and unconfined type of recreation” as a defining characteristic (Wilderness Act, 1964). But the Act indicates that Wilderness areas "…may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value," and further mandated that they be managed in such a way as to

leave them "unimpaired for future use and enjoyment as wilderness." An objective of the California Desert Protection Act of 1994 was to preserve the "scenic, geologic, and wildlife values" along with "historical and cultural values" specific to California desert wildlands (CDPA, 1994). Other environmental legislation has recognized numerous values as well. The Endangered Species Act recognizes that plant and animal species provide "esthetic, ecological, educational, historical, recreational, and scientific values to the Nation and its people." The Federal Land Policy and Management Act of 1976 mandates that "public lands be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological values" (FLPMA, 1976). These laws acknowledge that wilderness areas (and other natural areas with similar characteristics) provide many benefits to humans (often called anthropocentric values), and many of these benefits have been studied extensively by economists using a variety of valuation techniques. The preservation of the values of wilderness and natural areas often generates measurable economic benefits to the general society, as well as economic impacts to nearby counties and communities. Today, scientists and public land managers emphasize the importance of additional values such as protection of biodiversity and endangered species, as well as the sustainable uses of natural resources. In addition to the numerous direct and indirect benefits to humans, wilderness areas also protect important ecological values. While it may be difficult to measure some of these values, many of the benefits humans receive from wilderness and natural areas actually can be quantified and measured in monetary or economic terms. Economic analysis of wilderness preservation has been used for decades to measure and communicate the values of natural resources to public officials who must ultimately choose between alternative management plans for public lands.

The decision to designate certain public lands as wilderness is often contentious. The designation of a parcel of land as wilderness ensures that wilderness values will be preserved, but at the cost of foregoing other uses of the land, which in some cases includes mining, road construction, and motorized vehicle access. Arguments against wilderness designation often assert that wilderness "locks up" public resources and excludes use, but wilderness designation actually ensures that particular uses and values are

provided and protected for future generations. Author David Havlick suggests that the protection of roadless areas actually *liberates* lands—by allowing a broader array of public interests to thrive, including "forms of recreation that may have been displaced due to road use, healthy wildlife and plant populations, clean air and water, and healthier soils" (Havlick, 2002).

One important economic benefit of public lands is the impact of visitor spending on local economies. Visitors to national parks, wilderness areas, and other wildlands make purchases at area businesses such as gasoline stations, hotels, campgrounds, and restaurants. Such expenditures generate income and support local jobs. A report published by the National Parks Conservation Association (NPCA, 2002) estimated that national parks in California generate $1.18 billion in annual visitor spending, which supports 30,000 jobs. Table 6 below presents the findings of this report for the three national park sites in the California desert region. The results show that visitors to Death Valley, Joshua Tree, and Mojave spend approximately $95.4 million annually, which generates over $40 million in personal income and supports nearly 2,500 jobs.

Table 6: Economic impact of visitor expenditures at national parks in the California desert region

National Park	Total Recreation Visits	Total Spending	Spending Per Party Per Night	Personal Income Generated	Total Jobs Created
Death Valley	1,014,636	$44,000,000	$73	$16,210,000	1,212
Joshua Tree	1,280,917	$46,300,000	$77	$21,920,000	1,115
Mojave	492,745	$5,100,000	$24	$2,000,000	121
TOTAL, Desert Region	**2,788,298**	**$95,400,000**	**n.a.**	**$40,130,000**	**2,448**

Source: National Parks Conservation Association, 2002.

While some of the benefits of wilderness tourism and recreation are important to the economies of local communities, there are numerous other benefits of wildlands—such as the protection of wildlife habitat—that are valued by the general public. In a 1995 survey of U.S. residents, nearly 80% of respondents indicated that the protection of wilderness for each of the purposes of air and water quality, wildlife habitat, and endangered species was "very" or "extremely" important (Cordell *et al*., 1998). Only

23% indicated that the benefits of wilderness recreation were as important. This implies that the U.S. population attaches great significance to some of the ecological values protected by wilderness areas in addition to the cash flow they generate through recreational use. More than 55% of the survey respondents said that the present amount of designated wilderness is "not enough," while only 2.5% said that it is "too much."

The purpose of this study is to estimate the total value of economic benefits provided by wildlands in a four-county region of the California desert. The framework of the economic analysis was originally developed by Morton (1999), and categorizes approximately thirty distinct economic benefits of wilderness and natural areas into eight groups. The objective of this report is to estimate the total value for each of the categories of benefits, based on published data and research studies of the value of wildland uses. The categories are:

- Direct use benefits
- Community impacts
- Off-site benefits
- Scientific benefits
- Educational benefits
- Ecosystem services benefits
- Biological diversity benefits, and
- Passive use benefits.

Each of these categories of economic benefits meets two criteria for valuation as an economic benefit—first, each is relatively scarce, and second, society is willing to pay for each of them. The sections that follow are arranged in order of the above categories of economic benefits, and present the methodology used in valuation estimates, the source of data, and the value estimates.

DIRECT USE BENEFITS

Direct uses of wildlands include on-site recreation and the enjoyment of cultural and heritage sites, and the economic value of these uses are measured as the benefit to the users. Wilderness and other natural areas provide opportunities for non-motorized recreation, including hiking, horseback riding, backpacking, camping, wildlife viewing, fishing, and hunting. Wildland recreation is significant throughout the desert region: data collected for this study indicates that California desert wildlands attract more than three million visitors annually. The preservation of desert wildlands for recreation use is important to visitors. In a 1997 visitor study at Mojave National Preserve, roughly 80% of respondents indicated that scenic views and their desert recreation experience were either "extremely important" or "very important." Interestingly, 87% of respondents indicated that the preservation of wilderness and open space was "extremely" or "very" important, and 86% rated the importance of solitude and quiet at the same level. When asked about the importance of clean air, nearly 85% responded with ratings of "extremely" or "very" important. About 70% of respondents rated viewing wildlife and wildflowers at the same degree of importance (MNP, 1997).

Economists treat recreation use as a consumer good—that is, the number of recreation trips taken (or consumed) is assumed to vary depending on the associated costs, or prices. Costs of travel (*e.g.*, gasoline prices, lodging) and recreation (*e.g.*, park fees) are among the factors that influence consumer decisions about the number of trips taken. The economic benefit of recreation use is defined as *net willingness to pay* (or consumer surplus) and should be understood as the benefits accrued to the recreation user. It is a measure of the total demand for recreation, after subtracting travel and recreation costs (Loomis and Walsh, 1997). The recreation benefit per visitor day can be interpreted as the amount that the average visitor would be willing to pay rather than forego one day of recreation.

There are two methods used by economists to measure the economic benefits to recreation users. The travel cost method uses variations in visitation and travel costs to statistically estimate the net benefits of recreation for a particular site (Loomis and Walsh, 1997). This method assumes that visitors who travel longer distances (and incur greater travel costs) for recreation receive greater net economic

benefit from the experience, as revealed by their willingness to pay higher costs. The contingent valuation method is a survey technique that creates a hypothetical market for recreation to calculate visitors' willingness to pay for goods for which there is no market. Both of these methods have been approved by two federal agencies as recommended approaches for estimating non-market values such as the economic benefits of recreation and costs of natural resource damages (U.S. Water Resources Council, 1983; U.S. Department of Interior, 1986, 1994). The recreation use values cited in this report were developed using these two methods and were published in peer-reviewed academic journals.

Visitation data for the national parks reviewed in this study are collected annually and are publicly available and accessible. However, recreation use data for BLM wilderness areas are only collected for certain areas in Inyo County. The BLM does not collect or even estimate recreation use data for dozens of wilderness areas and wilderness study areas throughout the California desert. The agency maintains a national database called Recreation Management Information System (RMIS) which is intended to be the storehouse for recreation use on BLM lands, but there are no historical data for thousands of wilderness acres in several BLM districts throughout California. In fact, Loomis (1999) noted that wilderness visitation data are reported for less than half of the designated wilderness acreage in the state. The low priority of wilderness recreation management within the BLM provides little incentive for agency staff to measure recreation use or utilize the RMIS database. Recreation management is integral to an agency's wilderness management program (Loomis, 1999); with no record of current use levels, it is nearly impossible to assess trends, monitor impacts, and evaluate management alternatives.

Loomis (1999) studied the recreation impact of the designation of additional wilderness to determine whether designation results in additional use or simply spreads existing use across a greater range of wilderness recreation choices. He found that the designation of additional wilderness areas does result in an overall increase in wilderness recreation use, at a rate of elasticity of 0.89 (*i.e.*, that a 10% increase in designated wilderness would result in an average increase in visitor use of 8.9%). He developed a model to statistically estimate recreation use by relating visitation data with acreage. This model was used in this study in order to estimate recreation use where recreation data was not available.

Table 7 provides annual visitation data for the wildlands under review in this study. Where available, visitation data represent an average of annual visitation between 1998 and 2000. Visitation is measured in Recreation Visitor Days (RVDs); one RVD is equivalent to a 12-hour visit (thus, one RVD may represent one person for a 12-hour visit or two people visiting for 6 hours, etc.).

Table 7: Annual visitation data for California desert wildlands

AGENCY	Imperial County (RVDs)	Inyo County (RVDs)	Riverside County (RVDs)	San Bernardino County (RVDs)	Region Total (RVDs)
National Park Service					
Death Valley National Park	- -	1,014,636	- -	- -	1,014,636
Joshua Tree National Park	- -	- -	512,367	768,550	1,280,917
Joshua Tree Additions	- -	- -	177,632	- -	177,632
Mojave National Preserve	- -	- -	- -	492,785	492,785
Bureau of Land Management					
Wilderness	22,449	29,725	61,968	181,719	295,861
WSAs/Other Wildlands	5,651	17,320	- -	73,001	95,972
TOTAL	**28,100**	**1,061,681**	**751,967**	**1,516,055**	**3,357,803**

Source: National Park Service, 2001; Bureau of Land Management, 2000; data for some BLM areas estimated by acreage (see text and Loomis, 1999).

There have been more than twenty empirical studies of the economic value of recreation in wilderness areas (and other primitive areas in the U.S.); these were originally compiled by Sorg and Loomis (1984) and updated by Loomis *et al* (1998). These studies valued recreation benefits at wilderness areas throughout the U.S., including California, and revealed an average value of wilderness recreation per day of $47.38 (adjusted for inflation to 2004 dollars). This is the amount that the average wilderness visitor would be willing to pay in additional costs rather than forego one day of recreation. When this value is applied to the estimate of over three million recreation visitor days at wildlands in the California desert region, the aggregate value of recreation benefits is $159 million per year ($1.3 million in Imperial County; $50.3 million in Inyo County; $35.6 million in Riverside County; $71.8 million in San Bernardino County). Recreation use levels for each county and the associated recreation benefits are provided below in Table 8.

Table 8: Annual direct use benefits of wildlands in the California desert region

COUNTY	Recreation Use Days	Direct Use Benefits ($ millions per year)
Imperial County	28,100	$ 1.3
Inyo County	1,061,681	50.3
Riverside County	751,967	35.6
San Bernardino County	1,516,055	71.8
REGION TOTAL	**3,357,803**	**$159.00**

Recreation use values differ between counties because of variations in wildland acreage as well as the popularity of particular recreation sites.

Detailed studies of particular wilderness recreation activities suggest that these estimates may be conservative. Recreation visits to unique or unusual sites often generate even greater economic benefits. As an example, rock climbing in wilderness areas has gained enormous popularity in Joshua Tree National Park and Mojave National Preserve; studies of the economic benefits of rock climbing have yielded recreation use values of nearly $100 per trip (Grijalva *et al*., 2002; Shaw and Jakus, 1996).

COMMUNITY IMPACTS

Wilderness and other natural areas affect their surrounding human communities in a variety of ways (Rudzitis and Johnson, 2000). Proximity to wildlands affects the employment, population, and economy of many communities throughout the California desert. Public land agencies employ rangers who live in nearby communities and are directly involved in the management of wilderness areas. Popular wildland recreation sites often generate economic growth opportunities for businesses in the tourism sector. Recreation visitors, as well as students and research scientists studying wildlands, make purchases in towns and communities near such areas that support jobs and generate income for local residents. Moisey and Yuan (1992) compared the expenditures of wildland and non-wildland recreation visitors to Montana, and found that wildland-based visitors (backpacking, fishing, and nature study) spent more money for their trips and stayed about twice as long as non-wildland visitors. Another community impact of wildlands throughout the western U.S. is population growth. It has been shown that the recreation and environmental amenities of wilderness and other natural areas contribute to the quality of life of nearby residents, and often attract new residents, retirees, and businesses who wish to locate near such places. Rudzitis *et al* (1996) found that "among the fastest growing counties in the nation are those adjacent to federally designated wilderness areas." They noted that the population of wilderness counties increased six times faster than the national average for other nonurban counties in the 1980s, and nearly twice as fast as other nonurban counties in the western U.S.

Population growth throughout most of the California desert region outpaced the state average during the 1990s. The population of Imperial County grew 30.2%, Riverside County grew 32%, and San Bernardino County grew 21%, while the population of California increased about 13.5%. (The population of Inyo County declined 1.8% during that decade.) While urban expansion, climate, and other factors have contributed significantly to population growth in the California desert, studies such as Rudzitis *et al* (1996) demonstrate the influence of wilderness proximity to migration and population growth. Population levels from 2000 and 1994 for cities in the desert region are provided below in Table 9.

Table 9: Population of cities in the California desert region – 2000 and 1994

County	City/Town	2000 Population	1994 Population	% Change
Imperial	Brawley	22,052	21,300	3.5%
	Calexico	27,109	23,250	16.6%
	El Centro	37,835	35,750	5.8%
Inyo	Bishop	3,575	3,550	0.7%
Riverside	Blythe	20,463	12,400	65.0%
	Cathedral City	42,647	35,800	19.1%
	Desert Hot Springs	16,582	14,550	14.0%
	Hemet	58,812	50,300	16.9%
	Indio	49,116	42,550	15.4%
	Palm Desert	41,155	28,150	46.2%
	Palm Springs	42,807	41,450	3.3%
San Bernardino	Barstow	21,119	21,400	-1.3%
	Needles	4,830	5,350	-9.7%
	Twentynine Palms	17,464	14,400	21.3%
	Yucca Valley	16,865	16,300	3.5%

Source: U.S. Census Bureau, 2000; State of California, 2000.

Some community impacts of wildlands can be estimated with the use of an input-output model. Spending by recreation and non-recreation visitors on lodging, food, and supplies has a direct effect on local businesses that provide such goods and services to tourists. These expenditures have indirect or multiplier effects on the regional economy through the increased demand of these businesses for the goods and services they purchase from other local firms (a kind of "rippling effect" through the local economy). Local spending supports jobs and generates income for communities. In this report, economic impacts to local communities were calculated using IMPLAN (MIG, 1997). IMPLAN is an input-output model that was originally developed by the U.S. Forest Service to estimate the direct and indirect economic impacts of agency actions on regional income and employment. Model results are based upon economic linkages between local industries and the associated multipliers for counties in the California desert region. The IMPLAN model uses these linkages, along with visitor expenditure data and the number of annual visitors, to calculate the direct and indirect effects of visitor spending, and estimates the local income (personal wages, business profits) and jobs supported by the expenditures.

There are few studies that estimate wilderness visitor expenditures. Rudzitis and Johnson (1999) compiled the results of seven studies of expenditures of visitors to wilderness areas, and found that daily

spending per person ranged from $36.48 to $48.92 across different regions in the western United States. Average daily expenditures per person across the studies are $43.38 (adjusted to 2004 dollars). Visitors to wilderness and natural areas spend their money in a variety of ways. The data collected in the expenditure studies were used to calculate an average distribution of expenditures among the various sectors of the local economy. Table 10 provides the average distribution of visitor expenditures among local economic sectors. They represent a range of visitor types, locations, and recreation activities.

Table 10: Average expenditures of wilderness visitors by category of purchase

Expenditure type	**Average expenditures per person per day (2004 $)**
Gasoline	$9.04
Food: Groceries	9.05
Food: Restaurant	7.45
Lodging & campground	7.11
Automobile rental	1.71
License fees/admission/permits	1.25
Recreation equipment/outfitter/guide	1.75
Retail purchases	6.02
TOTAL	**$43.38**

Source: Rudzitis and Johnson, 1999

Recreation visitor data is also required as an input to the IMPLAN model. Data gathered for the previous section of this report indicated that California desert wildlands attract over three million visitors per year. Using these estimates of average daily expenditures per person, along with visitor use levels for wildlands in the California desert, the IMPLAN input-output model estimates that visitors to such areas support 3,674 jobs, $120 million in total income (including business and personal income), and $189.4 million in output (the value of all goods and services produced within the region) for the four-county region. Table 11 presents these community impact estimates by county.

Table 11: Regional employment, income, and output supported by wildland visitors in the California desert region

REGIONAL IMPACT	Imperial County	Inyo County	Riverside County	San Bernardino County	Region Total
Employment Impact (# jobs)	38	914	882	1,840	3,674
Annual Income Impact ($ millions)	$ 1.0	$ 28.2	$ 29.7	$ 61.1	$ 120.0
Annual Output Impact ($ millions)	$ 1.6	$ 44.2	$ 46.7	$ 96.8	$ 189.4

Regional impact estimates differ between counties because of variations in wildland acreage and recreation demand. The local industries most affected by wildland visitors are the ones mentioned above in Table 9 (*i.e.*, gasoline stations, food stores, restaurants, lodging, etc.). However, because of the indirect and induced effects, there are estimated impacts to numerous other sectors, including transportation, construction, communication, health services, business services, and government.

It has been demonstrated that counties near wilderness areas attract new residents who value such places for their scenic views and recreation opportunities. A study funded by the National Science Foundation surveyed people who had moved into counties with federally-designated wilderness in the previous ten years, as well as longer term residents of these counties (Rudzitis and Johansen, 1991). The results indicated that 72 percent of new residents considered wilderness a "major factor" in their decision to move to the county; 55 percent of longer-term residents stated that wilderness was an important reason for living in the area. More than a third of all residents indicated that they use wilderness areas at least twelve times a year.

Counties adjacent to wildlands have been shown to attract new businesses that offer equipment and services related to recreation activities, and others whose owners and managers prefer to locate near scenic areas. Commercial guides and outfitters offer numerous recreational trips and courses in wilderness areas in the California desert region, and there is considerable demand for these services. Several of these businesses are located in Bishop, San Bernardino, and Riverside. In interviews, several managers estimated that as much as 75% of their business is related to recreation in designated wilderness

areas, and numerous pack stations indicated that 100% of their trips take place in designated wilderness. Death Valley National Park issues nearly 150 permits per year for special events and business uses such as outdoor recreation guiding, commercial filmmaking, and private weddings, many of which bring revenue to local businesses and communities. Joshua Tree National Park issues over 150 incidental business permits per year for the backcountry alone. Mojave National Preserve issues two to three incidental business permits per year for wilderness areas.

Concerns have been raised in the past that wilderness designation will somehow result in a loss of jobs for a region. However, empirical evidence does not support these concerns. Duffy-Deno (1998) studied 250 nonurban counties in the western U.S., and found no evidence that resource-based employment is adversely affected by the existence of federal wilderness. Lorah (2000) studied 113 rural counties in the western U.S. and found that the presence of wilderness is *positively* correlated with employment growth, income growth, and population growth; the relationship is more highly correlated when the environmental amenities are expanded beyond wilderness to include the presence of national parks and BLM wilderness study areas.

Historical data shows that employment has risen significantly in the California desert region since the passage of the California Desert Protection Act of 1994, particularly in the accommodation and food services sector. Table 12 below presents employment levels in the accommodation and food services sector of each county's economy in 2001 and 1994, as well as total employment levels and employment growth rate by county during that period. Employment in the accommodation and food sector increased by 29.0% since the passage of The Act, and outpaced total employment growth in several counties.

Table 12: Employment in the four counties of the California desert region – 2001 and 1994

County	Accommodation and Food Employment		Total Employment		% Change in Employment	
	2001	1994	2001	1994	Accommodation and Food	Total Employment
Imperial	2,697	2,467	25,103	24,110	9.3%	4.1%
Inyo	1,350	1,013	5,567	4,300	33.3%	29.5%
Riverside	49,282	37,489	410,073	282,669	31.5%	45.1%
San Bernardino	41,615	32,612	426,422	362,609	27.6%	17.6%
REGION TOTAL	**94,944**	**73,581**	**867,165**	**673,688**	**29.0%**	**28.7%**

Source: U.S. Census Bureau, 2000.

OFF-SITE BENEFITS

Most of the research to-date on the economic benefits of wilderness has focused on the value of uses that occur on-site, such as recreation. However, the total economic benefits of wilderness and other natural areas include some values generated outside of the areas. For example, wilderness areas provide scenic backdrops for resorts and residential areas on nearby lands, thereby enhancing the value of personal and commercial property and increasing tax revenues. Wildlands also provide picturesque views for pleasure travelers who drive across the region—and the off-site benefits of the desert viewshed may be significant. The California Department of Transportation estimates that over 10 million vehicles travel along Interstate 15 adjacent to Mojave National Preserve each year. Over 6 million vehicles travel along Route 62 adjacent to Joshua Tree National Park annually (CalTrans, 2002). The desert landscapes of Joshua Tree National Park and its neighboring wilderness areas are enjoyed by travelers along CA62 in San Bernardino County and U.S. Interstate 10 in Riverside County, underscoring the importance of scenic viewsheds along highways to counties throughout the desert region.

While wilderness and other natural areas generate numerous off-site benefits—some of which are difficult to value—the benefit of property price enhancements attributable to proximity to wilderness areas can be estimated using the hedonic property pricing model (Rosen, 1974). It has been demonstrated that the wilderness areas do in fact enhance, rather than diminish nearby land values. The value of private land near wilderness areas is expected to be higher due to the wilderness amenity value, thereby generating off-site benefits to adjacent landowners. A hedonic pricing model was used to estimate the enhancement value of private land near Green Mountain National Forest wilderness areas in Vermont (Phillips, 1999). Private property located in towns[1] that contain designated wilderness areas were sold for prices that are 13 percent higher than in towns without wilderness, even after controlling for the presence of alpine ski resorts.[2] That is, all else being equal, a parcel that sells for $1,000 per acre in a town without wilderness would be expected to sell for $1,130 per acre if it were in an area containing wilderness. The

[1] In this study, "towns" were geographic areas of less than approximately 10,000 hectares.
[2] The combined effect of the proximity to wilderness areas and ski areas was found to be approximately 24 percent.

study demonstrated further that land prices decreased by 0.8 percent per acre with each kilometer of distance from the nearest wilderness boundary.

Using the Phillips results, a conservative estimate of the private-property enhancement value of wildlands in the California desert region would consider only private property values in communities adjacent to wilderness and wildland areas (that is, excluding the urban centers of San Bernardino, Riverside, Palm Springs, and others). U.S. Census data (2000) reports that there are 8,609 housing units in communities near wildlands within Imperial County. Using the median housing value (adjusted to 2004 dollars) in these communities of $99,895 along with the 13% wilderness value factor, the estimate of off-site wildland benefits is $111.8 million per year. There are 4,783 housing units in communities near wildlands in Inyo County; using the median housing value there of $169,646, the estimate of off-site wildland benefits in those communities is $105.5 million per year. There are 12,984 housing units in communities near wildlands in Riverside County; using the median housing value there of $93,283, the estimate of off-site wildland benefits in those communities is $157.5 million. Finally, there are 28,720 housing units in such communities within San Bernardino County; using the median housing value there of $84,155, the estimate of off-site wildland benefits in those communities is $314.2 million per year. The estimate of total off-site wilderness benefits for the four counties of the California desert region is therefore $689 million.

It is worth mentioning that this estimate of the off-site benefits of wildlands may be conservative, as it does not include the private property enhancement value of many other communities that likely benefit from their proximity to desert wildlands, nor does it include the enhancement values of commercial property or the value of other relevant off-site benefits such as viewshed protection. Palm Springs and other communities in the Coachella Valley attract thousands of golfers to their picturesque golf courses, and many of these visitors credit the scenic mountain views and forested slopes near the city as part of their attraction to the area. In addition, scenic wildland areas within the desert region are frequently used for commercial filmmaking, advertisements, and photography, which generate additional off-site benefits. Mojave National Preserve as well as Joshua Tree and Death Valley National Parks grant

dozens of permits to commercial applicants for such uses. Other off-site uses of wildlands in the region include the enjoyment and consumption of art and photography, and artistic images of Joshua trees, sand dunes, and rock formations in the California desert region figure prominently in galleries throughout southern California and the United States. It would be difficult to value the economic benefits of scenic viewsheds and artistic images in desert wildlands, but for purposes of this study, the enhancement value of private property near wilderness areas is presented as a proxy for off-site benefits.

SCIENTIFIC BENEFITS

Wilderness has often been referred to as a benchmark of relatively unmodified natural conditions in which to observe unfettered ecological processes at work (Loomis and Richardson, 2000). As such, wilderness areas are often the subject of scientific research and publications. Wilderness has been the focus of study for more than 400 scientific journal articles in the natural and social sciences, as well as for several hundred federal agency research publications. In some cases, wilderness areas are used as control areas for understanding human effects, and in others, wilderness is directly used to understand the influence of natural conditions on flora, fauna and physical environments. Scientific articles contribute to scientific progress and understanding, and often, in turn, to greater efficiency in policymaking, productivity improvements, and overall increased human well-being.

The value of new discoveries and the knowledge that arises from the opportunity to study largely unfettered ecological processes has the potential to prevent costly natural resource management mistakes that lead to expensive endangered species recovery efforts and environmental restoration activities. New knowledge often has 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 advancement in knowledge. Ongoing research projects today in California desert wildlands have made important advances in diverse fields such as population biology, climatology, and seismology. Research findings often lead to cost savings in dune restoration, wildlife protection, and earthquake damages. The advances in knowledge arise from scientific discovery and their dissemination via scientific journal articles (Black, 1996).

Scientific research in the California desert wildlands takes many forms. Some of the most active research programs on federal wildlands are conducted by scientists from several natural reserves in the area, which are operated by The University of California (UC). Wilderness areas are often seen as outdoor laboratories where scientists can analyze natural systems and attain better understanding of the impact of

humankind upon the world and it upon us. Some areas serve as representative sites for carrying out studies with regional implications. Others are unique and allow scientists to conduct site-specific research work that cannot be carried out anywhere else in the world (UCNRS, 2002). UC Natural Reserves in the desert region include the Boyd Deep Canyon Reserve and the Motte Rimrock Reserve in Riverside County, and the Sweeney Granite Mountains Reserve in San Bernardino County, which uses wilderness areas extensively for research. California State University operates the Desert Studies Center at Soda Springs near the Mojave National Preserve. In addition, for over 20 years, the Bighorn Institute in the Coachella Valley has studied the ecology of bighorn sheep, with particular attention to the population declines of the Peninsular desert bighorn sheep, which is on the brink of extinction. Through field and laboratory experiments, the Institute promotes scientific knowledge to assist in the judicious management of wild sheep (Bighorn Institute, 2003).

The Sweeney Granite Mountains Reserve has conducted numerous studies of the structure and disturbances in desert soils, as well as the factors that contribute to wind erosion (which contributes to significant visibility and human health problems—see the section on the Benefits of Ecosystem Services). Scientists at the Boyd Deep Canyon Reserve have maintained ongoing research studies of various lizard populations, including the endangered Coachella Valley fringe-toed lizard. Other centers have made major contributions to the study of migratory bird populations, reptile diversity, climate variability, and dune degradation (UCNRS, 2002). Some reserves report that up to 90% of their research is conducted in wilderness areas. Scientists who use wilderness areas for research are able to pursue their interests untroubled by the frequent and unpredictable disturbances from motorized vehicles and industrial activities that afflict those who attempt to work in some other areas. The reserves themselves remain relatively free from the varying degrees of disruption that natural habitats elsewhere sustain under the pressures of growing population, urbanization, and intensified use of natural resources (UCNRS, 2002).

Research at the Soda Springs Desert Studies Center is multi-faceted. Scientists conduct ongoing studies of wildlife and vegetation populations, including several endangered and threatened species; they have used gravimetric techniques to resolve questions of fault extensions in the vicinity of the Avawatz

and Soda Mountains; and they have used modern dating techniques to study the Cima volcanic field. The Center hosts an annual Desert Symposium, which usually draws dozens of scientists and students to numerous research presentations and discussion sessions (CDSC, 2002).

Death Valley National Park, Joshua Tree National Park, and the Mojave National Preserve all issue permits to scientists to conduct soil surveys and study toads, desert tortoise, butterflies, mammalian predators, and Joshua Trees. In fact, funding constraints have left the Parks unable to monitor all of the species that have been identified for special concern (JTNP, 2001). The scientific potential of research sites in Mojave National Preserve has been improved in recent years from the reduction of grazing activities, the removal of feral burros, and the elimination of target shooting (MNP, 2000).

The link between the value of research and the number of wilderness-related scientific publications provides a partial estimate of the scientific values contributed by wilderness. The economic contribution of a scientific article is difficult to estimate, and there is no standard approach. Black (1996) provided some indication of the economic value by incorporating 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 estimated an economic value to society per scientific article of approximately $350,000 (adjusted to 2004 dollars). Annualizing this amount at a discount rate of 4% yielded a value of $15,000 per journal article per year in terms of the advancement of knowledge that leads to additional economic growth, as measured by national income. The application of this estimate to roughly 50 yearly research publications generated by scientists in California desert wildlands yields an annual value of wildland research articles of about $750,000.

However, publications alone do not fully represent the scientific value of wildlands for research purposes. All seven of the University of California Natural Reserves as well as the Soda Springs Desert Studies Center provide housing, laboratory, and research space for independent scientists and university groups to conduct various studies of desert ecology and history, many of whom use wilderness areas protected by the California Desert Protection Act for their work. Scientific research in areas managed by the National Park Service support the management and protection of park resources. Annual user days at

these locations total more than 11,000, and an average of 50% reportedly are spent on wilderness- and wildland-related research activities. While there is no developed methodology for measuring the economic benefits of scientific use of wilderness and natural areas, an estimate of the value of scientific use may be obtained by using benefit transfer, a concept which refers to the adaptation and use of economic information from specific sites to other sites with similar resource and policy conditions. Rosenberger and Loomis (2001) estimated a benefit transfer value for general wilderness recreation for the Pacific Coast Area of $34.25 per day (adjusted to 2004 dollars); application of this value to annual scientific user days yields an estimate of additional scientific benefits of over $279,000 per year. With the added value of publications, the estimate of the scientific benefits of wildlands in the California desert region is more than $1 million per year (approximately $119,000 in Inyo County, $355,000 for research in Riverside County and $555,000 per year for San Bernardino County). While scientific research activities have taken place in Imperial County as well, data for user days and publications were not available.

EDUCATIONAL BENEFITS

Natural environments such as wilderness offer a living classroom for many high school and university courses (Loomis and Richardson, 2000). In addition, there are a number of human development programs such as Outward Bound and National Outdoor Leadership School that use wilderness and other natural areas to train managers, promote teamwork, teach coping skills, and provide various forms of emotional and physical therapy. Wilderness expedition programs have also been used with troubled youths to foster better emotional development and adaptation skills. In a survey of participants in wilderness experience programs, 88% of respondents indicated that such programs were highly or moderately dependent on the characteristics of wilderness resources (Dawson *et al.*, 1998).

While no quantitative indicators exist for the use of wilderness areas for such programs, Kellert (1998) studied the impact of wilderness education on participants of such courses and found that they contribute to improved physical fitness, problem-solving abilities, intellectual capacity, and a greater concern for families, communities, and the natural environment. The connection between the benefits realized by wilderness program participants and overall social benefits is intuitive; however, economic methods for valuing such social values are not fully-developed.

The University of California's Natural Reserves host hundreds of students and professors for field-based college courses in the desert region, many of which take place in wilderness areas and parks designated by the California Desert Protection Act. The Natural Reserve System itself is often accurately described as a classroom without walls or a library of ecosystems (UCNRS, 2002). The Soda Springs Desert Studies Center, a California State University (CSU) field station in the Mojave National Preserve at Zzyzx, CA, is used for dozens of science courses by nearly every CSU campus, and hosts over 5,000 user days per year for educational programs. The Park Education Program at Joshua Tree National Park delivers over 600 programs related to the history, ecology, and geology of the desert environment. In fact, there is considerable excess demand for educational programming—Joshua Tree National Park is unable to honor all of the requests for educational outreach programs due to insufficient funding (JTNP, 2001). The Joshua Tree National Park Association offers approximately 20 courses per season each spring and

fall that attract hundreds of participants. Several chapters of the California Native Plants Society host field trips and lectures throughout the year, which attract hundreds of attendees.

There have been no previous studies to date that have estimated the economic value of educational uses of wilderness areas, so the methodology for valuing such benefits is undeveloped. However, it is possible to get some indication of the value of educational uses of desert wildlands by applying the total number of education user days to the benefit transfer value for general wilderness recreation use of $34.25 per day (adjusted to 2004 dollars) provided by Rosenberger and Loomis (2001). Education user days in California desert wildlands are estimated at over 24,000 per year. The application of these data provides a total educational value of wildlands in the California desert region of nearly $826,000 per year (approximately $277,000 per year for Riverside County and $549,000 per year for San Bernardino County). Dozens of community-based programs and youth education activities are not included in this estimate, which implies that educational benefits may be even greater.

ECOSYSTEM SERVICES BENEFITS

Ecosystem services are the conditions and processes through which natural ecosystems sustain and fulfill human life (Daily, 1997). Without them, life on Earth would not exist. Examples of ecosystem services include clean air and water (for both human health and economic security), essential support in producing renewable resources (such as agriculture and forest products), and the absorption and treatment of waste matter. Wilderness and other natural areas play an important role in sustaining natural resources and providing ecosystem services that support human life on Earth (Odum, 1997). These areas provide high-quality undisturbed soil, water, and air, all of which are crucial to ecosystem health (Dombeck, 2002). The ecosystem services provided by wilderness and other natural areas include watershed protection, carbon sequestration, air purification, erosion control, natural pest control, nutrient cycling, and pollution absorption (Morton, 1999). Clean air and water are vital in their support of human life. Also, one in four medicines and pharmaceuticals owes its origin to vital products of plant species, and another one in four to animals and microorganisms (Joyce, 1992).

Ecosystem services may be valued in a number of ways. Some services are associated with market goods that carry a price. Indirect valuations may be used to measure society's willingness to pay for other services for which there is no market. Values of other services may be conceptualized as the costs avoided by protecting the ecosystem's ability to continue providing the services. While it would be cumbersome to attempt to value the comprehensive set of ecosystem services, I have chosen to highlight a particular ecosystem service that is unique to desert environments and vulnerable—the value of erosion control. This benefit is estimated at over $255 million per year for California desert wildlands.

The study of ecosystem services in desert environments has been of limited extent, but the service of erosion control is critical. Natural vegetation and soil aeration protects desert soil from wind and water erosion. Soil stability and productivity often depend upon surface cryptogamic crusts that develop slowly and thrive over many dozens of years. These crusts are easily destroyed, and loose soils consequently blow away in the rush of desert winds. Soil recovery is a slow process: in a study of soil recovery in the Mojave desert region, Webb and Wilshire (1980) found that in an arid desert environment, soils disturbed

by vehicle use may take centuries to recover. The construction of roads strips away the surface layer; the use of roads grinds desert soil into a fine dust powder that is extremely vulnerable to wind erosion. When such discrete particles become suspended in the air, they are known as particulate matter; it is a major source of air pollution, and is strongly associated with poor visibility and severe risks to human health. These tiny particles penetrate deep into human lungs and increase the risk of asthma and other health problems—and particulate pollution claims the lives of over 64,000 Americans every year (NRDC, 1996). Federal studies have found that high levels of particulate matter are associated with premature death, aggravated asthma, childhood respiratory problems, chronic bronchitis, haze, and visibility in national parks and wilderness areas (EPA). A peer-reviewed study (Woodruff *et al*., 1997) found a statistically significant relationship between particulate air pollution in the United States and post-neonatal infant mortality. A study of the effects of air pollution on children in southern California found that particulate matter can also retard the growth of children's lungs (Gauderman *et al*., 2000).

Federal and state air quality management agencies measure the levels of particulate matter with an aerodynamic diameter of 10 microns or smaller (PM-10) and of 2.5 microns or smaller (PM-2.5). (A micron is one millionth of a meter. One 10-micron particle (PM-10) is one-seventh the diameter of a human hair [EWG, 1997].) Air quality levels are measured as micrograms of particulate matter per cubic meter of air ($\mu g/m^3$). National standards indicate that levels of PM-10 should not exceed 150 $\mu g/m^3$ more than once per year or 50 $\mu g/m^3$ as annual arithmetic mean averaged over 3 years. State standards in California for PM-10 are set at a maximum of 50 $\mu g/m^3$ in 24 hours, or 30 $\mu g/m^3$ as annual geometric mean. Even with its stricter standards, the state of California ranks fifth in the nation in terms of emissions of PM-10 particulate matter (EWG, 1997). Air quality levels in the desert region are particularly poor—the Great Basin Valleys Air Basin (which includes parts of Inyo County) annual average PM-10 concentration in 2003 was 130.4 $\mu g/m^3$; the Salton Sea Air Basin (which includes parts of Imperial and Riverside Counties) average was 79.7 $\mu g/m^3$; and the South Coast Air Basin (which includes parts of both Riverside and San Bernardino Counties) average is 56.9 $\mu g/m^3$. These three air basins have the highest annual values of PM-10 concentration in the State, and the highest 24-hour concentrations

occur where the problem of windblown dust is widespread. PM-10 levels in the Salton Sea Air Basin exceeded the state 24-hour standard 315 days in 2003, and the South Coast Air Basin exceeded the state standard 252 days (Alexis and Cox, 2005).

There are many sources of PM-10 emission in the California desert region. Automobile emissions, cement production, military bases, and road dust all contribute to excessive PM-10 levels in the area. However, *area-wide* sources account for 88% of PM-10 emissions in California, and the dominant area-wide source is fugitive dust from roads (Alexis and Cox, 2005). Dust from unpaved roads is the highest source of PM-10 emissions in San Bernardino County (ARB, 2004a). Fugitive windblown dust and unpaved road dust combined account for 87% of PM-10 emissions in Imperial County. Gravel and unsurfaced roads, in particular, are sources of long-term soil loss and erosion, even in the absence of vehicular use (Havlick, 2002). Road use exacerbates surface erosion, particularly on unpaved road surfaces. Compacted soils of unpaved roadbeds discourage revegetation and are more prone to erosion than vegetated, undisturbed sites. The California Air Resources Board reports that roads on federal lands account for half of the unpaved road dust emitted in the state (ARB, 2004a). However, wilderness areas are primarily roadless and are managed for non-motorized recreation, and thus, do not contribute to the overall level of particulate matter. Roadless areas protect against other types of pollution as well—over 17,000 tons of carbon monoxide and over 3,000 tons of nitrogen dioxide are emitted each day in California (28% of which is emitted from off-road recreation vehicles alone). Both of these pollutants have been associated with increased risk of congestive heart failure, respiratory illnesses, birth defects, and in some cases, death (ARB, 2004b).

The issue of air quality in California is severe. Over 9,000 deaths in the State can be attributed to particulate pollution each year (more than motor vehicle accidents, accidental poisonings, and homicides combined). More than 1,200 deaths due to particulate pollution (15.3%) occur in the Riverside/San Bernardino area alone (the second highest in the state) (EWG, 1997; NRDC, 1996). A study of the effects of PM emissions on hospital admissions in the San Joaquin Valley found that higher levels of PM were associated with increased chronic and acute respiratory hospitalizations and emergency room visits (ARB,

2003). Visibility throughout the southern region of the State is frequently obscured by the effects of particle emissions, smog, and dust from wind erosion. Currently, over 99% of Californians breathe air that violates State PM-10 standards at least part of the year (Alexis and Cox, 2005; ARB/OEHHA, 2000). Although the Environmental Protection Agency (EPA) has mandated that air quality around national parks be subject to the most stringent level of protection, Joshua Tree National Park consistently exceeds the ozone concentration levels set by the EPA for human health (JTNP, 2002).

While it is difficult to measure the total value of erosion control, economists believe that demand for nonsubstitutable ecosystem services (such as air quality) escalates rapidly as supply diminishes (Balmford *et al*., 2002)—thus, with increasing industrial activity, pressures from motorized recreation, and an expanding human population, the economic costs of particulate pollution increase rapidly. Economists have measured some of the benefits of protecting air quality, including the avoidance of health care costs directly associated with particulate pollution as well as the benefits of preserving visibility in national parks. Estimates of the economic benefits of erosion control in the California desert wildlands can be categorized into these two groups.

First, using data from the California Air Resources Board and the Office of Environmental Health Hazard Assessment, the Environmental Working Group has estimated that PM-10 pollution is responsible for more than 16,000 hospital or emergency room admissions, at a cost of $132 million; nearly five million lost work days per year amounts to a loss to the state's economy of more than $880 million. Thus, the estimate of the total cost associated with PM-related illnesses in California is over $1 billion per year—not including the costs of thousands of less severe illnesses that result from excessive PM-10 levels (Sharp and Walker, 2002). The costs associated with asthma hospital admissions, emergency room visits, and work loss days from PM-10 exposure in the four-county region amount to approximately $115 million per year, and these estimates do not include the costs associated with chronic bronchitis, pneumonia, cardiovascular disease, and other ailments. Cost estimates tend to be much higher for the more heavily-populated counties of Riverside and San Bernardino. The public health benefits of erosion control in desert wildland counties can be estimated by allocating the costs avoided to each county based

on the number of acres of wildlands, accounting for the contribution of area-wide particulate pollution sources only (*i.e.*, road dust). The estimate of this benefit is $23.9 million per year for wildlands in the California desert region (nearly $653,000 per year for wildlands in Imperial County, nearly $124,000 per year in Inyo County, $12.0 million in Riverside County and $11.1 million in San Bernardino County).

In addition to the risks to human health, emissions from vehicles and industrial activities cause pollution that can worsen visibility in parks and desert wildlands, harm vegetation, and increase the risk of wildfires. The Los Angeles Basin, with a population of over 12 million, is the major contributor of ozone and other pollutants that impact air quality in the California desert. Visibility at Joshua Tree National Park is often obscured by haze caused by high concentrations of particulate matter (Sullivan *et al*., 2001)., and cumulative concentrations of ozone in the Park exceed levels known to cause injury to vegetation. Nitrogen pollution from vehicle exhaust, industrial emissions, and agricultural sources promote the growth of non-native species, which have been shown to increase the risk of wildfires. The sparse vegetation that is endemic at Joshua Tree protects against lightning-sparked fires; non-native plants provide fuel for fires and can quickly consume thousands of acres of slow-growing Joshua trees, juniper, and pinyon pines (JTNP, 2002). Schulze *et al*. (1983) measured the economic benefits of preserving visibility in national parks in the southwestern United States (Arizona, California, and Colorado). In a contingent valuation study, average household willingness to pay ranged from $12.45 to $18.15 (2004 dollars) per month for the preservation of air quality and visibility in three national parks in the Southwest. Extending the average value per household from this study ($17.06) to the nearly three million visitors to Death Valley National Park, Mojave National Preserve, and Joshua Tree National Park yields a total estimate of $47.6 million per year for the economic benefits of preserving visibility ($17.3 million per year in Inyo County, $18.9 million per year in Riverside County, and $11.3 million per year in San Bernardino County). This estimate is conservative, as the value of clean air can be extended beyond national parks to wilderness and natural areas throughout the desert region.

The combined estimate of the economic benefits of erosion control (public health and visibility) is over $71.4 million per year ($653,000 per year in Imperial County, $17.4 million per year in Inyo County, $30.9 million per year in Riverside County, $22.4 million in San Bernardino County).

It should be noted that the value estimate for erosion control is limited by the availability of cost data for particulate-related diseases and therefore does not include many other benefits. In addition to erosion control, there are numerous other ecosystem services provided by desert wildlands for which very little research has been conducted. Carbon sequestration properties of soils and vegetation help to regulate climate, yet little is known about the value of carbon in desert soils. The benefits of waste treatment and nutrient cycling in deserts have not yet been valued. However, present scientific understanding of ecosystem services is substantial and extremely policy-relevant; failure to ensure the continued delivery of ecosystem services in desert environments undermines economic prosperity, diminishes other aspects of human well-being, and threatens the very persistence of human communities in the California desert, as well as other ecosystems (Daily, 1997).

BIOLOGICAL DIVERSITY BENEFITS

Biological diversity refers to the variety of life on Earth and the natural patterns it forms (Heydendael, 2002). Biological diversity (biodiversity) includes the full array of species as well as the genetic diversity within species (Morton, 1999). Natural diversity incorporates the physical environment and climate within which species interact with biological diversity. Protecting biodiversity is in our self-interest. The loss of biodiversity reduces the productivity of ecosystems, shrinks stocks of natural resources, threatens food supplies, sources of wood, and opportunities for recreation and tourism (Heydendael, 2002). Biological diversity in fragile desert ecosystems can be seriously damaged by a single passage of a motor vehicle (Heydendael, 2002). Thus, by virtue of being roadless, desert wildlands in California offer the highest level of protection of biodiversity values.

Scientists and policymakers have raised the attention in recent years of the importance of preserving the biological diversity of plant and animal life and the natural diversity of physical environments. The economic methods for measuring the values of biodiversity are not well-developed; however, an analysis of other quantitative data can help determine where additional benefit gains to biodiversity might be realized. One approach is to consider the number of threatened and endangered species protected by area wildlands. Another measure of biodiversity benefits would consider the degree of uniqueness of the natural environment and the irreversibility of management decisions in the protection of biological diversity.

Under Bailey's (1995) system of ecosystem classification, most of the area considered in this study is classified as the American semi-desert and desert province. Mountains to the west are classified as California coastal range – coniferous forest (Bailey, 1995). The Mojave Desert region is geographically unique—it represents a distinct transition zone between the hot Sonoran Desert of the southwestern United States and the colder, shrub steppes of the higher elevations to the north (Ricketts *et al*., 1999). Most waterways drain into closed basins. The Mojave River is the main water system to the west and is an unpredictable source of water—it is a mostly dry streambed for much of the year (Mettermeier *et al*., 2002). Still the area sustains a surprising number and diversity of plant and animal species. Certain areas

within the region support more endemic plants per square meter than other similarly-sized areas in the U.S. (Ricketts *et al*., 1999). Even the sparse riparian vegetation significantly contributes to biodiversity in the region.

Several vegetation communities occur in the region. The Joshua tree (*Yucca brevifolia*) is the most visibly dominant species in the region. Creosote bush (*Larea tridentata*) reaches its northern limit in the Mojave Desert. Desert saltbrush (*Atriplex spp*.) and several cactus species occur in the area. The region also supports numerous species of bryophytes, mosses, and liverworts (Mettermeier *et al*., 2002). The desert supports an unusually large number of endemic ephemeral plants, and many are winter annuals; 80% to 90% of the 250 taxa with this characteristic are endemic in the area (Ricketts *et al*., 1999).

The region provides habitat for roughly 360 non-fish vertebrate species, which places it among the three richest ecoregions in the U.S. in terms of terrestrial vertebrate diversity. There are 230 bird species, 71 mammals (16 of which are bats), 45 reptiles, and 14 amphibian species (Mouat *et al*., 1999). There are 131 known fish taxa from the region, but of these, 10 (8%) are extinct, and 75 (62%) are either listed or under consideration for protection under the Endangered Species Act (Davis *et al*., 1998).

Major threats to the biological diversity of the California desert include the construction and use of roads. Roads slice up lands to create fragments of habitat that can no longer support the population or diversity of species found in large, unroaded areas. This fragmentation commonly reduces wildlife populations and creates a loss of biological diversity (Bald eagle production has been found to diminish with proximity to roads). In addition, roads, especially dirt and gravel roads, generate and disperse dust that can lead to reductions in plant photosynthesis, respiration, and transpiration, all of which threatens species viability (Havlick, 2002).

Furthermore, road use has been shown to act as a vector for biological invasion. In a study of public desert lands, research determined that roadsides are more substantially invaded by exotic species and contained fewer native species than adjacent interior habitat. Roads acted as conduits for biological invasions, especially when they passed through areas of multiple use common to BLM and national

forests (Havlick, 2002). The wilderness areas and other natural areas considered in this study are primarily roadless, and therefore offer greater protection of biological diversity.

There are an unusually large number of threatened and endangered species in the region, which highlights both the biodiversity of the desert as well as the increasing threats in the region. California has more listed species than all of its bordering states combined; about half of the State's federally-listed species' habitat is on public lands (BLM, 2003). Special status plants and animals in Imperial County, along with their federal and state status, are provided below in Table 13. Species with habitat in Inyo, Riverside, and San Bernardino Counties are provided below in Tables 14, 15, and 16, respectively.

Table 13: Special Status Plants and Animals in Imperial County, California

IMPERIAL COUNTY	Federal Status	California Status
Plants		
Peirson's milk-vetch	Threatened	Endangered
Wiggins's croton	None	Rare
San Diego button-celery	Endangered	Endangered
Algodones Dunes sunflower	None	Endangered
Fish		
Desert pupfish	Endangered	Endangered
Colorado squawfish	Endangered	Endangered
Razorback sucker	Endangered	Endangered
Birds		
Western yellow-billed cuckoo	Candidate	Endangered
Gilded flicker	None	Endangered
Willow flycatcher	None	Endangered
California black rail	None	Threatened
Gila woodpecker	None	Endangered
Elf owl	None	Endangered
Yuma clapper rail	Endangered	Threatened
Arizona bell's vireo	None	Endangered
Mammals		
Peninsular bighorn sheep	Endangered	Threatened
Reptiles		
Barefoot banded gecko	None	Threatened
Desert tortoise	Threatened	Threatened

Source: California Department of Fish and Game, Natural Diversity Data Base, 2003.

Table 14: Special Status Plants and Animals in Inyo County, California

INYO COUNTY	Federal Status	California Status
Plants		
Fish Slough milk-vetch	Threatened	None
Sodaville milk-vetch	None	Endangered
Bristlecone cryptantha	None	Rare
July gold	None	Rare
Ash Meadows gumplant	Threatened	None
Father Crowley's lupine	None	Rare
Rock lady	None	Rare
Amargosa nitrophila	Endangered	Endangered
Eureka Dunes evening-primrose	Endangered	Rare
Owens Valley checkerbloom	Species of concern	Endangered
Eureka Valley dunegrass	Endangered	Rare
Fish		
Owens pupfish	Endangered	Endangered
Cottonball Marsh pupfish	None	Threatened
Owens tui chub	Endangered	Endangered
Paiute cutthroat trout	Threatened	None
Amphibians		
Black toad	None	Endangered
Mountain yellow-legged frog	Endangered	None
Birds		
Swainson's hawk	None	Threatened
Western snowy plover	Threatened	None
Western yellow-billed cuckoo	Candidate	Endangered
Willow flycatcher	None	Endangered
Bald eagle	Threatened	Endangered
Inyo California towhee	Threatened	Endangered
Bank swallow	None	Threatened
Least bell's vireo	Endangered	Endangered
Mammals		
California wolverine	None	Threatened
Amargosa vole	Endangered	Endangered
California bighorn sheep	Endangered	Endangered
Mohave ground squirrel	Species of Concern	Threatened
Reptiles		
Desert tortoise	Threatened	Threatened

Source: California Department of Fish and Game, Natural Diversity Data Base, 2003.

Table 15: Special Status Plants and Animals in Riverside County, California

RIVERSIDE COUNTY	Federal Status	California Status
Plants		
San Diego button-celery	Endangered	Endangered
San Diego ambrosia	Endangered	None
Parish's daisy	Threatened	None
Mojave tarplant	None	Endangered
Nevin's barberry	Endangered	Endangered
Marsh sandwort	Endangered	Endangered
San Jacinto Valley crownscale	Endangered	None
Triple-ribbed milk-vetch	Endangered	None
Coachella Valley milk-vetch	Endangered	None
Cuyamaca larkspur	None	Rare
Hidden Lake bluecurls	Threatened	None
Parish's meadowfoam	None	Endangered
Slender-horned spineflower	Endangered	Endangered
Santa Ana River woollystar	Endangered	Endangered
Tahquitz ivesia	None	Rare
Spreading navarretia	Threatened	None
Vail Lake ceanothus	Threatened	Endangered
Munz's onion	Endangered	Threatened
Thread-leaved brodiaea	Threatened	Endangered
California orcutt grass	Endangered	Endangered
Fish		
Santa Ana sucker	Threatened	None
Razorback sucker	Endangered	Endangered
Southern steelhead trout (California esu)	Endangered	None
Desert pupfish	Endangered	Endangered
Amphibians		
California tiger salamander	Threatened	None
Desert slender salamander	Endangered	Endangered
Arroyo toad	Endangered	None
California red-legged frog	Threatened	None
Mountain yellow-legged frog	Endangered	None
Birds		
Arizona bell's vireo	None	Endangered
Bald eagle	Threatened	Endangered
Coastal California gnatcatcher	Threatened	None
Least bell's vireo	Endangered	Endangered
Yuma clapper rail	Endangered	Threatened
Western snowy plover	Threatened	None
Western yellow-billed cuckoo	Candidate	Endangered
Elf owl	None	Endangered
Gila woodpecker	None	Endangered
Gilded flicker	None	Endangered
Willow flycatcher	None	Endangered
Southwestern willow flycatcher	Endangered	None

Mammals		
Stephens' kangaroo rat	Endangered	Threatened
San Bernardino kangaroo rat	Endangered	None
Palm Springs round tailed ground squirrel	Candidate	None
Peninsular bighorn sheep	Endangered	Threatened
Reptiles		
Desert tortoise	Threatened	Threatened
Coachella Valley fringe-toed lizard	Threatened	Endangered
Southern rubber boa	Species of concern	Threatened
Invertebrates		
Vernal pool fairy shrimp	Threatened	None
Riverside fairy shrimp	Endangered	None
Quino checkerspot butterfly	Endangered	None
Delhi Sands flower-loving fly	Endangered	None

Source: California Department of Fish and Game, Natural Diversity Data Base, 2003.

Table 16: Special Status Plants and Animals in San Bernardino County, California

SAN BERNARDINO COUNTY	Federal Status	California Status
Plants		
Ash-gray Indian paintbrush	Threatened	None
Parish's daisy	Threatened	None
Parish's checkerbloom	Candidate	Rare
Mojave tarplant	None	Endangered
California dandelion	Endangered	None
Nevin's barberry	Endangered	Endangered
San Bernardino Mountains bladderpod	Endangered	None
Gambel's water cress	Endangered	Threatened
Slender-petaled thelypodium	Endangered	Endangered
Marsh sandwort	Endangered	Endangered
Big Bear Valley sandwort	Threatened	None
Cushenbury milk-vetch	Endangered	None
Lane Mountain milk-vetch	Endangered	None
Salt Marsh bird's beak	Endangered	Endangered
San Bernardino blue grass	Endangered	None
Triple-ribbed milk-vetch	Endangered	None
Thread-leaved brodiaea	Threatened	Endangered
Bird-foot checkerbloom	Endangered	Endangered
Thorne's buckwheat	None	Endangered
Southern mountain buckwheat	Threatened	None
Cushenbury buckwheat	Endangered	None
Cushenbury oxytheca	Endangered	None
Slender-horned spineflower	Endangered	Endangered
Santa Ana River woollystar	Endangered	Endangered
Fish		
Mohave tui chub	Endangered	Endangered
Bonytail	Endangered	Endangered
Santa Ana sucker	Threatened	None
Razorback sucker	Endangered	Endangered
Unarmored threespine stickleback	Endangered	Endangered
Amphibians		
Arroyo toad	Endangered	None
California red-legged frog	Threatened	None
Mountain yellow-legged frog	Endangered	None
Birds		
Bald eagle	Threatened	Endangered
Swainson's hawk	Species of Concern	Threatened
Yuma clapper rail	Endangered	Threatened
Western snowy plover	Threatened	None
Western yellow-billed cuckoo	Candidate	Endangered
Elf owl	None	Endangered
Gila woodpecker	None	Endangered
Willow flycatcher	None	Endangered
Southwestern willow flycatcher	Endangered	None

Coastal California gnatcatcher	Threatened	None
Arizona bell's vireo	None	Endangered
Least bell's vireo	Endangered	Endangered
Mammals		
Mohave ground squirrel	Species of Concern	Threatened
Stephens' kangaroo rat	Endangered	Threatened
San Bernardino kangaroo rat	Endangered	None
Reptiles		
Desert tortoise	Threatened	Threatened
Southern rubber boa	Species of Concern	Threatened
Invertebrates		
Delhi Sands flower-loving fly	Endangered	None

Source: California Department of Fish and Game, Natural Diversity Data Base, 2003.

By managing for non-motorized recreation uses, California desert wildlands protect the diversity of plant and animal species that might otherwise suffer under other management alternatives. The effects of motorized recreation in this region are well-documented (Bury *et al*., 1977, Carter, 1974). In a U.S. Fish and Wildlife Service study of the effects of off-road vehicles on vertebrates in 16 desert test sites in San Bernardino County, Bury *et al*. (1977) found that the diversity of reptiles and mammals are inversely related to levels of off-road vehicle (ORV) usage. Census tracking at three of the study sites showed decreased diversity of breeding birds in areas used for motorized recreation. Studies have shown that ORV noise can cause bleeding from the ears and frantic behavior in endangered kangaroo rats, and hearing loss in lizards such as the Mojave fringe-toed and desert iguana (Brattstrom and Bondello, 1983). ORV usage was found to have a direct impact on wildlife populations by either killing or maiming ground-dwelling animals, and also an indirect effect by crushing ground nests and breaking bushes containing nests. The authors extrapolated their findings to estimate that ORV use on a square kilometer of creosote shrub habitat is associated with 12.5% to 45.1% fewer terrestrial vertebrates than a comparable area of the same size without motorized recreation.

Research on the economic benefits of protecting biodiversity has been of a limited extent. The contingent valuation method (CVM) has the potential to estimate the value of biodiversity, but such an analysis would be quite complex and expensive. It has been well documented that biological diversity in

the California desert faces many threats, including rapid urbanization, air pollution, and motorized recreation. For purposes of this study, the benefits of biodiversity are merely noted, along with the limitations of economic research to estimate their values. The uniqueness and fragility of California desert wildlands underscore the high values of the biological diversity that is protected there.

PASSIVE USE BENEFITS

The preservation of wilderness areas and other wildlands generates significant passive use values as well. The benefits of passive use relate to the very presence of particular natural resources, independent of directly visiting or observing them. The passive use values of wilderness—as well as many other natural resources for which there is no market—have been studied extensively by economists. Passive use values include *existence* value (the benefit of simply knowing that wilderness resources exit in a preserved state), *option* value (the benefit of maintaining the option to visit the areas in the future), and *bequest* value (the benefit of knowing that future generations will also be able to enjoy the benefits of wilderness) (Loomis, 1987). Passive-use values are measured using the contingent valuation method (CVM), a survey-based approach that quantifies the willingness of individuals to pay for the so-called "passive" uses of wilderness areas and the particular resources they protect. In valuation studies, passive-use values are often found to comprise the majority of the total economic value of natural resources. Loomis (1989) studied the value of protecting California's Mono Lake, and found that passive use values represented 94% of total economic value, whereas the value of recreation uses represented only 6%.

Using the results of previous studies of the passive use values of wilderness areas, it is possible to estimate the annual passive use values for the preservation of California desert wildlands. A study by Walsh *et al.* (1984) measured the passive use values for the preservation of various quantities of wilderness areas on public land in Colorado. The study estimated passive use values of $28.65 (adjusted to 2004 dollars) per household for the preservation of five million acres of wilderness. The application of this value to the more than 14 million households in the southwestern states of California, Arizona, and Nevada alone yields a total estimate of the passive use values of California desert wildlands of over $405 million per year. This estimate is considered conservative for several reasons. First, many individuals living throughout the United States (and in other parts of the world) may value the existence of the unique desert wildlands in California, so passive use values for the California desert may extend well beyond the southwest. Species such as the desert tortoise and the Joshua tree have become known as icons of this unique area, and such features often contribute to greater willingness to pay for passive use values.

Second, the uncommonly large number of threatened and endangered species in California and the noteworthy biological diversity protected by desert wildlands in the region may yield even greater passive use values than those estimated here.

The total passive use value for the region can be allocated between the four counties in the region based on wildland acreage. For Imperial County's 255,457 acres of wildlands, the estimate of passive use values is $12.2 million per year. When applied to the four million acres of wildlands in Inyo County, the estimate of passive use values is nearly $193 million per year. When applied to the more than 1.1 million acres of wilderness and natural areas in Riverside County, the estimate of passive use values is $53.4 million per year. San Bernardino County's 3.1 million acres of wildlands generate an estimate of passive use values of over $147.3 million per year. A contingent valuation study of the passive use benefits of particular areas within the California desert region, such as Jacumba Wilderness, Kelso Dunes, or the Cady Mountains, would help refine this estimate, but such studies are often expensive to conduct.

CONCLUSION

Humans receive numerous direct and indirect benefits from the protection of wilderness areas and other wildlands. While such areas are used extensively for non-motorized recreation, they also provide opportunities for scientific research and education and generate extensive off-site benefits and passive use values, many of which are significant. Also notable are the numerous ecosystem services provided by wildlands which directly and indirectly support human life—protection of wildlands provides economic benefits in the form of cost savings to society. The California Desert Protection Act of 1994 described desert wildlands as a "resource of extraordinary and inestimable value." Certainly there are many intrinsic values associated with desert wildlands, but several categories of benefits can in fact be measured using economic analysis. This study of the economic benefits of wildlands in the California desert region found that they generate more than $1.3 billion per year in economic benefits and support nearly 3,700 jobs in nearby communities in Imperial, Inyo, Riverside, and San Bernardino Counties. This estimate of economic benefits is considered conservative because it does not account for many benefits for which there is no standard economic valuation method.

Recognition of these economic benefits supports the "enduring heritage of wilderness, national park, and public land values" specified in the California Desert Protection Act of 1994. Ten years since its passage, this landmark legislation ensures the protection of millions of acres of unique natural landscapes and unrivaled ecological values in the California desert for this and future generations of Americans.

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