Economic Benefits Provided by Natural Lands: Case Study of California's Mojave Desert

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Defenders of Wildlife

Economic Benefits Provided by Natural Lands: Case Study of California's Mojave Desert

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List of abbreviations

AADT	Average annual daily traffic
ACEC	Area of Critical Environmental Concern
ATV	All-terrain vehicle
BEA	Bureau of Economic Analysis
BLM	Bureau of Land Management
BT	Benefit transfer
CARB	California Air Resources Board
CDP	Census designated place
CEC	California Energy Commission
CERES	California Environmental Resources Evaluation System
CS	Consumer surplus
DOD	Department of Defense
DTNA	Desert Tortoise Natural Area
DVNP	Death Valley National Park
FWS	Fish and Wildlife Service
FY	Fiscal year
JTNP	Joshua Tree National Park
kWh	Kilowatt hour
L.A.	Los Angeles
MNP	Mojave National Preserve
MWh	Megawatt hour
MWe	Megawatt electricity output (installed capacity)
NPS	National Park Service
OHV	Off-highway vehicle
O&M	Operation and maintenance
PC	Production cost
PM	Particulate matter
PS	Producer surplus
RCD	Resource Conservation District
RIMS II	Regional Input-Output Modeling System
RPS	Renewable Portfolio Standard
SEGS	Solar Electric Generating System
TEV	Total economic value
USGS	United States Geological Survey
WTA	Willingness to accept
WTP	Willingness to pay

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Executive summary

California's Mojave bioregion is one of the largest remaining open and still predominantly natural areas located at the doorstep of a major population center in the United States. The region, located northeast of the Los Angeles metropolitan area, covers approximately 19.9 million acres in a total of seven California counties. Although still mostly pristine, the Mojave is undergoing rapid changes. Housing developments are fast expanding, both in the towns and cities in the Mojave and in unincorporated areas. The region attracts large numbers of outdoor recreationists, who are drawn to it because of the sense of remoteness it conveys and because of the scenic beauty that characterizes its wide open landscapes. The Mojave also is used heavily for military purposes, and in some areas for agriculture. The Mojave Desert's attractiveness for recreation, tourism and human occupancy derives from the area's high amenity values – its remoteness, its wide open spaces with scenic vistas, and its large number of major, permanently protected "natural" areas. The expected expansion of some of the current extractive and degrading uses is likely to place increasing stress on the structural and functional integrity of the fragile semi-desert Mojave ecosystem. This may have detrimental impacts on the quantity or quality of some or all of the current benefits provided by the system, and may reduce the economic values associated with those benefits. To avoid such unintended consequences, and to inform the deliberation of alternative development paths for the Mojave, it is necessary to gain an understanding of the economic importance of the values conserved lands in the Mojave provide to the region. It is the goal of this report to contribute to that understanding.

Our overall methodology is as follows. First we identified and quantified all major uses of the Mojave region in the most recent year for which data were available. We then identified the different categories of economic values associated with these uses that together make up their total economic value – direct use values, indirect use values, and passive use values. This distinction among different types of values is needed because the economic tools available for the monetary quantification of the values depend on the value type. Direct and indirect use values are at least partly reflected in market transactions or can be inferred from such transactions, while passive use values can only be derived by asking individuals directly about the value they place on the resource in question. By including both use and non-use (passive use) values in our analysis, we capture the economic benefits of both the market and the non-market values of the Mojave. Finally, we apply common economic valuation tools to derive estimates of the monetary values associated with the various human uses of the Mojave.

Our results should be interpreted within the context of the available information. For some uses occurring in the desert, such as off-road vehicle use and some types of military activities, we were able to compile information on the economic benefits these uses generate, but were unable to quantify the costs associated with the resulting negative impacts on ecological integrity and other ecosystem services of the impacted lands. In these cases, it is imperative that interpretation of our findings take into account the one-sidedness of the analysis as discussed in the report. It is impossible to assess to what degree the economic benefits documented for these sometimes degrading activities would be reduced if their associated costs could be adequately accounted for, but it should be kept in mind that the net benefit to society from these activities is certainly smaller than their estimated benefits.

In addition, there were some benefits provided by pristine Mojave lands we were unable to quantify due to a lack of the requisite data, such as the value of preserving local and global biodiversity and many other ecosystem services. As a result, our analysis is likely to substantially underestimate the total economic value of conserved Mojave lands.

That said, the uses for which we were able to generate benefit estimates are shown in Table ES-1. The table shows the benefits of the various uses and indicates the respective benefit measure. With the exceptions of benefits measured in the form of earnings, all benefit values listed represent net benefits, that is, they are the actual contributions to human welfare generated by the respective human uses of the Mojave, net of any costs associated with these activities.[1] Earnings are likely to overstate actual net benefits because they do not account for the full opportunity costs associated with the respective activities. Nevertheless, in some cases we used earnings as a benefit measure because they were the closest available proxy for net benefits.

The quantified uses of the Mojave in 2003 generated an estimated $1.4 billion in net benefits. The largest net benefits stem from military uses, recreation, passive use values, ecosystem services such as provision of water for human use, and house price premiums. $1.1 billion (80 percent) of the total net benefits were captured in markets, in the form of profits and earnings, property value increases, water sales, and avoided medical costs. These benefits are shown in blue font in Table ES-1. Switching from an economic value to an economic impact perspective, the uses of the Mojave studied in this report in 2003 generated a total output in the regional economy of close to $1.5 billion (excluding the economic impact associated with base salaries), and total earnings of $339 million from recreation activities alone. In addition, in 2003 the gain in property value from open-space amenity premiums received by properties close to wildlands amounted to an estimated $84 million in San Bernardino County alone.

Table ES-1 shows several benefits for which we were unable to develop net benefit estimates. These include the option and passive use values of the Mojave to people outside of California, and the benefits associated with the use of the region for the generation of renewable electricity, agriculture, and by the film and other media industries. In addition, activities in the Mojave generate economic impacts beyond the arbitrary boundary we chose in our economic impact analysis, namely, the four-county area composed of Inyo, Kern, Riverside, and San Bernardino Counties. Furthermore, the total value of environmental amenity premiums on house prices across all cities, town, and unincorporated places in the Mojave is expected to be far larger than the value of the premiums associated with wildlands in San Bernardino County. We also lack estimates of the net benefits associated with the scientific, educational, and space-related uses of the Mojave. Finally, our estimates do not capture the value of a number of ecosystem services provided by the Mojave. Examples of such services are the pollination of agricultural crops by wild pollinators and the maintenance of the region's biodiversity.

For the human uses of the Mojave for which we were able to develop benefit estimates, our estimates generally represent lower bound values, due to the conservative nature of most of the assumptions we needed to made in generating them, and the lack of comprehensive data on some uses. This, in combination with the benefits omitted from our analysis, makes our total

[1] Earnings comprise wages and salaries, proprietors' income, directors' fees, and employer contributions for health insurance less personal contributions for social insurance.

benefit estimate very conservative. Even so, our analysis indicates that the net benefits generated by present human activities in the Mojave are substantial. Any strategy for the development of the Mojave would be well-advised to consider the potential impacts on the flows of existing benefits the Mojave provides to current users.

Table ES-1: Net benefits of selected human uses of the Mojave desert in 2003 *

	Benefit measure	*Net Benefits*
		Million 2003$
Direct use values		
Recreation		
- to recreationists	CS	99.9
- to regional economy [1]	Earnings	338.8
House price premium – environmental amenities [2]	Market value	84.0
Military uses [3]	Earnings	>585.0
Agricultural value		>0 [4]
Renewable energy generation		>0 [4]
Film industry		
- federal fee and permit revenue	Earnings	0.2
- avoided costs of alternative "settings"		>0 [5]
- local earnings from productions		>0
Option value of CA households not visiting the Mojave	WTP	55.1
Option value of rest of U.S. households not visiting the Mojave		[5]
Indirect use values (ecosystem service value)		
- health benefits of erosion control by wildlands	Avoided cost	23.0
- benefits of use of Mojave water		
-- urban	Price	67.9
-- agricultural	Price	22.2-42.9 [6, 7]
- biodiversity maintenance, crop pollination, etc.		>0 [5]
Passive use values		
Existence and stewardship values of CA households not visiting the Mojave	WTP	136.3
Existence and stewardship values of U.S. households not visiting the Mojave		>0 [5]
Total		1,422.7 [8]
Total reflected in markets		1,131.5 [8]

Notes: WTP – willingness to pay. *See appendix for a discussion of the value of renewable energy produced in the Mojave. CS – consumer surplus. All values are for benefit flows in 2003. Benefits of non-market values represent total economic value; benefits of market values are based on prices. Benefits registered in market transactions and values are highlighted in blue. [1]Earnings from trip expenditures and OHV related equipment expenditures. [2]Gain in open-space premiums accruing to private properties in San Bernardino County in 2003. [3]Twentynine Palms Marine Corps Base only. [4]Not estimated due to lack of information on input costs and negative environmental or amenity impacts. [5]Not quantified. [6]Does not include the value of agricultural water subsidies. [7]The net benefits of agricultural water use would be captured by the earnings of agricultural producers in the region, in which case adding the net benefits of water use and of agricultural output would lead to double counting. Since we lack an estimate of agricultural earnings, this is not an issue here. [8]Based on average agricultural water values.

I. Introduction

Land conservation in California's Mojave Bioregion competes with other land uses. Both residential, commercial, and industrial development and motorized off-highway vehicle traffic have the potential to adversely affect the structural and functional health of ecosystems in the area, and thereby the economic benefits provided by these systems. All of these activities have been increasing rapidly in the last two decades, leading to the loss or degradation of parts of the Mojave ecosystem. Arguments in favor of land conversion or high-impact land uses often center around the increased revenues these uses bring for the local and regional economy. In many cases, such arguments are not convincing from an economic perspective because they do not fully consider the negative impacts associated with these uses. Residential development and motorized recreation do generate revenues, although the net benefits of these activities are often considerably smaller than the private profits they generate, due to the high public infrastructure costs associated with suburban development and the environmental and public health impacts from increased emissions due to longer commuting distances. The conservation of natural ecosystems also generates economic benefits, both market and non-market. An assessment of the economic benefits generated by the Mojave ecosystems should contribute to informed public debate and policy-making about the comparative economic values of alternative land use options in the Mojave. Our study provides such an assessment, by estimating the economic value of those land uses that are compatible with conservation of the Mojave ecosystem in its current state.

The report is organized as follows. In the remainder of this chapter we discuss the relation between ecosystems and economic value, and introduce the basic concepts and methodologies used in the estimation of economic values. We also present the types of economic values generated by activities in the Mojave. Finally, we define our study area boundaries, and present some of its relevant demographic, economic, and environmental characteristics that help the reader develop a picture of the area. The second part of the report presents estimates of the monetary value of the activities taking place in the Mojave.

Ecosystems and economic value

The Mojave desert ecosystem is a resource that provides a variety of benefits to people. As such, it holds value for society. The size of the value society assigns to a resource is a function of the held values of the individuals that make up society, both in their capacities as individuals and as members of society.[2] From an economic perspective, the values provided by an ecosystem (or any other resource) can be distinguished into several components on the basis of the particular ways in which the system is used. These components are direct use values, indirect use values, option value, and non-use values, also referred to as passive use values (Prato, 1998). Examples of direct use of ecosystems are recreation, timber extraction, and water withdrawal. Indirect use occurs in the form of utilization of ecosystem services that serve as inputs for, or make possible at all, human production of goods and services (Daily *et al.*, 1997; Balmford *et al.*, 2002). Ecosystem service functions include maintenance of the hydrological and nutrient cycles, soil

[2] These two different roles played by every individual (see for example Sagoff, 1988; Brouwer *et al.*, 1999; Kontogianni *et al.*, 2004) reconcile observed behaviors that appear contradictory when viewed from the perspective of utility maximization based on consumption.

formation and erosion control, pollination, habitat provision, nursery for fish or game species, provision of food and water for livestock, climate regulation, disturbance regulation, waste management, and biological control. Finally, non-use values include existence, stewardship, and bequest values, which individuals, even in the absence of any actual use at all, may attach to the fact of simply knowing that particular species and habitats exist, are maintained, and are passed on to posterity, even though the individuals themselves may never come into contact with the species or habitats (Krutilla, 1967; Kramer *et al.*, 2002).

Both use and non-use values represent assigned economic values, that is, they are a measure of the benefits society receives from the various uses to which it puts the resources at its disposal. Assigned economic values are informed by (among other things), but are distinct from, held values, that is, the social ordering principles society regards as desirable, such as for example fairness, freedom, or legal and political equality. Hence, the economic value derived from a given use of a resource is not necessarily indicative of the desirability of that use from a social perspective.

It is also worth noting that both use and non-use values represent purely anthropocentric values. It can be argued on philosophical grounds that all living things, and perhaps even ecosystems, also have *intrinsic values*, that is, that they are valuable independently of their importance for, or usefulness or appeal to, humans (see for example Kneese and Schultze, 1985). It is conceptually impossible to assign an economic value to this intrinsic component.[3]

Quantification of economic value

The economic value an individual assigns to a particular good or service is commonly measured by the maximum amount of resources the individual would be willing to give up in order to obtain the good or service in question, or the minimum amount in compensation she would demand in order to give up that good or service.[4] For example, if someone is willing to spend up to, but no more than, five dollars to acquire a particular object, that person's willingness to pay (WTP) for that object is five dollars.[5] WTP is the conceptually correct indicator of economic value because it is based on the assessment of the actual individuals whose values are being measured (Arrow *et al.*, 1996).[6] Economic value and hence WTP are context-specific, that is, they are dependent on a number of variables. The most important ones of these are income, preferences, the relative scarcity of the good or service in question, and the relative scarcity of its complements and substitutes. Property values in the southwestern Mojave serve as a good

[3] Heal (1997) suggests that this intrinsic value could potentially be incorporated into decision making by interpreting it as placing a constraint on society's economic activities.

[4] The two approaches, willingness to pay (WTP) and willingness to accept (WTA) compensation, generally yield different estimates of economic value for a good or service. Studies have shown that individuals' WTP to obtain a hypothetical gain (benefit) is generally substantially smaller than their WTA a hypothetical loss (Adamowicz *et al.*, 1993; Haneman, 1991). This difference is caused by the psychological impact of a difference in the nature of the ownership regarding the hypothetical resource change, often referred to as the endowment effect (Kahneman *et al.*, 1990), and by the fact that income constraints bind WTP, but not WTA.

[5] WTP and economic value are commonly expressed in monetary units, although they could be expressed in any metric.

[6] It should however be noted that in cases where individuals are assigning values to future impacts, these values may not be rational and often are not compatible with society's best interests (Caplin and Leahy, 2001).

example of the impact of changing relative scarcity. The expansion of the Los Angeles metropolitan area, first into suburban and then into exurban areas, has increased the relative scarcity of housing and developable properties in the Mojave. As a result the price of properties in the southwestern Mojave has increased much faster than the prices of goods in general, making housing relatively (*i.e.*, compared to other goods) more expensive.[7]

From a production and consumption perspective, the total economic value (TEV) of a good or service can be broken down into the components that are captured by the producer and the consumer, respectively. Using recreation in a public park as an example, let us assume that the demand for recreation in the park is represented by the line *D* in Figure 1, indicating that the amount of recreation is inversely related to its price.[8] For example, at a particular price, *p**, the amount of recreation in the park that is "consumed" by the public is *Q**, where *Q** stands for a number of individuals accessing the park at a specific day.

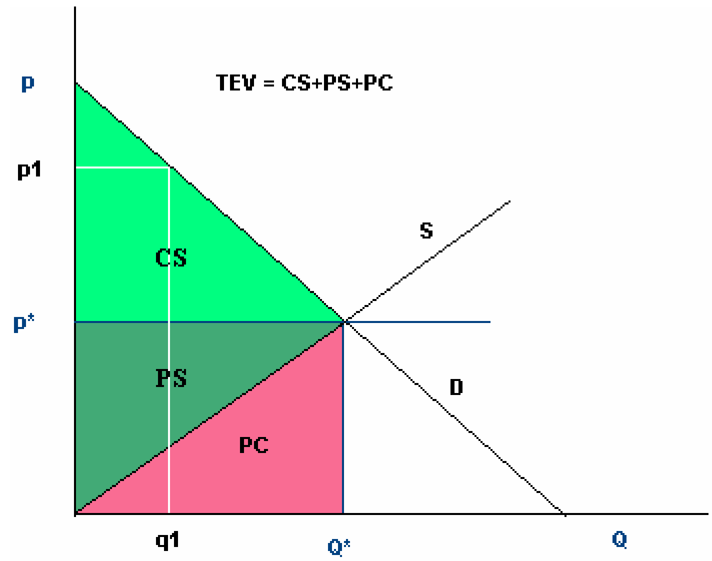

Figure 1: Consumer surplus (CS), producer surplus (PS), production cost (PC), and Total economic value (TEV)

The downward slope of the demand curve indicates that reducing the price of recreation (that is, moving to the right on the *Q* axis) would attract additional individuals to use of the park. The total economic value a particular park user receives is indicated by the point on the demand curve *D* that corresponds to that user. For example, the user *q1* in Figure 1 has a WTP of *p1*, approximately four-fifths higher than *p**.

The supply of recreation (*S*) is "produced" by the public authority that owns and manages the park. The authority's production cost (PC) includes the salaries and benefits of park employees, installation and maintenance of park infrastructure, etc. The production cost indicates the price at

[7] Many towns and cities in the Mojave in the last few years have experienced *annual* increases in the median house price of between 10 and over 50 percent (County of San Bernardino, 2004b; California Association of Realtors, 2005a).

[8] All users are arranged according to their WTP for use of the park, from the one with the highest WTP (leftmost point on the *Q* axis) to the one with the lowest WTP (where the demand curve *D* meets the *Q* axis).

which use of the park would be offered in a perfectly competitive recreation market. In Figure 1 the supply curve (*S*) is upward sloping, which could result for example from administration costs that increase with the number of people using the park.[9] In this particular example, the demand (*D*) and supply (*S*) of recreation would result in the access price *p** and the number of visitors *Q**. At this price, all visitors who are willing to spend the amount *p** are using the park. However, essentially all of the park users would be willing to spend more than *p** (in fact, all but the ones whose WTP is exactly equal to *p**), that is, their WTP for using the park is higher than the asking price. Since WTP is a measure of the benefit an individual receives from using the park, or, in other words, of the value he or she assigns to using the park, in the example presented here almost all park users receive a value that is higher than the amount of resources they give up to obtain that benefit (namely, the price *p**). That surplus in value for each individual is indicated graphically by the difference between the price *p** and the demand curve (*D*) at each point on the *Q* axis. For all park users as a whole, the surplus is equal to the area marked consumer surplus (CS) in Figure 1. This area represents the value that the users as a group receive above and beyond what they are paying, or their net benefit (benefits minus costs). At price *p**, the supplier of the park incurs costs totaling PC, but earns revenues equivalent to the areas PC and PS. Hence, the supplier's net benefit (or profit) is indicated by the area labeled PS, the producer surplus. The park generates *net* benefits to society equivalent to the sum of the areas CS and PS.

The park example illustrates the limitations of using market data as a basis for estimating WTP: actual WTP is often not known. In our example, the fact that park users are willing to pay the price *p** does not give us any indication of their real WTP. Rather, it only shows that their WTP is *at least* equal to *p**. If we assessed the TEV of the park on the basis of the market price for park use (*p**), we would underestimate it substantially (by the amount represented by the area labeled CS in Figure 1). Rather, in cases where such information is available, all expenditures by the park users that can be attributed to the park use must be added when estimating WTP for park use on the basis of observed behavior, in order to minimize the underestimate of WTP. For example, the travel costs associated with the park visit (expenditures on gasoline, food and lodging, souvenirs, etc.) must be added to the entrance fee. Still, even the most comprehensive expenditure accounting cannot overcome the fundamental shortcoming associated with estimating WTP on the basis of market transactions – namely, that a potentially substantial part of the WTP, and hence of the TEV, will always be missed by this approach. This is particularly true with respect to people's WTP for rare, endangered or threatened animals or for protected natural areas: the value people attach to the passive use component, which often does not have any market transactions associated with it, has regularly been found to dominate the use component (see for example Kramer *et al.*, 2002; Steven *et al.*, 1991; Loomis and White, 1996). Using only market data to impute the value people assign to species and ecosystems will therefore generally result in substantial underestimates of the latter's total economic value.

In addition, some uses are not commonly traded in markets – such as many ecosystem

[9] Public parks are not usually operated on a competitive (*i.e.*, profit maximizing) basis, but that is of no relevance to the discussion here, the purpose of which simply is to introduce the fundamental economic concepts that will later be used in the economic analysis.

services and passive uses.[10] Hence, other approaches must be used to estimate the economic benefits associated with those values. In fact, the development and refinement of techniques for the economic valuation of environmental benefits during the past four decades has been one of the primary foci of the subdisciplines of environmental and natural resources economics. Thanks to the advances that have been achieved it is now possible to estimate the monetary value of most types of environmental benefits (Cropper, 2000). The various approaches that can be used to estimate the economic value of environmental benefits are shown in Figure 2.

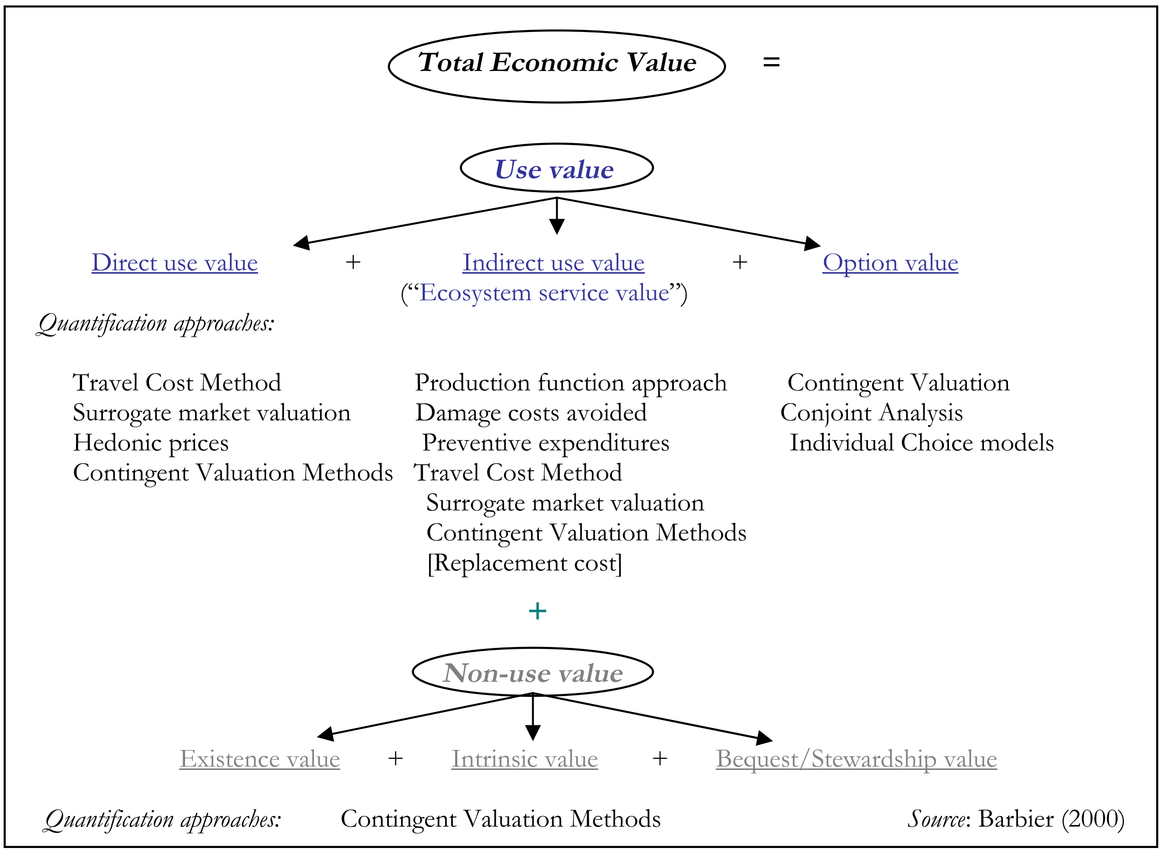

Figure 2: Categories of economic values of ecosystems and available valuation approaches

At the most basic level, most valuation approaches rely either on individuals' revealed preferences or on their stated preferences. Revealed preference approaches (hedonic prices, travel cost method, preventive expenditures) are based on the premise that individuals' WTP for a good or service is reflected in their actions. For example, if an individual during a visit to a National Park spends a total of $100 on gasoline, lodging, entrance fees, etc., it seems reasonable to assume that the benefit the individual receives from visiting the park is *at least* equivalent to those $100. By contrast, stated preference approaches (contingent valuation, individual choice) directly ask

[10] Markets appear to be developing with respect to some ecosystem services. The perhaps best-known example is that of the city of New York buying conservation easements in the Catskills watershed in order to preserve the watershed's water filtration and provision services (see Chichilnisky and Heal, 1998).

individuals to state their WTP for a specific good or service.

As Figure 2 shows, the method employed depends on the type of value (direct use, indirect use, non-use). Contingent valuation is the only method that, at least in theory, is applicable to all value categories, and is often the approach of choice (Arrow *et al.*, 1996; Krupnick and Portney, 1991).[11] In contingent valuation surveys, respondents first are presented with a hypothetical situation, and then are asked to assign a monetary value to a specific good or service, or a bundle of goods or services. If the survey format follows best-practice design principles (see Arrow *et al.*, 1993), valid value estimates can be generated, with respondents' replies representing reasonably accurate expressions of their willingness-to-pay (WTP) for that good or service in question.[12]

Ecosystem service values are the only value category to whose quantification willingness to pay approaches (either stated or revealed) may be generally poorly suited (Cropper, 2000; Vatn and Bromley, 1995).[13] These values, therefore, may in many cases better be estimated through other approaches (De Groot *et al.*, 2002; Barbier, 2000; Pagiola *et al.*, 2004). The most commonly used of these are the production function and replacement cost approaches. For example the value of the drinking water provision services provided to New York City by the Catskills watershed was estimated using a replacement cost approach, by costing out a water filtration plant that could provide the same service (Chichilnisky and Heal, 1998). However, limitations in our understanding of the functioning of most systems suggest that estimates of ecosystem function values be considered with caution. An additional problem in the quantification of ecosystem functional values lies in the multi-attribute character of most ecosystems. For example, a wetland provides water filtration services that could be replaced by a water filtration plant. However, the avoided cost of the plant does not represent the value of the wetland, as the natural system provides many additional functions that the human-made one (the plant) does not; examples of these services are sediment and flood control, spawning ground and nursery for fish, maintenance of biodiversity, etc. Accurate valuation requires a careful inventory of all services and of the direct, indirect, and non-use values they generate (see for example Barbier, 2000).

Benefits transfer

Ideally, individuals' WTP for a given good (*e.g.*, a particular recreation activity, a scenic view, preservation of a particular species, habitat, or ecosystem) is estimated on the basis of primary research at the policy site. This can take the form of a survey conducted at the location of the resource and its surroundings, or the collection of data by any other means, such as from official statistics on recreation expenditures. In many cases, however, such site-specific studies do not yet exist, and due to a lack of resources it may not be feasible to carry them out for a given project.

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[11] Conjoint analysis however is becoming increasingly popular (see for example Zinkhan *et al.*, 1994). In conjoint analysis, researchers ask respondents to state their WTP for goods or bundles of goods with varying attributes. Based on their choices, the relative benefits respondents receive from the various attributes can be estimated.

[12] The difficulty of designing the survey instrument in such a way as to obtain unbiased and consistent value estimates (Diamond and Hausman, 1994; Stevens *et al.*, 1991, Stevens *et al.*, 1993) can be overcome through the careful design and administration of the instrument (Arrow *et al.*, 1993). There exists by now ample evidence in the benefits estimation literature that contingent valuation-based WTP estimates are generally in line with estimates based on revealed preference approaches (Hanemann, 1994).

[13] An excellent discussion of the conceptual problems underlying the use of contingent valuation in the valuation of ecosystem services can be found in Vatn and Bromley (1995).

This is true for several of the benefits produced by the Mojave Desert that are examined in the present study, such as for example the multitude of recreation activities practiced in the area. In cases where no primary data are available, the only option to derive value estimates is to employ the second-best approach to estimating WTP, namely, benefits transfer. Benefits transfer (BT) is commonly defined as the adaptation of value estimates generated at a study site to another site (the "policy site") for which such estimates are desired but no primary data for their generation are available (Rosenberger and Loomis, 2001). Benefit transfer generates valid benefit estimates for the policy site if the following conditions are met: 1) the policy context is precisely defined, including the type and magnitude of the expected policy impacts, the characteristics of the population affected, the type of value measure (average or marginal value) used, the category of value measured (direct use, indirect use, non-use, total economic value), and the degree of certainty surrounding the transferred data; 2) the data available for the study site are of sufficient quality (sample size, sound economic method, sound empirical technique, and sufficient number of similar study sites to allow credible statistical inferences) and the background information is sufficient (population characteristics); and 3) study and policy site possess similar characteristics (similar resource, type and degree of change in resource, and source of change; similar demographic characteristics, especially income and cultural background; and, if recreation activities are valued, a similar condition and quality of the recreational experience at both sites) (Rosenberger and Loomis, 2001; Brower, 2000).

Approaches to Benefits Transfer

Benefits transfer (BT) can take the form of a value transfer or of a function transfer. A value transfer is the application of a single-point or average-value estimate from a study site to the policy site. For example, in an average value transfer, the average WTP of hikers at site A is used to estimate the average WTP of hikers at site B. In a benefit function transfer, a model is used that statistically relates benefit measures to the independent study variables, that is, the study characteristics (demographics and resource characteristics). Benefit function transfers either are based on demand or benefit functions estimated for a study site, or on meta-analysis. Meta-analysis is commonly defined as a regression analysis of the findings of several empirical studies that systematically explores study characteristics as possible explanations for the variation of results observed across primary studies (Brouwer, 2000; U.S. EPA, 2000). In both function transfer approaches (demand and meta-analysis), the values of key variables from the policy case are inserted into the benefit function in order to develop policy-site-specific value estimates.

Although benefit transfer often is the approach of choice in cases where primary valuation studies cannot be carried out, it is not without its problems. There rarely are policy sites whose most important WTP-relevant characteristics exactly match study sites for which original data have been generated. Furthermore, studies do not always measure all aspects of the perceived resource quality of the environmental amenities of a study site for which WTP is elicited and thereby prevent the incorporation of all relevant resource quality aspects into meta-analysis functions. For these reasons, meta-analysis-based benefit transfer potentially may introduce large errors into benefit estimates (see for example Kirchhoff *et al.*, 1997). Nevertheless, benefit transfer may provide a useful tool for estimating the order of magnitude of values (ibid.).

In this study, we apply benefit transfer to generate estimates of the economic value of recreation activities in the Mojave. In all cases, we discuss the valuation context of the source studies from which the values are being transferred.

Economic value of lands in the Mojave Desert

Conservation of desert lands and their constituent ecosystems provides a wide variety of economic benefits to society. Applying the type-of-economic-use perspective introduced in the previous section, these benefits can be distinguished into three categories, as shown in Table 1.

Table 1: Value categories and their associated benefits in the Mojave bioregion

Value category	*Benefit*
Use values	
• Direct use values [1]	Non-consumptive recreation (hiking, wildlife watching, photography) Hunting & fishing Social, religious, and spiritual events Education & Research Electricity generation (geothermal, wind, solar-thermal) Agriculture & Grazing Mining Nature-inspired art, crafts, and publications (calendars, TV shows etc.) Film industry *+ Economic multiplier effects associated with above activities* Real estate value premium in undeveloped/low density areas Open space for military aircraft training and alternative landing sites for U.S. space program
• Indirect use values ("ecosystem service" value)	Pollination services Hydrological services Natural erosion prevention Carbon sequestration Biodiversity maintenance Habitat provision, etc.
• Option value	Possibility to engage in direct use of the resource in the future
Non-use values (passive use values)[2]	
• Existence value	Appreciation of the scenic beauty of the Mojave, and of the natural systems it contains
• Stewardship value	Appreciation of the fact that this scenic beauty and the natural systems are maintained for and are ....
• Bequest value	...passed on to future generations

Notes: [1] Market and non-market values. [2]Primarily non-market values.

1) Direct use values

All human activities that entail the physical use of the desert fall into this category. These uses may be consumptive or extractive, or they may be non-consumptive. Consumptive and extractive uses appropriate renewable or non-renewable natural resource flows and stocks, as in the case of mining, agriculture, grazing, and resource degrading recreational uses, as in the case of the use of off-road vehicles off established routes. By contrast, non-consumptive uses do not impact the natural resource base, or at least they generally do not lead to changes in the structure and functioning of the ecosystems. Hiking, wildlife watching and photography are examples of non-consumptive direct uses.

Some of the direct uses listed in Table 1 have mainly market impacts (electricity generation, agriculture, grazing, mining, film making), while others generate substantial (non-consumptive recreation, hunting and fishing), or even primarily, non-market values (social, religious, and spiritual events, and nature-inspired art, crafts, and publications, education and research). For example, recreation generates individual enjoyment as well as tourism spending and associated multiplier effects that increase output, earnings, tax revenues, and employment in the local and regional economy. These direct use values are partially captured in markets[14], in the form of recreationists' expenditures on lodging, food, equipment, gasoline, etc., and the multiplier effects that these expenditures have in the local and regional economies. As pointed out in the previous section, however, the total direct use value of recreation actually is generally larger than these visible market impacts indicate, because the expenditures recreationists incur seldom exhaust their willingness to pay for the recreation activities (see for example Kramer *et al.*, 2002; Loomis, 2005).

All activities involving expenditures have economic impacts that are larger than the initial market transaction. For example, recreationists' expenditures on food, lodging, equipment etc. represent direct market impacts of recreation. These impacts lead to an increase in output in the sectors of the local economy that provide these goods to recreationists. These sectors for their functioning in turn require inputs from other sectors (such as agriculture, machinery, financial services, etc.). As a result, the expenditures by recreationists do not only have direct economic impacts on the sectors that supply the goods purchased by recreationists, but also cause indirect and induced increases in output in all sectors that provide inputs to the recreation sector (U.S. Department of Commerce, 1997).[15] The sum of indirect and induced effects in all other sectors that result from a change in output (or earnings, or employment) in a given sector is referred to as the output (or earnings, or employment) multiplier of that sector. For example, if a $1 in spending on lodging results in a total additional spending in the regional economy of $1.1, then the multiplier effect of the lodging industry in the economy is 1.1. In this example, every dollar spent on lodging generates a total of 2.1 dollars in output in the regional economy. The size of this multiplier effect varies with the sector experiencing the increase in output (see U.S. Department of Commerce, 1997) and the capture rate of the regional economy (Stynes, 1999). The capture rate is the share of all sales that is produced within the region, as opposed to being imported from outside the region. The capture rate, and hence the multiplier effect, is positively related to the size and the structural diversity of the regional economy (Hughes, 2003).

[14] The consumer surplus (CS) of recreationists is not captured in markets. Therefore, if revealed preference approaches are used to estimate the direct use value, the CS portion of the recreation use value will go unrecorded, with the result that the total economic value (the sum of consumer surplus and direct market impacts) will be underestimated.

[15] Induced effects are those resulting from a change in household income as a result of direct and indirect effects.

Estimates of the total market impacts of a given change in output are commonly developed with input-output models, such as the Minnesota IMPLAN Group's IMPLAN (Impact Analysis and Planning) or the Bureau of Economic Analysis' RIMS II (Regional Input-Output Modeling System; see U.S. Department of Commerce, 1997). In this analysis, we develop total impact estimates for direct use values using RIMS II. In addition, we compare our estimates with those generated by Stynes and Sun (2003), who estimate total economic market impacts associated with visitation of the three National Parks in the Mojave.

2) Indirect use values

Ecosystems in the Mojave Bioregion contribute to marketed output by providing essential services, such as erosion control, vegetation for pasture, or provision of wildlife habitat, that provide the framework for, or indirectly enter, the human production of goods and services. In economic and ecological terminology, the values of these services are referred to as indirect use or ecosystem service (or function) values, respectively (Costanza *et al.*, 1997; Daily *et al.*, 1997). Ecosystem services contribute to economic output, commonly measured as gross production (for example, on the national level, the familiar gross domestic product, or GDP). Therefore, they carry an economic value in proportion to their contribution to that output (Barbier, 2000).

Most economic analyses of the goods and services produced in a geographic area have tended to ignore ecosystem service values. Instead, economic analyses commonly focus on human-produced goods and services only. Fortunately, this is beginning to change.[16] Neglecting the value of environmental services often generates grave misperceptions as to what makes human economies function (Hall *et al.*, 1986; Cleveland and Ruth, 1997), and has the potential to undermine the quality and efficacy of public policies (Pagiola *et al.*, 2004; Banzhaf and Boyd, 2005). A rigorous analysis of the relationships between ecosystem functions and human well-being, and an integration of ecological services into existing economic accounting systems are needed if the goal is to achieve economically sensible natural resource policies (Banzhaf and Boyd, 2005).

Like direct use values, indirect use values are captured in market transactions, because they become embodied in the prices of goods and services produced in the human economy.[17] However, the estimation of these values is often difficult, because in many instances it requires a sound understanding of the functioning of the systems, that is, of the biophysical processes operating in them. At a minimum, estimation of indirect use values requires quantitative information on the size of the particular service flows that enter the human economy. Generally, the size of the economic value of the services generated by an ecosystem depends on the type of ecosystem (for example, coastal wetland, freshwater wetland, shrubland, forest, etc.), as different ecosystems provide a different mix of services. The economic value of ecosystem services also generally is site-specific, depending, among other factors, on the proximity of the particular ecosystem to locations of human activity, the size of the affected economy (*i.e.*, the number and

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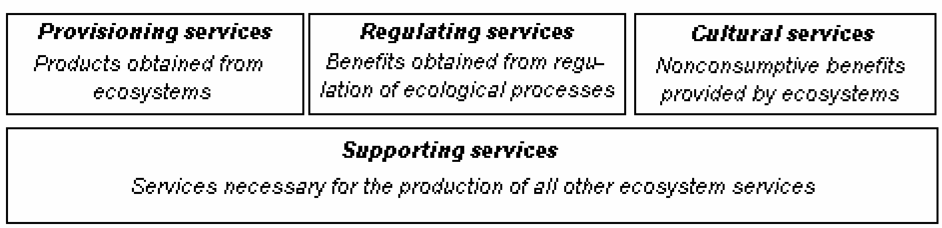
[16] See for example The Economist (April 23rd 2005). Local, regional, national, and international markets have been developing for ecosystem services ranging from single service functions (e.g., water supply and purification, carbon sequestration) to multiple functions (e.g., wetlands banking).

[17] The same caveat pointed out in the discussion of direct use values also applies to indirect use values: both only get captured in market values to the extent that the prices of the respective goods and services are equal to the WTP of consumers. In most instances, this may not be the case.

wealth of individuals and the size and composition of output), and the relative scarcity of particular ecosystem services (Salzman and Ruhl, 2000; Wainger *et al.*, 2001). For example, the economic value of the hydrological services provided by the Catskills watershed is so immense only because these services deliver the public drinking water supply for essentially all of New York City.[18] If instead it supplied these services to 10,000 people as opposed to 10 million, their value obviously would be correspondingly smaller.

The literature on indirect use values often uses the terms "functions" and "services" interchangeably. From an economic perspective, however, it is helpful to distinguish between these two terms. Banzhaf and Boyd (2005) define ecosystem functions as the biogeochemical flows that connect the different constituent parts of ecosystems. By contrast, ecosystem services are those outputs of these functions that are "consumed" by humans.[19] For example, water purification by a wetland is a function, because humans do not value water purification per se. They value the outcome of the process – clean water for human use – which is the actual service.

Ecosystem functions can be categorized into supportive (those that lead to the maintenance of the conditions for life, for example nutrient cycling), provisioning (those that provide direct inputs to human economy, for example food and water), regulating (for example, flood and disease control), and cultural functions (for example, provision of opportunities for recreation and spiritual or historical purposes) (see Fig. 3). Note that what in Figure 3 is labeled "supporting services" would, under our definition, be considered functions. A comprehensive listing and discussion of ecosystem functions and services can be found in De Groot *et al.* (2002).



Source: Adapted from Millennium Ecosystem Assessment (2003)

Figure 3: Typology of ecosystem services following the Millennium Ecosystem Assessment

Table 2 lists the primary functions and services provided by the ecosystems in California's Mojave bioregion. These systems include primarily shrublands, but also areas of coniferous forest, small areas of grasslands, and a few rivers, lakes, and wetlands, some of which are ephemeral.

18 To replace the drinking water supplied by the Catskills watershed, New York City would have needed to make capital investments of between $6 - $8 billion for a water purification plant, and in addition it would incur annual operating costs for the plant of around $300 million (Chichilnisky and Heal, 1998).

19 The term "consumed" here is used in the economic sense, indicating that the service enters a firm's or a household's production function, thereby contributing to the generation of utility or profit. In this context, consumption need not imply a change in the physical structure of the resource. An example of such a non-degrading consumption is a person enjoying a scenic view.

Table 2: Functions, and goods and services provided by dryland ecosystems and likely to be provided by systems in California's Mojave Bioregion

Function	*Ecosystem processes*	*Goods and services (examples)*
Supporting and regulating services	*Maintenance of essential ecological processes and life support systems*	
Water regulation	Role of land cover in regulating runoff and river discharge	Drainage and natural irrigation
Water supply	Filtering, retention, and storage of fresh water (*e.g.*, in aquifers)	Provision of water for consumptive use (residential, agricultural, and industrial uses)
Waste treatment	Abatement of pollution	Reduced dust particles and noise pollution (military training grounds)
Soil retention	Role of vegetation root matrix and soil biota in soil retention	Prevention of damage from erosion/siltation
Soil formation	Weathering of rock, accumulation of organic matter	Healthy and productive soils and ecosystems
Disturbance prevention	Ecosystem structure dampens environmental disturbances	Reduction of intensity of runoff from rainstorms, mudslides, droughts
Carbon uptake/ Climate regulation	Land cover influence on climate	Climate conditions suitable for humans and animals
Nutrient cycling	Storage and recycling of nutrients	Maintenance of healthy soils and productive ecosystems
Pollination	Dispersal of floral gametes	Pollination of wild plant species and crops
Refugium	Suitable plant and animal habitat	Biodiversity maintenance
Nursery	Suitable reproduction habitat	Production of harvested plant and animal species
Provisioning services	*Provision of natural resources*	
Food production	Capture and conversion of solar energy into biomass	Plants and animals
Cultural and amenity services		
Cultural and artistic information	Variety in natural features with cultural and artistic value	Nature as motive in books, films, paintings, folklore, national/local symbols, architecture, advertising, etc.
Spiritual and historic information	Variety in natural features with spiritual and historic value	Use of nature for religious or historic purposes (*i.e.*, heritage value of natural ecosystems and features)
Aesthetic information	Attractive landscape features	Enjoyment of scenery
Science and education	Variety in nature with scientific and educational value	Use of natural systems for school excursions and scientific research
Recreation	Variety in landscapes with (potential) recreational uses	Recreation and tourism

Sources: De Groot *et al.* (2002), Millennium Ecosystem Assessment (2003), White and Nackoney (2003), Wessel *et al.* (2004).

The purpose of this study is the estimation of the total economic value generated in the Mojave desert. As shown in Figure 2, this value is estimated as the sum of the direct use, indirect use, and passive use values. A comparison of the goods and services provided by ecosystem functions

(Table 2) with the direct and passive use values listed in Table 1 shows that the economic value of many of those goods and services is captured in the direct use and passive use categories.

Examples of these are recreation (consumptive and non-consumptive), agriculture, grazing, hunting, media products based on the Mojave, and education and research. This overlap is due to the fact that ultimately all human activity depends on the functioning of ecosystems (Daily *et al.*, 1997; Pagiola *et al.*, 2004). By accounting separately for the direct and passive uses of the Mojave, we already account for a large portion of the value of the Mojave's ecosystem services. In this study, when estimating the total economic value of the lands in the Mojave as the total of direct, indirect, and passive use values, we avoid double-counting by only including in the indirect use value category the value of those ecosystem services that are not already accounted for as direct use values and passive use values.

3) Passive use values and option value

Many people who do not actually visit the landscapes and ecosystems of the Mojave desert in person nevertheless value the region simply because they know and appreciate that this beautiful area exists, that it is being preserved and passed on to future generations, and that it provides habitat for a variety of endangered, threatened, and rare species (Krutilla, 1967; Freeman, 2003; Smith, 2004). The same is true for many visitors to the Mojave: some of the benefits they receive while recreating in the Mojave are not due to the actual recreation activity (the direct use), but are a result of the visitors' valuing the existence of, and the stewarding for and bequesting to future generations, of the unique ecosystems, history, and beauty of the region. These *non-use* or *passive use values* are referred to as existence, stewardship, and bequest values, respectively. Similarly, in the case of option value, individuals may derive benefits from knowing they will have the option of using the resource in the future should they wish to do so (Freeman, 2003; Prato, 1998). Non-use values and option values have long been established in economic theory as components of a resource's total economic value (Freeman, 2003). They have also been recognized as legitimate components of the economic value of natural resources by the courts (U.S. Court of Appeals, 1989) and by legislation (U.S. Department of the Interior, 1994).

Passive use and option values associated with protected areas and species are not commonly captured in markets, because the objects of value do not enter market exchanges. These values can, however, be elicited through carefully designed survey instruments. A large body of literature has documented many instances of individuals expressing a willingness to expend resources for the preservation of ecosystems or particular species they never visit or see in person, thereby indicating that they do attribute real economic value to the existence and conservation of these systems and species. Although a large part of the economic value associated with passive use of the desert is not captured in market transactions, passive uses sometimes do generate some market activity. An example of market impacts associated with such passive uses is the purchase of media that focus on the desert (literature, calendars, documentaries, photos and picture books, etc.). As Kramer *et al.* (2002) point out based on Smith and Desvouges (1986), such vicarious consumption could be seen as indirect use, but in practice it is not separable from pure existence value.

Some studies have used elicitation formats that allowed the researchers to decompose respondents' total WTP into use and non-use components. These analyses have often shown non-use values dominating use values by a large margin (*e.g.*, Kramer *et al.*, 2002; Haefele *et al.*, 1991; Walsh *et al.*, 1990). No such study is available for the Mojave Desert. It is, however, very likely that the Mojave Desert generates substantial passive use values, as there is nothing that would make it fundamentally different from other protected areas for which large passive use values have been demonstrated. In a 1993 study (Richer, 1995) that examined California residents' WTP for the desert protection measures spelled out in the California Desert Protection Bill (S.21 of 1993), average WTP of respondents who had engaged in desert recreational activities in the year preceding the survey was found, not surprisingly, to be higher than WTP of those individuals who had not engaged in such activities. Nevertheless, individuals who had not participated in desert activities in the last year exhibited a positive WTP for desert protection too.

What exactly is it that we are measuring? Defining the boundaries of the analysis

Analyses of the economic value of natural resources in recent years have received increasingly widespread attention. Media coverage of these analyses, and the analyses themselves, sometimes have lacked clarity in communicating to their audience what exactly it was that was being measured. Clarity on this point is extremely important in order to allow a comparison of the results of a study to other studies of the same type.

In this study, we generate an estimate of the total economic value of the uses taking place on conserved lands in California's Mojave bioregion in a particular year, 2003. We choose the year 2003, as that is the latest year for which many of the data required for our analysis are available. In other words, we quantify the economic value of all *flows* of benefits generated by the Mojave bioregion in one specific year. We do *not* quantify the *stock* value (in the economic, not the financial sense), that is, the value of the assets that make up the Mojave bioregion. That stock value would be equivalent to the present value of all future flows of benefits generated by economic activities associated with the Mojave bioregion.

The benefits generated by conserved lands in the Mojave bioregion in 2003 are the benefits that flow from all conservation-compatible activities (uses) ongoing in that year in the bioregion. Extractive and some consumptive uses generally are, by definition, not compatible with conservation, to the extent that they degrade or convert ecosystems. For this reason, agriculture, and to a lesser degree, large-scale energy installations generally are not compatible with conservation and are not included in this analysis. (We do, however, provide an estimate of the value of agricultural and energy production in the Appendix for purposes of comparison.) Some activities potentially degrade ecosystems, such as off-highway vehicle use and water withdrawal, depending on the way in which they are practiced. We include the value of those activities in our analysis, noting however that we do not have sufficient information to take into account the economic costs associated with these activities. From this perspective, our analysis takes the view that existing types and levels of extractive and consumptive uses ongoing in the year we analyze (2003) are compatible with conservation of the undeveloped lands in the region; therefore, the economic benefits associated with these uses are included in the present analysis. By contrast, additional extractive and consumptive activities, or the expansion of such activities in their current locations, to the extent that these degrade ecosystem quality or quantity, are incompatible with the conservation of desert lands. Our study also does *not* attempt to assign values to specific *changes* in these benefit flows, such as those that may results from an expansion of residential areas, increased off-designated route OHV traffic, expansion of mining or grazing activity, or any other change in the state of affairs observed in 2003. The latter would be the objective of an economic impact analysis that evaluates the change in the state of the world brought about by a specific action. Such an analysis would also need to take additional values into account, such as health impacts associated with changes in air pollution (*e.g.*, increased suspension and transport of respirable particulate matter from increased soil erosion rates, increased generation of other air pollutants, especially ozone and its precursors, associated with increased consumption of fossil fuels in the transport, industrial, and commercial and residential sectors), possibly other negative externalities of urban sprawl (*e.g.*, increased costs of public services provision, such as schooling and other infrastructure), and possibly the loss of social cohesion due to increased fragmentation of communities due to sprawl.[20]

[20] For a comprehensive assessment of the cost of sprawl, see Burchell et al., 2000).

II. Study area selection

The magnitude of the economic benefits generated by an area depends, among other things, on the size of the area in question. Use and ecosystem service benefits generally increase approximately proportionally with system size. Even though such a linear area-value relationship may not always be the case for non-use benefits, the latter are also likely to show a positive relationship to system size. For example, it would appear likely that people attach a higher value to the mere existence of the current-scale Yellowstone National Park than they would to a significantly smaller park in the same location. The primary rationale for this argument is that people generally are aware that the protection afforded to both species and whole ecosystems improves with an increase in the size of the protected area. Therefore, in order to assess the economic benefits generated by the ecosystems in the Mojave desert, we first must define the extent of the area to be included in the analysis.

As with any ecosystem, the delineation of the Mojave desert system is to some extent arbitrary, given the many biotic and abiotic interactions between the Mojave lands and surrounding areas. As in any ecosystem assessment, selection of our study area is therefore based on pragmatic reasons, the principal among these being the availability of the ecosystem, economic, and demographic information needed for the economic assessment.

The Mojave desert forms part of a larger system, or ecoregion, classified as the American Semidesert and Desert Province (Bailey, 1995), that stretches from southeastern California to southwestern Arizona and southern Nevada (Figure 4). Besides the Mojave Desert, this ecoregion also includes the Colorado and Sonoran Deserts (Bailey, 1995). The western part of this ecoregion, located in California, is referred to as the Mojave Bioregion (California Biodiversity Council, Interagency Natural Areas Coordinating Committee, 1992). This region is bounded on the west by the western edge of the BLM California Desert Conservation Area and on the east by the Nevada state line; on the south by the northern base of the San Gabriel and San Bernardino Mountains, the southern edge of Joshua Tree National Monument, and the southern edge of San Bernardino County (between Joshua Tree and the Nevada state line) (see Figure 5). This area is approximately coextant with the part of Bailey's American Semidesert and Desert Province that is located in California.

All lands in the Mojave bioregion are covered by management plans (see Figure 6): the West Mojave Plan (BLM, 2003a) covers the western part of the region, the Northern and Eastern Mojave Plan (BLM, 2001a) covers the parts surrounding Death Valley National Monument and the Mojave Preserve; Death Valley National Park, Joshua Tree National Park, and the Mojave Preserve have their own respective management plans, and the part of the Mojave Bioregion located in San Bernardino County is covered by the Northern and Eastern Colorado Plan (BLM and California Department of Fish and Game, 2001). Detailed information on the biophysical, economic, and demographic characteristics of the complete area is available from the management documents as well as from the California Environmental Resources Evaluation System (CERES). For this reason, we choose California's Mojave Bioregion as our study area.

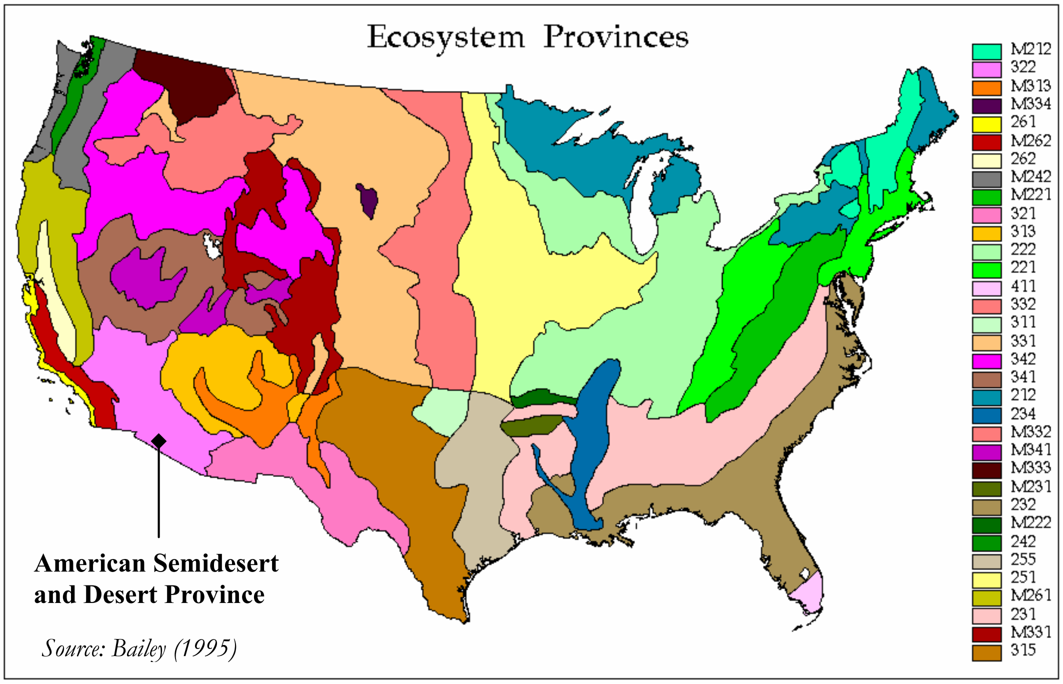


Figure 4: Bailey's (1995) ecoregions of the United States

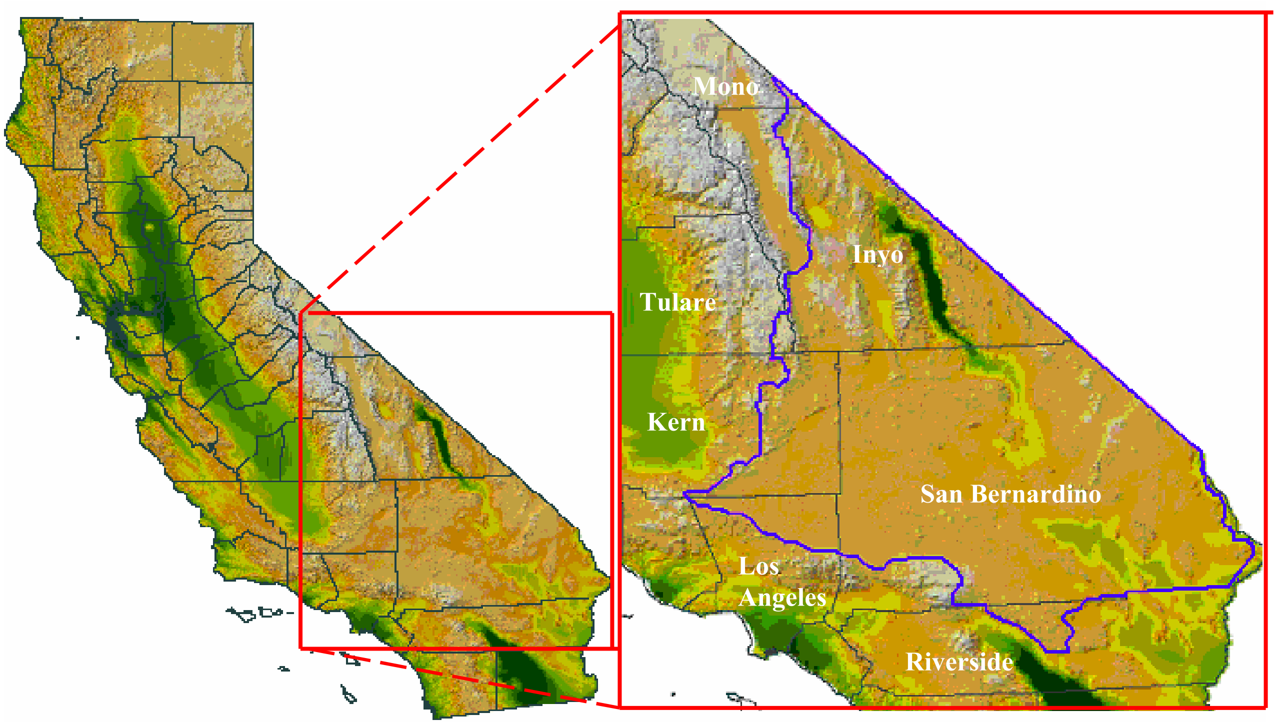
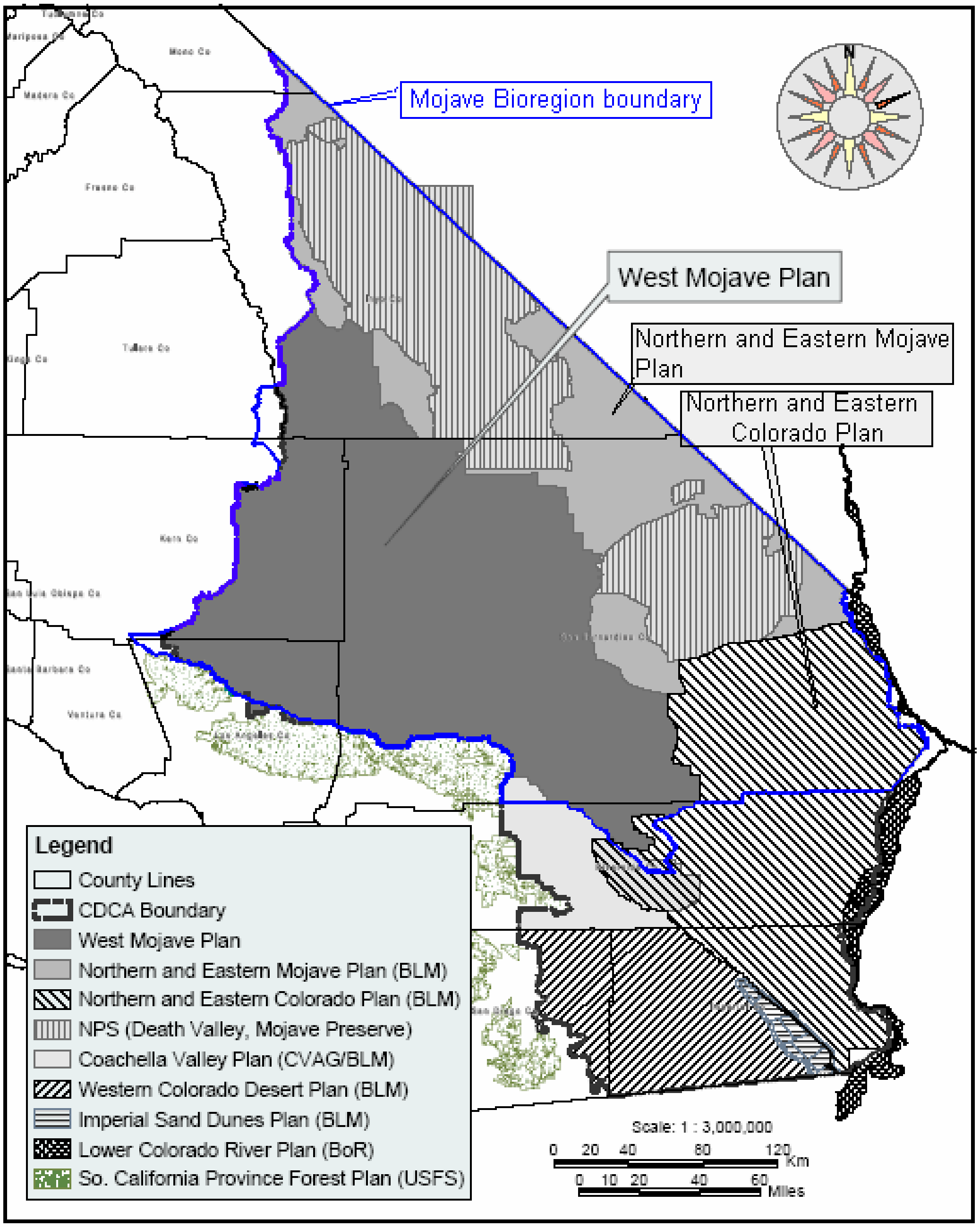


Image source: ICE MAPS, Information Center for the Environment, UC Davis

Figure 5: Location of California's Mojave Bioregion (blue boundary, right panel)



Source: BLM (2003a), West Mojave Plan DEIR/S, Map 1-2.

Figure 6: The Mojave bioregion in relation to other planning boundaries in the area

Study area characteristics

Before proceeding to the analysis of the uses of the Mojave and their associated values, we briefly present some general characteristics of the study area. These are the composition of land ownership, the size of the population, the main economic activities, and the vegetation found in the Mojave.

Land ownership composition

The Mojave bioregion covers approximately 19.9 million acres (California Resources Agency. 1998a). Of these, 79 percent are under federal ownership, mostly BLM, NPS, and DOD (see Table 3). Of the remaining lands, almost 90 percent are privately owned.

Table 3: Land ownership composition in the Mojave

Habitat type	*Federal* *BLM*	*NPS*	*FS*	*other*	*Non-Federal* *Local*	*State*	*Private*	*Total*	
				acres				acres	%
Conifer	199,000	220,000	37,000	67,000	0	7,000	138,000	668,000	3.5%
Desert	7,155,000	4,451,000	27,000	2,410,000	11,000	386,000	3,166,000	17,606,000	92.6%
Grassland	53,000	1,000	0	0	0	4,000	79,000	137,000	0.7%
Shrub	152,000	159,000	19,000	0	0	16,000	222,000	568,000	3.0%
Woodland	8,000	0	1,000	0	0	0	29,000	38,000	0.2%
Total	7,567,000	4,831,000	84,000	2,477,000	11,000	413,000	3,634,000	19,017,000	
Percent	39.8%	25.4%	0.4%	13.0%	0.1%	2.2%	19.1%		

Notes: Numbers rounded to nearest thousand. Numbers do not include urban, agriculture, or water.
Source: California Resources Agency (1998a).

The bioregion falls into seven counties: it contains nearly all of San Bernardino County, most of Inyo County, the eastern third of Kern County, the northeastern desert part of Los Angeles County, a part of north central Riverside County, and the southeastern tips of Tulare and Mono Counties.

Population

The Mojave bioregion is located in close proximity of the Los Angeles metropolitan area, the largest urban agglomeration in the United States. Not surprisingly, the total population of the counties into which the bioregion falls is large, approaching 15 million in mid-2003 (see Table 4). Only a small fraction of this population actually lives within the boundaries of the Mojave bioregion: the combined population of the towns and cities (including bases) located in the bioregion was approximately 650,000 in mid-2003, with Lancaster and Palmdale together accounting for about 40 percent of the total (see Table 4). However, the northeastern edge of the L.A. metropolitan area, including the cities of Fontana, San Bernardino, Redlands, Rialto, and Riverside with a combined population of 800,000 (2003) lies within 20 miles of the southern border of the Mojave bioregion. In fact, the whole northern periphery of Los Angeles lies within 30 miles of that southern border. This close proximity to Los Angeles explains why more than 85 percent of all recreation visitors to the bioregion come from southern California counties (BLM, 2003a).

Population growth in the Mojave bioregion has been rapid in the last two decades. In fact, the population in the bioregion has been growing more rapidly than the population of the seven counties in which the bioregion is located. The average annual growth rate of the population in cities and towns in the bioregion during 2000 to 2003 was 3.0 percent, while that of the seven counties was 1.9 percent. For California as a whole, it was 1.6 percent.

Table 4: Population in the Mojave bioregion and its proximity

County	*Cities/towns in Mojave bioregion*	*Population* 2003	2000	*Δ, 2000-03*
San Bernardino		1,859,678	1,709,434	9 %
	Adelanto	20,002	18,130	10 %
	Apple Valley	60,076	54,239	11 %
	Barstow	23,073	21,119	9 %
	Hesperia	69,179	62,582	11 %
	Joshua Tree (CDP)	6,721[a]	4,207	60 %
	Needles	5,276	4,883	8 %
	Twentynine Palms	25,971	28,590	-9 %[b]
	Victorville	74,987	64,029	17 %
	Yucca Valley	18,301	16,865	9 %
	Fort Irwin N.T.C. (2004)	*18,532*	*(18,532)*	*n.a.*
	Twentynine Palms M.C.B.(2004)	*17,180*	*(17,180)*	*n.a.*
	*China Lake N.W.C. (2003)**	*5,383*	*(5,383)*	*n.a.*
Inyo		18,326	17,945	2 %
Kern		713,087	661,645	8 %
	Boron	2,027	2,025	.1%
	California City	11,221	8,385	34 %
	Mojave	3,879	3,836	1%
	Ridgecrest	25,635	24,927	3 %
	Edwards A.F.B. (2000)	*(5,909)*	*5,909*	*n.a.*
Los Angeles		9,871,506	9,519,338	4 %
	Lancaster	125,896	118,718	6 %
	Palmdale	127,759	116,829	9 %
Mono		12,988	12,853	1 %
Riverside		1,782,650	1,545,387	15 %
Tulare		390,791	368,021	6 %

Notes: Counties are those with at least some land located in the Mojave bioregion. Cities and towns listed are those actually located inside of the Mojave bioregion. [a]Estimate – see Table 30. [b]The Census Bureau numbers differ from County statistics, which between 2000 and 2003 indicate a 70 percent increase in the population of Twentynine Palms (County of San Bernardino, 2004a). This may be due to a change in methodology in accounting for those family members that live off base (approximately 10,000). *China Lake's north range stretches into Inyo and Kern counties. CDP – Census Designated Place. A.F.B. - Air Force Base; M.C.B. - Marine Corps Base; N.T.C. - National Training Center; N.W.C. - Naval Weapons Center.

Sources: U.S. Census Bureau, Population Division, 2004; Kern Council of Governments, 2004. Information on military bases is from *http://www.militarymatch.com/*; *http://www.irwin.army.mil/ Post/FactsAndFigures/*; and *http://boxer.senate.gov/CAbases/sb_29p.cfm*; U.S. Census Bureau, 2000a; U.S. Census Bureau, Census 2000 Summary File 1 (SF 1) and Summary File 3 (SF 3).

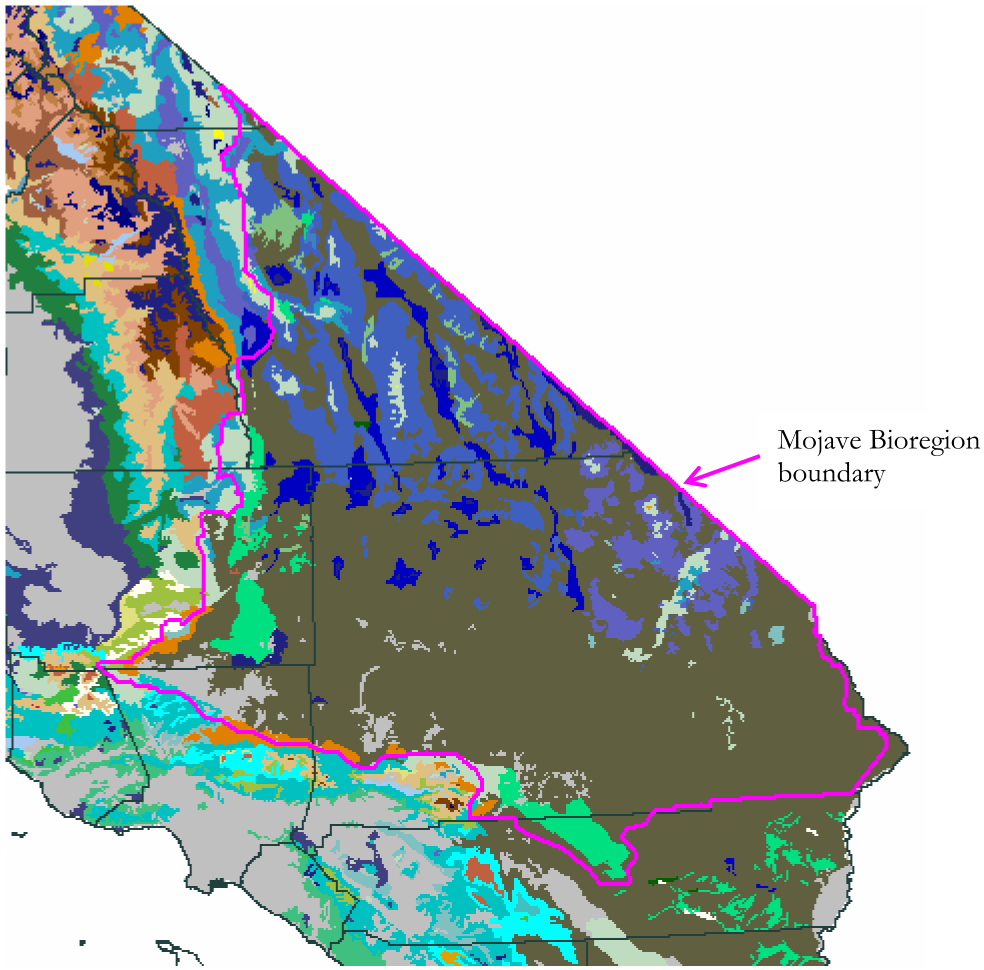
Although population growth in the Mojave area is slower than in the 80s and 90s, it is expected to remain strong, principally because of the relative affordability of housing (BLM, 2003a). Indeed, the total population in the Mojave bioregion by 2020 is expected to be almost twice its 2000 level (ibid.). The encroachment on habitat of threatened and endangered species associated with this population growth could be drastically reduced if the increase would take the form of high-density development (20 persons per hectare) as opposed to current density levels (3.8 persons/hectare in 2000) (Hunter *et al.*, 2001).

Economy

The economy of the Mojave region is dominated by recreation, resource extraction, and military installations (Hunter *et al.*, 2001; Bureau of Land Management, 2003a). All of these activities support local businesses and related employment. The Mojave also is home to several major renewable energy installations that support operation and maintenance jobs in the region. The projected strong increases in installed renewable capacity expected during the next two decades (California Energy Commission, 2003b) will have sizeable output and employment impacts in the affected local sectors. The Mojave also supports agricultural and grazing operations (California Department of Conservation, 2004; Bureau of Land Management, 2001a, 2003a). The construction sector recently has experienced rapid growth, due to the continuing housing boom taking place especially along the southwestern periphery of the Mojave that is closest to the Los Angeles metropolitan area.

Vegetation

The Mojave ecosystem contains a large variety of plants (Bureau of Land Management, 2001a, 2003a), accounting for most of the over 1,800 vascular plants recorded for the California Desert Conservation Area (Bureau of Land Management, 2003a). The predominant vegetation types in the Mojave are creosote bush scrub and saltbush scrub plant communities (see Figure 7). However, 30 other distinct plant communities are found in the western Mojave alone (Bureau of Land Management, 2003a). The communities vary in response to the diverse topography and landforms of the Mojave. The Mojave contains at least 13 endemic plants, that is, species not found anywhere else (ibid.).



Source: ICE MAPS, Information Center for the Environment, UC Davis

Figure 7: Vegetation in the Mojave bioregion (see legend on next page)

Legend to Figure 7:

Source: ICE MAPS, Information Center for the Environment, UC Davis

Endangered, threatened and rare species

Due to its large variety of unique microhabitats, the Mojave supports a large number of endemic species. Several of these are listed as threatened or endangered under the California or the Federal Endangered Species Act (ESA) (Table 5). Several dozen more are classified as California Special Concern species, Bureau of Land Management sensitive species, Federal Species of Concern, or Fish and Wildlife Service Migratory Nongame Birds of Management Concern (Bureau of Land Management, 2001a, 2003a).

Table 5: Endangered, threatened, and rare species in the Mojave bioregion

Common name	*Scientific name*	*Federal ESA status*
CA ESA: Endangered		
Amargosa niterwort	*Nitrophila mohavensis*	E
Amargosa vole	*Microtus californicus scirpensis*	E
Arizona Bell's vireo	*Vireo bellii arizonae* (Nesting)	None
Bald eagle	*Haliaeetus leucocephalus*	T
California condor	*Gymnogyps californianus*	E
Elf owl	*Micrathene whitneyi* (Nesting)	None
Gila woodpecker	Melanerpes uropygialis	None
Inyo California towhee	*Pipilo crissalis eremophilus*	T
Least Bell's vireo	*Vireo Bellii Pusillus (Nesting)*	E
Mohave tui chub	*Gila bicolor mohavensis*	E
Mojave tarplant	*Hemizonia mohavensis*	SoC
Owens tui chub	*Gila bicolor snyderi*	E
Owens valley checkerbloom	*Sidalcea covillei*	SoC
Razorback sucker	*Xyrauchen texanus*	E
Sodaville milk-vetch	*Astragalus lentiginosus var sesquimetralis*	SoC
Southwestern willow flycatcher	*Empidonax traillii* (Nesting)	E
Thorne's buckwheat	*Eriogonum ericifolium var*	SoC
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis* (Nesting)	None
CA ESA: Threatened		
Black toad	*Bufo exsul*	SoC
Cottonball marsh pupfish	*Cyprinodon salinus milleri*	None
Desert tortoise	*Xerobates agassizii*	T
Mohave ground squirrel	*Spermophilus mohavensis*	SoC
Swainson's hawk	*Buteo swainsoni* (Nesting)	None
Yuma clapper rail	*Rallus longirostris yumanensis*	E
CA ESA: Rare		
Eureka dunes	*Oenothera californica ssp eurekensis*	E
Eureka valley dune grass	*Swallenia alexandrae*	E
July gold	*Dedeckera eurekensis*	SoC
Mexican flannelbush	*Fremontodendron mexicanum*	E
Red rock tarplant	*Hemizonia arida*	SoC
Rock lady	Maurandya Petrophila	SoC
CA ESA: None		
Arroyo toad	*Bufo californicus*	E
Ash Gray Indian paintbrush	*Castilleja cinerea*	T
Ash meadows gumplant	*Grindelia fraxino-pratensis*	T
Big Bear Valley sandwort	*Arenaria ursina*	T
California red-legged frog	*Rana aurora draytonii*	T
Cushenbury buckwheat	*Eriogonum ovalifolium var. vineum*	E
Cushenbury milk-vetch	*Astragalus albens*	E
Lane Mtn. milk-vetch	*Astragalus jaegerianus*	E
Parish's daisy	*Erigeron parishii*	T
Spring-loving centaury	*Centaurium namophilum*	T
Triple-ribbed milk-vetch	*Astragalus tricarinatus*	E
Western snowy plover	*Charadrius alexandrinus nivosus* (Nesting)	T

Notes: E - endangered; T - threatened; SoC - Species of concern.
Sources: California Resources Agency, 1998a; BLM 2001a, 2003a.

Uses of the lands in the Mojave bioregion

The principal uses of the undeveloped lands in the bioregion are those that generate the benefits listed in Table 1. Of these, recreation is the spatially most extensive use, followed by residential development and related infrastructure.

Recreation

The Mojave receives large volumes of recreation visitors every year. Table 6 displays the total number of annual visits and visitor days in the Mojave, according to the ownership of the lands visited.[21]

Table 6: Visitation of specific locations in the Mojave bioregion

	Recreation Visits	*Recreation Visitor Days*
National Parks		
Mojave National Preserve	615,269	312,758
Death Valley National Park	890,375	557,476
Joshua Tree National Park	1,283,346	760,488
BLM lands *	4,157,077	2,308,849
State Parks		
Red Rock Canyon State Park	247,439	100,540
Saddleback Butte State Park	7,885	7,966
Antelope Valley CA Poppy Preserve	11,380	1,897
Providence Mountains SRA	11,900	7,443
Antelope Valley Indian Museum	8,418	1403
Private Lands		
Pipes Canyon Preserve	3,917	653
Desert Tortoise Research Natural Area	1,243	104
Total	7,238,249	4,059,577

Notes: Data are for 2003, except state parks (FY 2002), BLM lands (FY 2004), and Pipes Canyon Preserve (2002). A Recreation Visitor Day is the equivalent of twelve person hours. For example, two persons visiting for six hours each, or one person visiting for twelve hours would both be counted as one recreation visitor day. Visitation of state parks was converted to visitor days using the average length of stays for the respective recreation activities reported on BLM lands. *Visitation on all BLM lands, including wilderness areas (see Table 7) and Areas of Critical Environmental Concern (ACEC).
Sources: NPS Visitation Database Reports; BLM Recreation Management Information System; California Department of Parks and Recreation, 2003; Connor and Hemingway, 2003; The Wildlands Conservancy (pers. comm., Frazier Haney, 4/11/05).

Not surprisingly, federal lands, which account for the majority of the area, dominate total visitation, receiving a combined 97 percent of total visitor days. The high level of recreation activity in the area is a function both of the Mojave's proximity to the Los Angeles metropolitan

[21] A visit is defined as one individual entering a particular park, recreation area, etc. A visitor day is defined as 12 daytime hours. Hence, if an individual enters a given park three times during a year, and spends two hours on average during each of those visits, that activity would be counted as three visits and half a visitor day, respectively.

area, and of the high quality of the recreation opportunities it provides. These recreation opportunities include not only two National Parks, Death Valley and Joshua Tree, and the Mojave National Preserve, but also a large number of wilderness areas (see Table 7) and Watchable Wildlife Areas (*e.g.*, Harper Lakes and Mojave Monkeyflower conservation areas, and Kelso Creek) on BLM lands, as well as ample opportunities for OHV activities of all kinds, with the High Desert (West Mojave) alone attracting nearly two million visitor trips per year for off-highway vehicle recreation (BLM, 2003a).

Table 6 does not include recreation activities practiced on municipal lands. For example, the OHV area in the north of California City alone attracts up to two thousand visitors on an average weekend, with visitation being many times higher on holiday weekends (*e.g.*, Easter Weekend often attracts around 20,000 to 30,000 visitors).[22] The numbers of recreation visitors and visitor days shown in Table 6 therefore are underestimates of the actual volume of recreation activity taking place in California's Mojave bioregion.[23]

Table 7: BLM wilderness areas in the Mojave

Argus Range	Golden Valley	Pahrump Valley
Bigelow Cholla Garden	Golden Trout (southern tip)	Piper Mountain
Bighorn Mountain	Grass Valley	Piute Mountains
Black Mountain	Hollow Hills	Resting Spring
Bright Star	Ibex	Rodman Mountains
Bristol Mountains	Inyo Mountains	Sacatar Trail
Cadiz Dunes	Kelso Dunes	Saddle Peak Hills
Chemehuevi Mountains	Kiavah	San Gorgonio
Chimney Peak	Kingston Range	Sleephole Valley
Cleghorn Lakes	Malpais Mesa	South Nopah
Clipper Mountain	Manly Peak	Stateline
Coso Range	Mesquite	Stepladder Mountains
Darwin Falls	Newberry Mountains	Surprise Canyon
Dead Mountains	Nopah Range	Sylvania Mountains
Domeland	North Mesquite Mountains	Trilobite
El Paso	Old Woman Mountains	Turtle Mountains
Funeral Mountains	Owens Peak	Whipple Mountains

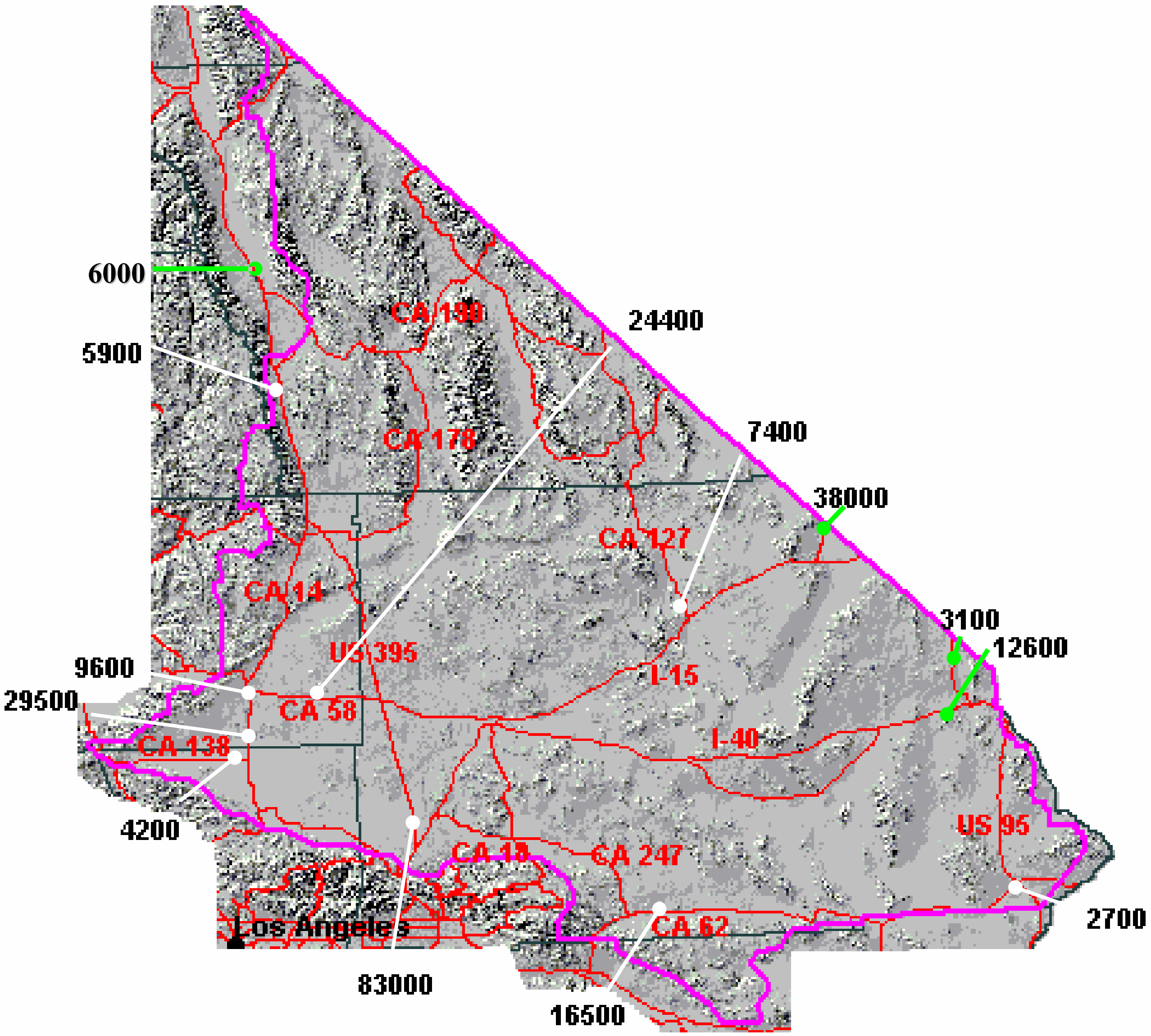
Source: USGS, 2004.

Passive recreation

The Mojave region experiences a high volume of transit traffic. Figure 8 shows the average annual daily traffic flows at selected points in the Mojave

22 Personal communication with Mike Edmiston of the California City city council, 3/23/05.

23 Also not included in the recreation estimates is the visitation of popular museums in the area, such as the America Railroad Museum and the Mojave River Valley Museum in Barstow, and the Route 66 Museum in Victorville. These attractions generally are not primary targets of recreation trips, and generally do not involve long stays. The Mojave River Valley Museum (MRVM) Association organizes four-wheel drive field trips at least once a month, but most of these are likely to take place on BLM or NPS lands, so they are accounted for in the visitation statistics for those lands.



Sources: ICE MAPS, Information Center for the Environment, UC Davis; California Department of Transportation, 2004.

Figure 8: Average annual daily traffic (AADT) at selected points in the Mojave

The overwhelming majority of the traffic in the Mojave is not associated with visitation of the National Parks, State parks, BLM lands, or private lands listed in Table 6. As shown by traffic counts (see Figure 8), the total volume of traffic in the Mojave is a multiple of the trips made to these areas. Rather, a large share of the total traffic volume is attributable to area residents commuting by between work and home. That is especially true for residents of the largest population centers in the southwestern part of the Mojave, Lancaster and Palmdale, a sizeable share of whom commute to work in the Los Angeles metropolitan area (BLM, 2003a). There is a large volume of traffic, however, that cannot be attributed to daily commute or to visits of the recreation areas listed in Table 6. In particular, a substantial part of the traffic on I-40 over the Arizona border, on US 95 and I-15 into Nevada (Las Vegas), and on US 395 north of the junction with California Route 136 towards Mammoth Lakes (Inyo National Forest), is caused by long-distance and outdoor recreational traffic, respectively. In 2003, 21.8 million vehicles were recorded on these three road segments (see green pointers in Figure 8). To the extent that the individuals passing through the Mojave enjoy the scenic beauty of the area (which arguably many do – in fact, "the public often cites scenic values as the deserts' most important resource" [BLM, 2003a, p. 3-239]), there is an economic benefit associated with their enjoyment of the visual beauty of the landscape. This benefit takes the form of non-consumptive direct use value and existence value.

Housing, renewable energy, agriculture, film

The same attributes that attract large numbers of recreational users to the Mojave also attract home buyers. In recent years, the combined population in the cities and towns in the Mojave (Table 4) has been growing at an average of three percent per year. The open-space and scenic vistas that characterize the Mojave increase the market value of houses and of properties slated for residential development. This effect of environmental amenities on house and property values is commonly referred to as an amenity value premium. The size of this premium varies in response to differences in the quality of the amenities received in a particular location. For example, a property located directly adjacent to a very attractive, permanently protected area and with scenic vistas and easy access to that area will command a larger amenity premium than a house located farther away from an area that is currently, but not permanently, protected, and that offers somewhat less scenic views and easy access to that area. Given that in the Mojave there are several towns that offer exceptional amenity values due to their proximity to permanently protected National Park Service lands, the amenity value premiums in the Mojave are likely to be substantial.

Due to its geographical and climatic features, the Mojave also boasts some of the largest renewable energy installations found anywhere in the U.S. These include several large-scale wind farms and geothermal and solar-thermal power plants. Especially wind and solar-thermal installations are expected to experience strong growth over the near and medium-term future (California Energy Commission, 2003b). Although the dry climate makes much of the Mojave not particularly conducive for agriculture, some areas, primarily those in the somewhat less arid southern and southwestern periphery, do produce a variety of specialty crops.

Due to its many remote areas and the high diversity of its landscapes, the Mojave also constitutes an important resource for the motion picture industry. Over the years, it has provided a unique and convenient backdrop for a large number of major Hollywood productions. The desert also provides motives for countless other media, such as books, catalogues, music videos and commercials, and was the topic of a number of large documentary productions.

Educational and scientific uses of Mojave ecosystems

Protected areas, and in particular wilderness areas, provide important opportunities for education, both at the high school and university levels (Loomis and Richardson, 2001). They also are used for scientific research (ibid.). As the Bureau of Land Management points out, the Mojave's "Wilderness areas and BLM ACECs [Areas of Critical Environmental Concern] provide good opportunities to study rare or endangered plant and wildlife species, geological and archeological features and desert ecology" (BLM, 2001a: 3-29). It is not surprising therefore that the Mojave attracts a considerable amount of both education and research activities (Richardson, 2004).

Other direct uses of the Mojave

Due to its large open areas, its remoteness, and its historically low population, the Mojave has also been heavily used for military purposes. It features three major bases: the Fort Irwin National Training Center, the Twentynine Palms Marine Corps Base, and the China Lake Naval Weapons Center. A particular benefit of the large open spaces and low population density is that these provide ideal conditions for the operation of military aircraft training sites, and of crash and alternative landing sites for NASA spacecraft.

Historically, the Mojave also has supported gold and silver mining since the 18th century. Although gold continues to be mined, today most large mines are for the extraction of nonmetals such as borax, gypsum, and limestone (Kramer *et al.*, 2000; Bureau of Land Management, 2003a).

The scenic attributes and remoteness of the Mojave also attract a large number of artists, as well as music (Coachella Valley Music and Arts Festival, Morongo Basin Desert Arts Festival, and Open Studio Art Tours, among others) and nature festivals (for example the Cactus Flower Festival in Twentynine Palms) and other activities that center on the natural resources of the desert (Watchable Wildlife Conference in Twentynine Palms).[24]

All of these uses provide benefits to individuals and communities. However, an economic evaluation of these benefits lies beyond the scope of this analysis.

Indirect and passive uses of the Mojave

In addition to these direct uses, the Mojave is also used indirectly. As shown in Table 2, the ecosystems that make up the Mojave bioregion deliver a number of services to individuals and communities that live in the area. These services include the provision of water for residential, commercial and agricultural uses, the pollination of wild plant species and crops, and the maintenance of biodiversity, among many others.

Finally, like other unique areas of outstanding beauty, the Mojave provides opportunities for so-called passive uses to people who do not actually visit the area. Many individuals around the country who only know the Mojave from documentaries, books, calendars, movies, or other media still cherish the fact of knowing that this unique landscape and the ecosystems or species it contains exists and is passed on to future generations.

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[24] See for example The Sun Runner – Desert Arts & Entertainment Magazine (February/March 2005); Morongo Basin Cultural Arts Council, Inc., "The Art Link", Volume 1, Winter 2005; Sanneh, Kelefa, "Embracing the random" - Music Review: Coachella Valley Music and Arts Festival, New York Times, 3 May 2005; and pers. comm. with Pat Flanagan, Twentynine Palms Chamber of Commerce, 22 March 2005.

III. Estimation of the economic values generated by the lands in the Mojave bioregion

In this part of the report we develop monetary estimates of the economic benefits associated with human use of the Mojave. We begin with the analysis of direct use values of the Mojave, followed by that of indirect and passive use values. In all cases, we discuss the value of the benefits generated by a particular use, as well as the value of the *net* benefits generated by that use. Net benefit is the appropriate measure for assessing the contributions the Mojave makes to individuals' welfare, because it indicates the difference between the total benefit they receive from a particular activity and the costs they incur for engaging in that activity.

We also assess the magnitude of the direct, indirect, and induced economic impacts caused by the market transactions associated with the various uses, insofar as the economic data needed for this analysis are available. The actual direct and multiplier impacts of market transactions themselves do not represent benefits as defined in the analysis framework of welfare economics. However, these impacts do generate net benefits for households and firms that are not measured by the analysis of the direct impacts of the various uses of the Mojave, and thus need to be considered separately to complete the discussion of the economic value of these uses.

1. Direct use values of the Mojave

The direct uses of the Mojave for which we have sufficient information to allow the development of estimates of net benefits are recreation activities and real estate amenity premiums. In addition, we have information on the value of the agricultural production in the Mojave, the value of the receipts from issuance of film and photography permits on Federal lands, and the value of renewable energy generation. However, lack of information on the input cost and on the associated negative environmental consequences make it impossible to generate a net benefit estimate for agriculture. Likewise, lack of production cost estimates and of the amenity costs of renewable energy installations prevent the estimation of net benefits for that use. Finally, the lack of information on the cost of substitutes for the Mojave scenery in film productions prevents the estimation of net benefits from filming. Estimates of the gross benefits of these uses are presented in the Appendix.

Recreation

The economic literature on recreation values focuses on the benefits individuals derive from engaging in various recreation activities. However, recreation may also generate benefits for the communities of the participants. For example, people who spend more of their free time in "natural" environments often experience relaxation, both physical and psychological. In this sense, protected natural areas like those found in many parts of the Mojave function as sinks for the stress and aggression associated with modern life in large urban centers. By providing urban recreation visitors with outlets for this stress, the Mojave may contribute to a higher quality of life in urban communities.[25] Unfortunately, economic analyses of these community benefits associated with recreation do not exist, so here we focus on the benefits of recreation to individuals.

[25] Many of these ideas are explored in more detail in Trzyna (2003) and Trzyna (forthcoming) and the sources cited therein.

Research suggests that the value an individual assigns to recreation activities varies with the type and quality of the recreational experience.[26] The quality of recreation is a function of the specific characteristics of the context in which recreation takes place. Important context factors are the type of recreation practiced (*e.g.*, hiking, mountain biking, kayaking) and the perceived attractiveness of the locale in which it is practiced (*e.g.*, scenic attractiveness, degree of difficulty, crowding), among others (see for example Rosenberger and Loomis, 2001; Loomis and Walsh, 1997).

Because of the context specificity of economic values, ideally our estimates of the value of recreation in the Mojave should be based on information generated in the study area. Such information is available for the part of the recreation value of the two National Parks and the Mojave National Preserve that is captured in visitor expenditures in those areas. Alas, such study area-specific values do not exist for the non-NPS lands in our study area. Our estimates of the economic value of recreation activities on BLM and private lands in the study area are based on studies conducted in other areas. Similarly, our estimates of the value of recreation on State lands in the Mojave are based on data that represent the average recreational value of lands in the California State Park system as a whole.

In all cases, the available data are restricted to travel costs. However, as discussed in the Introduction, travel costs only capture part of the total economic value individuals attribute to recreation. Research shows that the consumer surplus (CS), or the benefits from recreation that individuals receive above and beyond the amount they are spending to engage in recreation, are substantial. Therefore, we augment recreationists' travel expenditures by the associated CS in order to derive an estimate of the total economic value of recreation to participants. We use published CS estimates for specific recreation activities. Many of these estimates were not generated specifically for desert environments; some were.

In addition to the value recreation activities carry for the people engaging in them, the expenditures associated with these activities also generate economic output. This output in turn generates employment and earnings, both directly as well as through multiplier effects. Earnings, although not strictly equivalent to producer surplus (see "PS" in Figure 1), can serve as an approximation of the net economic value to society of the provision of the market-based inputs to recreation. Together with the consumer surplus of recreationists, recreation-related earnings therefore can be used to estimate the total net economic value to society of recreation activities in the Mojave.

Recreation visitor expenditures in the Mojave

Visitor surveys administered by the University of Idaho's Park Studies Unit provide detailed information on expenditures by visitors of the NPS lands in the Mojave (Littlejohn, 1997; Le *et al.*, 2004a and 2004b). Specifically, these surveys provide estimates of the average per-capita expenditures in and around each National Park or Preserve, where "in and around" is defined as

[26] As discussed in the previous section, economic value, as measured by WTP, always also depends on the economic situation of the individual, as well as on social and cultural factors.

within 50 miles of the Park or Preserve.[27] The Park visitor studies also provide estimates of the number of times the average visitor enters a given NPS unit during a visit. We derive estimates of the number of recreation visitors to each NPS unit in 2003 by dividing the number of total recreation visits by this re-entry factor. Finally, by multiplying the number of visitors by the site-specific average per-capita expenditures of visitors, we develop estimates of the total visitor expenditures for each NPS unit in 2003 (see Table 8).

Table 8: Estimates of total local expenditures by visitors of the National Parks and Preserve in the Mojave, and breakdown by spending category, 2003

	Mojave National Preserve		*Death Valley National Park*		*Joshua Tree National Park*	
Recreation visits	615,269		890,375		1,283,346	
Re-entry factor	1.73		1.75		2.08	
Visitors	355,647		508,786		616,993	
Avg. per-capita expenditures in and around Park/Preserve (*2003$*)	$ 77		$ 122		$ 77	
Total expenditures in and around Park/Preserve (*million 2003$*)	$ 27.4		$ 70.0		$ 47.5	
Expenditure breakdown:	*%*	*$*	*%*	*$*	*%*	*$*
Hotels, motels, cabins, B&B	27	20.48	45	62.44	25	19.48
Camping fees and charges	2	1.54	n.a.	n.a.	6	4.62
Guide fees and charges	<1	0.31	n.a.	n.a.	1	0.77
Restaurants and bars	18	13.55	n.a.	n.a.	17	13.32
Groceries and take-out food	14	10.78	27	36.55	14	10.78
Gas and oil	18	13.55	12	17.01	13	10.01
Other transportation expenses	1	0.77			7	5.39
Admissions, recreation, entertainment fees	2	1.54	n.a.	n.a.	4	3.08
All other purchases (film, gifts, etc.)	19	14.63	16	21.58	11	8.47
Donations	n.a.	n.a.	n.a.	n.a.	<1	0.77

Notes: The re-entry factor indicates the number of times the average visitor enters the Park or Preserve during the visit. Expenditures "in and around" a Park or Preserve are defined as those that occur within 50 miles of the Park or Preserve.
Sources: Littlejohn, 1997; Le *et al.*, 2004a and 2004b.

The visitor surveys also provide a breakdown of total expenditures into particular spending categories, which is needed for the estimation of the multiplier impacts of visitor expenditures in the local and regional economies (see next section).

Total estimated visitor expenditures in 2003 were highest for Death Valley National Park ($70 million), followed by Joshua Tree National Park ($47.5 million) and Mojave National Preserve ($27.4 million) (see Table 8). We regard the sum of these three values, $144.9 million, as an upper-bound estimate of total direct local spending by visitors to the two National Parks and the

[27] The surveys also report visitors' expenditures *inside* and *outside* each park or preserve. The total of these two expenditure categories is larger than the expenditures *in and around* the park or preserve, because outside expenditures include spending that occurred beyond the 50 mile boundary.

Preserve. This estimate is likely to represent an upper bound because summing of expenditures by visitors to the two Parks and the Preserve may result in some double-counting. Although visitors were asked to list their expenditures associated with their visit to a particular Park or Preserve within a 50 mile radius of the Park or Preserve, the close proximity of Mojave National Preserve to both Death Valley National Park (30 miles) and Joshua Tree National Park (45 miles) may have resulted in some of those visitors to Mojave National Preserve who also visited Death Valley National Park or Joshua Tree National Park assigning part of their out-of-Park/Preserve expenditures to both the Preserve and the Park(s). In 2003, 28 percent of the surveyed visitors to Mojave National Preserve stated that they also visited, or planned to visit, Joshua Tree National Park during their trip, while 17 percent stated that they also visited, or planned to visit, Death Valley National Park (Le *et al.*, 2004a). Double-counting would be expected to be limited to those expenditures that occurred roughly equidistant from the Preserve and the respective Park, that is, to only a part of total expenditures. No information on the size of those expenditures is available. We can construct an estimate of visitors' expenditures outside the Preserve but within a 50 mile radius by subtracting estimates of expenditures in the Preserve (an average of $21 per person) from the expenditures in and around the Preserve ($77 per-capita on average). If one were to assume that all visitors to Mojave National Preserve who also visited Death Valley or Joshua Tree National Park assigned their expenditures around the Preserve to both the Preserve and the Park(s), a maximum of 45 percent of all Preserve visitors could have assigned up to a maximum of $56 on average to both the Preserve and the Park(s). Hence, the maximum overestimate of expenditures of visitors to NPS lands in the Mojave in 2003 could be as large as $8.96 million, resulting in a revised estimate of total visitor expenditures on NPS lands of $135.9 million. However, it is important to note that overestimation of expenditures would only result if we assume that those visitors to Mojave National Preserve who on their trip also visited another Park attributed some of their expenditures around the Preserve to *both* the Preserve and the Park(s), leading to these expenditures being registered in the visitor surveys of both the Preserve and the Park(s). By contrast, instances of simple misattribution of visitors' expenditures in Death Valley or Joshua Tree NP to Mojave National Preserve would not lead to overestimation of total visitor expenditures on NPS lands in the study area. Rather, such misattribution to Mojave National Preserve would result in the *underestimation* of total visitor expenditures on NPS lands, because visitation of the Preserve is substantially lower than for either one of the National Parks (see Table 8).

A large volume of recreation activities in the Mojave takes place on BLM lands. In fact, as shown in Table 6, the volume of recreation visitor days on BLM lands in our study area is two and a half times that on NPS lands. While no information is available on the overlap between visitors to NPS lands and BLM lands, by counting visitor days instead of visitation we avoid double-counting of recreation activities and expenditures between NPS and BLM lands.

As shown in Table 9, recreation practiced on BLM lands spans a wide range of activities. The local per-capita expenditures associated with these activities are likely to vary. The per-capita expenditures on BLM lands also are likely to be different, in composition and level, from expenditures in the National Parks and Preserve in the area. Although little information is available on the place of origin of recreation visitors of BLM lands, it is likely that area residents (*i.e.*, southern California residents) make up a larger share of total visitation of BLM lands than they do for the National Parks and Preserve. One reason for this is that the National Parks and

Table 9: Recreation visitor days on BLM lands in the Mojave, FY2004

Activity		*Barstow*	*Needles*	*Ridgecrest*
Archery	(w)	-	255	-
Backpacking	(w)	79	1,354	80,072
Bicycling-Mountain	(w)	3,365	56	10,353
Camping	(w)	752,582	28,993	385,432
Climbing-Mountain/Rock	(w)	7	-	7,900
Driving for Pleasure	(ohv)	10,418	14,016	28,098
Env. Education	(w)	193	846	327
Gather non-commercial products	(w)	-	-	67
Geocaching	(w)	-	964	-
Hangliding/Parasailing	(ohv)	498	226	-
Highspeed Time trials	(ohv)	141	-	-
Hiking/walking/running	(w)	5,981	3,854	107,360
Horseback riding	(w)	3,103	147	20,301
Hunting-Big game	(h)	-	3,384	9,784
Hunting-Small game	(h)	4,293	169	-
Hunting-Upland bird	(h)	7,370	1,128	42,544
Interpretive programs	(w)	30	-	-
Land/Sand sailing	(ohv)	2,676	7,952	-
Model Airplane/Rocket	(ohv)	498	-	-
Nature study	(w)	1,775	787	13,174
OHV-ATV	(ohv)	88,094	11,050	56,581
OHV-Cars/trucks/SUVs	(ohv)	83,768	5,978	56,765
OHV-Dunebuggy	(ohv)	12,328	4,850	21,415
OHV-Motorcycle	(ohv)	71,861	2,256	135,441
Other Motor Land Sport Event	(ohv)	415	-	-
Photography	(w)	4,451	141	9,610
Picnicking	(ohv)	13,944	3,384	1,742
Racing-Auto track	(ohv)	117	-	-
Racing-Motorcycle	(ohv)	3,901	-	-
Racing-OHV Cars/Trucks/Buggies	(ohv)	-	-	501
Re-enactment Events/Tours	(ohv)	18	-	-
Rock Crawling 4WD	(ohv)	240	-	-
Rockhounding/Mineral collection	(w)	8,795	13,628	8,176
Social gathering/Festival/Concert	(ohv)	12,743	6,769	3,757
Specialized Sport/Event (Non-Motor)	(ohv)	8,474	-	74
Spectator Sport	(ohv)	13,394	-	1,002
Staging/Comfort stop	(ohv)	55	924	-
Target practice	(ohv)	6,428	28	6,957
Trapping	(ohv)	977	113	-
Trials-Motorcycle	(ohv)	121	-	-
Viewing-Cultural sites	(w)	324	5,641	14,092
Viewing-Interpretive Exhibit	(w)	1,100	81	513
Viewing-Other	(w)	4,317	162	16,849
Viewing-Scenery/Landscape	(w)	7	-	1,600
Viewing - Wild horses	(w)	-	-	1,278
Viewing-Wildlife	(w)	13,556	353	4,892
Wind surfing	(ohv)	-	266	-
		1,142,437	119,755	1,046,657

Notes: w – wilderness compatible; ohv – Off-highway vehicle based; h – hunting.
Source: BLM, 2005.

Preserve in the Mojave are nationally well-known recreation sites and as such attract visitors from all across the U.S. and indeed the world.[28] In addition, the Parks and Preserve charge visitor fees that drive up the private cost of recreation on these lands compared to BLM lands. Area residents engaging in recreation activities are likely to spend less on food and lodging in the vicinity than visitors from outside of the area. Hence, the average per-capita trip expenditures of visitors of BLM lands are likely to be lower than those of visitors of NPS lands.

In the absence of specific expenditure data for activities on BLM lands, and given the substantial share of BLM lands in the study area designated as wilderness (Table 7), it may be useful to group recreation on BLM lands into wilderness and non-wilderness activities. This grouping is justified because the composition and level of expenditures associated with undeveloped recreation (wilderness) are likely to differ from those characterizing developed recreation. It is also convenient because several studies are available that provide information on trip expenditures by wilderness visitors. We distinguish recreation activities on BLM lands into those primarily associated with wilderness and those not primarily associated with wilderness, based on a rough assessment of their compatibility with wilderness area regulations. We further distinguish activities not primarily associated with wilderness recreation into hunting and OHV based (see Table 9).

Our estimates of average trip expenditures of BLM wilderness recreation visitors are based on a study by Rudzitis and Johnson (2000), who report recreation expenditures on selected Western wilderness lands. We use their average expenditure of wilderness visitors of $40.17 (in 2003 dollars) as our estimate of average trip expenditures per day of wilderness visitors to BLM lands in the Mojave. Richardson (2004) provides a detailed breakdown of these expenditures into different categories (Table 10). Total trip expenditures for wilderness compatible recreation activities in the Mojave are estimated at $61.8 million in 2003.

Table 10: Average trip expenditures of wilderness visitors by category

Expenditure category	*Average expenditure per person day, 2003$*
Gasoline	8.37
Food: Groceries	8.39
Food: Restaurant	6.90
Lodging and campground	6.58
Automobile rental	1.58
License fees/admission/permits	1.16
Recreation equipment/ outfitter/guide	1.62
Other retail purchases	5.58
TOTAL	40.17

Source: Richardson, 2004.

Our estimates of the average trip expenditures associated with motorized activities such as OHVs, dune buggies, and ATVs are based on a study by the California Department of Parks and

[28] In 1996, 69 percent of all visitors to Death Valley National Park were from outside of the U.S., with only seven percent of visitors being from California (Littlejohn, 1997). Sixty percent of total visitors to the Mojave National Preserve were from California, while five percent were international (Le *et al.*, 2004a). In Joshua Tree National Park, 70 percent were from California and eight percent were international (Le *et al.*, 2004b).

Recreation (1994), which contains OHV trip expenditure data for the Los Angeles region. Based on information on total trip expenditures, party size, and trip length, we estimate average per-capita expenditures of $27 per OHV recreation day (Table 11). This estimate is reasonably similar to the average per-capita OHV recreation trip expenditure of $19 reported by Silberman (2003) for Arizona's Mohave County (Table 12).

Table 11: Average expenditures of OHV recreationists, Los Angeles area, CA

Expenditure category	*2003$ per OHV trip*
Overnight lodging	43.28
Groceries, Food, and Drinks	305.04
First Aid supplies/medical	22.44
OHV activity equipment, supplies, and services	246.75
Other recreational related expenses	47.21
Other non-OHV travel expenses	221.08
TOTAL trip expenditures	885.80
Avg. group size per trip (*number of persons*)	9.73
Avg. trip length (*days*)	3.4
Avg. OHV trip expenditure per person per day	26.78

Source: California Department of Parks and Recreation, 1994.

Per-capita trip expenditures of participants in special motor sport events can be substantially higher than $27 per day. For example, English *et al.* (2002) report $100 to $200 in expenditures per participant in special OHV events in Tennessee and North Carolina for two to three day events, not including event fees.

Table 12: Average expenditures of OHV recreationists, Mohave County, AZ

Expenditure category	*2003$ per OHV day*
Fuel	21.29
Park, Parking fees	2.69
Lodging	5.04
Restaurants, Bars	11.46
Groceries, Liquor	15.93
Entertainment	4.83
Souvenirs, T-shirts, Shopping	2.91
Avg. trip expenditure per OHV day	64.14
Avg. group size per OHV trip (*number of persons*)	3.32
Avg. OHV trip expenditure per person per day	19.33

Sources: Silberman, 2003; Arizona State Parks, 2004.

However, because of the small number of participants in the BLM category "other land sport motorized events", we use the same estimate ($27 per capita) for trip expenditures associated with participation in such events on BLM lands (see Table 9). Total trip expenditures of OHV-related recreation in the Mojave in 2003 are estimated at $18.8 million.

Information on average daily trip expenditures per capita by hunters in California for the type of hunting activity that occurs on BLM lands in our study area is provided by the National Survey of Hunting, Fishing, and Wildlife related Recreation (U.S. FWS and U.S. Census Bureau, 2003). Using their expenditure estimates (Table 13), we estimate total trip expenditures in 2003 by hunters in the Mojave at $4.3 million.

Table 13: Average expenditures of hunters in California, 2003

	All hunting	*Big game*	*Small game*	*Migratory bird*
Avg. trip expenditures per hunter/year		*2003$*		
Food	198.59	262.17 *	94.94 *	195.97 *
Lodging	37.23	49.16 *	17.80 *	36.74 *
Transportation	159.28	192.38	59.99	214.10
Other	206.86	152.04	23.79	565.76
Total expenditures on trips	601.96	655.75	172.73	1012.58
Avg. trip days per hunter/year	12.50	9.96	6.36	15.50
Avg. trip expenditure per day/hunter	$48.14	$ 65.83	$ 30.91	$ 65.35

Notes: "Other" expenditures include privilege and other fees. * Source only gives sum of expenditures on food and lodging. Sum is broken down here according to the food-lodging expenditure ratio observed for all hunting in California (see left column).
Source: U.S. FWS and U.S. Census Bureau, 2003.

This is likely to be an underestimate of total expenditures, as permits for bighorn sheep in the Mojave commonly auction for $60,000 or higher.[29] However, the number of desert bighorn hunting permits is low, with a current total of 17 tags allocated for the 2005-2006 season in the study area (California Department of Fish and Game, 2005).

Total expenditures associated with recreation activities in 2003 on BLM lands in the study area are estimated at $84.9 million.

To estimate the expenditures associated with recreation activities on State Park lands and private lands (Pipes Canyon Preserve and Desert Tortoise Natural Area), we convert camping and day use visitation numbers for the respective areas to visitor days, using the ratio of visitation to visitor days reported for camping (2.57) and hiking (0.2), respectively, on BLM lands in the Mojave (BLM, 2005). Per capita expenditures of visitors to California State Parks in 1999-2000 were $28.65 on average, or $64.34 per visitor day (see Table 14). For comparison, visitor surveys at Arizona state parks show that visitors are estimated to spend on average $57.73 per visit within 50 miles of the Park (Arizona Hospitality Research and Resource Center, 2002). In 2003, total expenditures of state park visitors in the Mojave, calculated as the product of visitor days and average expenditures of visitors per visitor day, are an estimated $7.98 million. This may be an underestimate to the extent that not all State Park visitors are captured in the visitation statistics.[30]

[29] Personal communication, Larry LaPré, chief biologist, BLM Desert District Office, March 21, 2005.
[30] For example, visitors who enter the parks after 5pm without signing in will not be counted, leading to undercount of recreation visits.

Table 14: Estimates of total attendance and visitor spending in the California State Park system

Total visitation, FY 1999-2000	73,470,149
Total visitor spending, FY 1999-2000 (*2003$*)	2,104,708,409
Spending per visit per person (*2003$*)	28.65
Spending per visitor day (*2003$*)	64.34

Sources: California Department of Parks and Recreation, Marketing Division, 2001; California Department of Parks and Recreation, 2003.

Due to their special character, we treat Pipes Canyon Preserve and the Desert Tortoise Natural Area as wilderness, assuming that average expenditures per visitor day are $40.17. In any case, their visitation numbers are so small (see Table 6) and average length of visits, with an estimated one hour for the DTNA (Connor and Hemingway, 2003) and two hours for the Pipes Canyon Preserve so short that average expenditures per visitor are estimated at a mere $6.69 for the Preserve and $3.35 for the DTNA.[31] Total visitor expenditures in 2003 associated with these two areas are an estimated $26,224 for the Preserve and $4,161 for the DTNA.

Summing over all lands in the study area, total trip expenditures by recreation visitors are estimated at $237.8 million in 2003 (Table 15). Of these, 61 percent are from visitation of the two National Parks and Mojave National Preserve, 36 percent from visitation on BLM lands, and three percent from visitation of State Parks.

Table 15: Total trip expenditures by recreationists in the Mojave, 2003

		All in 2003$		Total
NPS	*MNP*	*DVNP*	*JTNP*	
	27,384,805	69,996,939	47,503,183	144,884,928
BLM (*by field office*)	*Barstow*	*Needles*	*Ridgecrest*	
	41,598,763	4,149,887	39,182,907	84,931,558
State Parks				7,981,203
Private lands				30,385
Total				237,828,074

Notes: State Park lands are those listed in Table 6. Estimate of private lands visitation expenditures only includes Pipes Canyon Preserve and Desert Tortoise Natural Area.

To put this estimate in perspective, it is useful to compare our estimated expenditures for recreation activities in the Mojave with total direct travel spending in the counties in the Mojave Bioregion in which most of the recreation activities occur. Total direct travel spending in Inyo, Kern, Riverside, and San Bernardino counties in 2002 was estimated at over $8.5 billion (see Table 16).

[31] Information on the average length of visits to Pipes Canyon Preserve was provided by Frazier Haney (personal communication, April 11, 2005.

Table 16: Total direct travel spending in counties in California's Mojave desert, 2002

County	*Direct travel spending, million 2003$ **
Inyo	157
Kern	856
Riverside	4,756
San Bernardino	2,760
Total	8,529

Notes: *Excluding air transportation and travel services. Tulare and Mono counties are not included because the study area only includes marginal shares of those counties. Los Angeles County is excluded because it only includes a small portion of the Mojave desert and because travel expenditures in that county are dominated by activities not related to the Mojave.
Source: Dean Runyan Associates, 2004.

This comparison shows that recreation trip expenditures in the Mojave account for less than three percent of total direct travel spending in the four counties in which these recreation activities occur. Nevertheless, the importance of recreationists' expenditures for local communities can be substantial.[32]

It is important to note that our expenditure estimates do not include equipment purchases, except for those that were made during the trips. Hence, our estimates do not include purchases of camping or hunting gear, OHV equipment or vehicles, or any other expenditures associated with recreation in the Mojave. Such expenditures can be substantial and for some recreation activities may be larger than trip expenditures (California Department of Parks and Recreation, 1994, and U.S. FWS and U.S. Census Bureau, 2003).

The estimates shown in Table 15 represent the direct spending by recreationists during their visits in the Mojave. However, in order to develop an estimate of the total earnings that expenditures by recreationists generate, we need to include the indirect and induced effects that these trip expenditures produce in the regional economy.

Multiplier effects of recreation expenditures

The economic impact of recreationists' expenditures goes beyond the direct effects discussed above. As pointed out in the Introduction, expenditures by recreationists on lodging, food, gasoline and other goods and services ripple through the economy, generating indirect and induced effects.[33] For this reason, the total economic impact of recreationists' expenditures is

[32] For example, tourism generates an estimated $400,000 in transient occupancy tax and an estimated total income of around $8 million per year in Twentynine Palms. An estimated two-thirds of this is related to recreation, with the remainder related to visitation of the Twentynine Palms Marine Corps Base. Pers. comm. with Paul Smith, president of the Twentynine Palms Innkeepers Association, 22 March 2005.
[33] Indirect effects (on output, earnings, and employment) are caused by the increases in demand by the industries from which recreationists purchase goods and services, for goods and services supplied to these industries by other

larger than the direct expenditures themselves. Multiplier analysis is the tool economists use to estimate the size of this total impact that results from an initial impact, such as a given amount of purchases of goods and services by recreationists. Multiplier analysis utilizes quantitative information on the linkages between output, earnings, and employment of all sectors of a particular, spatially defined economy.[34] This information is derived through an examination, at a particular point in time, of the flows of goods and services between all sectors. It allows the calculation of coefficients for every industry that indicate by how much output (or earnings, or employment) in every other industry in the economy changes as a result of a $1 change in the output (or earnings, or employment) of that industry. These coefficients, or multipliers, can then be used to estimate the total impact in output, earnings, or employment that results from a given change in demand for a particular industry.

The size of the multiplier effect, and therewith the size of the total effect that results from a given change in output (or earnings, or employment) depends, in addition to the structure of demand and supply relationships between the various sectors, also on the extent of interrelationships between the economy in question and the rest of the world. The higher the dependence of the economy in question on inputs from the rest of the world, the more of the indirect and induced effects of an initial demand change will leak out of, or occur outside of, the economy under consideration. In general, therefore, the narrower the spatial boundary that is drawn around the economic region of analysis, the lower the capture rate by the local economy of the multiplier effects, and the smaller the total multiplier effect in that economy of an initial change in demand (Hughes, 2003). The primary focus of this analysis is on the benefits the Mojave provides to the region – in this particular case, the total economic impact of trip expenditures by recreationists in the Mojave. Therefore we use the Bureau of Economic Analysis's (BEA) Regional Input-Output Modeling System (RIMS II) 2003 multipliers for the BEA's Bakersfield-Riverside-San Bernardino Region for our estimation. This region comprises Inyo, Kern, Riverside, and San Bernardino Counties. In other words, our analysis estimates the total economic impact of recreationists' expenditures in the Mojave on the combined economies of these counties. It does not capture the direct and indirect effects Mojave recreationists' expenditures may have on the surrounding counties.

To derive total regional output and earnings associated with recreation expenditures in the Mojave, we first must adjust total spending by recreationists for the value of sales that does not accrue to the region, that is, for leakage. In general, services (lodging, restaurants, guiding and outfitting, etc.) are produced locally, so all spending by recreationists on services is captured locally. However, some goods (gas, some foodstuffs, etc.) may not be produced locally. In the case of goods not produced in the region, the region only captures the retail or wholesale margin, and potentially the transport margin, of the sales of that product. The remainder of the value of these sales (the producer price and perhaps the transport price) leaves the region and does not produce multiplier effects in the region.

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industries. Induced effects are caused by the increases in household income of households employed in the industries experiencing direct and indirect impacts. The increased household income leads to increased household expenditures, which in turn further increase output.

[34] Earnings are defined as the sum of wages and salaries, proprietors' income, directors' fees, and employer contributions for health insurance less personal contributions for social insurance (U.S. Department of Commerce, 1997).

Unfortunately, no capture rates are available for our four-county area. However, given the size and diversity of the region's economy, and given that capture rates increase with the size of area, it is likely that a substantial share of the products sold in the region are produced within the region. We assume that the capture rate for lodging, restaurants, and guiding and outfitting is 100 percent, and that for the remaining products and services purchased by recreationists it is 60 percent, except in the case of gas, where we assume a 20 percent capture rate. Based on these assumptions, our estimated overall capture rates are 78 percent for Mojave National Preserve, 84 percent for Death Valley National Park, and 82 percent for Joshua Tree National Park. For comparison, Stynes and Sun (2003), in their analysis of the effects of spending by NPS visitors on the area immediately surrounding the parks (50-mile boundary), estimate overall capture rates of 74 percent for the Preserve, and 82 percent for the two Parks.[35] Their capture rates are slightly lower, which is not surprising given that their spatial boundary of analysis is narrower.

After deriving the direct regional output effect in this way, we multiply effective regional output in the various expenditure categories by the respective RIMS II total output and earnings multipliers for the four-county area. This procedure is applied separately to NPS lands, wilderness-compatible activities, OHV activities, and hunting on BLM lands, and California State Parks, because the expenditures patterns on these lands or activities vary (see Tables 8, 10, 11, 13, and 17). No information was available on the composition of expenditures by visitors of California State Parks. We disaggregated the total expenditures per visit for California State Parks (Table 14) using the composition reported for Arizona State Parks instead (see Table 17).

Table 17: Expenditures of visitors to California State Parks

Expenditure category	*Estimated spending per visit, 2003$*
Expenditures in park	3.78
Entrance fees or permits	1.55
Shopping and gifts	4.83
Food and drink	6.95
Tourist services (museums, tours)	0.87
Gas and Transport. Services	4.78
Lodging (hotels, camping)	4.88
Other	1.02
TOTAL per visitor	28.65

Notes: Values derived by applying the composition of expenditures in Arizona State Parks (Arizona Hospitality Research and Resource Center, 2002) to the total expenditures per visit reported for California State Park visitors (Table 14).

Total expenditures in the Mojave by recreationists in 2003 are estimated at $238 million (Table 15). These expenditures translated into sales by businesses in the four-county region of an estimated $185 million (yielding an overall capture rate of 78 percent), which constitute the direct

[35] See "Visitor Spending and Economic Impacts for National Park Units", 2005, online at *http://www.prr.msu.edu/yayen/NPS/NPSSelect.cfm* . The impact estimates are generated using the new version of the National Park Service's Money Generation Model (MGM2) developed by Stynes and Propst at Michigan State University.

effect of the spending by recreationists. These sales in turn generated indirect and induced effects of $152 million, for a total regional output effect of $337 million (Table 18). In 2003, total regional earnings associated with spending by recreationists were $124 million.

Table 18: Total final regional output and earnings impacts of recreation expenditures in the Mojave, 2003

	Total Output			*Total Earnings*		
	generated by expenditures of visitors of:			*generated by expenditures of visitors of:*		
Expenditure category	*NPS lands*	*BLM lands*	*CA state parks*	*NPS lands*	*BLM lands*	*CA state parks*
	2003$	*2003$*	*2003$*	*2003$*	*2003$*	*2003$*
Accommodations	89,286,516	19,658,092	2,375,545	26,812,001	12,768,088	713,356
Food	79,993,845	49,149,636	3,678,865	20,780,794	6,876,052	955,695
Transportation	11,151,227	19,218,263	487,524	4,185,364	6,502,882	182,981
Other	35,006,134	21,471,732	5,852,793	10,519,524	32,050,185	1,792,389
Total	215,437,722	109,497,722	12,394,727	62,297,683	58,197,207	3,644,422
	Total Output			*Total Earnings*		
	337.3 million			124.1 million		

Notes: Accommodations includes hotels, motels, bed and breakfasts, and cabins. Food includes restaurants and groceries. Transportation includes gas and oil, automobile rental, and other transportation expenses. "Other" includes camping and guide fees and charges, admission and recreation fees, license and permit fees, recreation equipment, and other purchases (gifts etc.).

Our estimate of the total output effect of NPS visitation spending in the Mojave is almost twice as high as that developed by Stynes and Sun.[36] There are several reasons for this difference. Our impact accounting boundary is wider, in order to capture the effects of recreation in the Mojave on the four-county economy. By contrast, Stynes and Sun estimate the local impacts within in the vicinity of the Parks. As already discussed, the wider the economic boundary setting, the higher the capture rate (and conversely, the smaller the leakage) of recreationists' expenditures, resulting in less of the initial expenditures being absorbed by the local economy. In addition, a narrower boundary setting produces a smaller local multiplier impact, as more of the multiplier impact accrues to outside of the area. Finally, Stynes and Sun's visitor spending estimate for the Mojave National Preserve is based on an assumed spending per-party day of $25 which, is much lower than their estimate for the two National Parks in the Mojave of $80 and $74, respectively, per party day, and appears inconsistent with data provided in Let *et al.* (2004) (see Table 8). This results in their estimate of total effects in the Preserve vicinity of $7 million, versus $61 million and $44 million, respectively, for the two Parks.

Our impact estimates are based on trip expenditures, which exclude most equipment purchases. In addition, our expenditure estimates for NPS visitors only count trip expenditures made in a 50-mile radius of the three NPS units. Therefore, our impact estimates may understate the total output effect on the four-county area of spending by Mojave recreationists.

[36] Stynes and Sun estimate a total effect of by spending NPS visitors of $111 million in 2003, versus our estimate of $215 million (Table 18).

Consumer surplus of recreationists

As discussed in the Introduction, recreationists' consumer surplus (CS), the part of WTP that exceeds their trip expenditures, is not captured in the market value estimates developed in the preceding section. This CS must therefore be added to trip expenditures to arrive at an estimate of the total economic value of recreation in the Mojave.

The published literature contains a number of studies that report CS for a variety of recreation activities practiced in the Mojave. However, many of the values reported in those studies were not estimated specifically for the Mojave. In Table 19 we present three sets of estimates of recreationists' average per-capita CS for selected recreation activities. The first two are taken from Rosenberger and Loomis (2000), who conducted a comprehensive review of recreation studies estimating CS that had been carried out between 1967 and 1998. Column three in Table 19 shows the average per-capita CS values for specific recreation activities in the U.S. reported in Rosenberger and Loomis. The authors also conduct a meta-analysis of the CS reported in the original studies in order to test the statistical significance of 47 methodology and site variables on recreation CS. They then use their regression model to generate forecasted average per-capita CS for recreation activities in specific regions in the U.S. The results of this analysis are shown in the fourth column of Table 19.

Table 19: Estimates of Consumer Surplus (CS) of non-motorized recreation activities per activity day per person

	Rosenberger and Loomis (2000)			*McCollum et al. (1990)*
Source of estimate:	*Avg. of studies,*		*Meta-Analysis,*	*Avg. of study,*
Area of estimate:	*U.S.*		*FS R5 and R6*	*FS R3*
	Number of estimates	*Avg. CS, 2003$*	*Avg. CS, 2003$*	*Avg. CS, 2003$*
Camping	40	34.21	27.64	20.25
Picnicking	12	39.73	27.64	17.49
Hiking	29	41.27	27.64	33.84
Biking	5	50.87	11.51	-
Big game hunting	177	48.64	44.98	16.28
Small game hunting	19	40.22	27.64	-
Wildlife viewing	157	34.56	27.64	14.87
Horseback riding	1	17.01	27.64	-
Rock climbing	4	59.67	97.53	-
General recreation	31	27.33	27.64	10.25
Sightseeing	-	-	-	22.71

Notes: Forest Service (FS) Regions comprise the following states: Region 3 - AZ and NM; Region 5 - HI and CA; Region 6 - WA and OR. All CS values are per recreation visitor day. Several of the recreation activities in Rosenberger and Loomis' (2000) meta-analysis model have the same CS. This is due to the fact that statistically no variability in CS was discovered across these activities.
Sources: Rosenberger and Loomis, 2000; McCollum *et al.*, 1990.

Several of the forecasted CS values are the same for different recreation activities. This is due to the fact that Rosenberger and Loomis could not statistically discover any variability in CS across these activities.[37] The third set of CS estimates reported in Table 19 is taken from McCollum *et al.* (1990) who report CS values for several recreation activities on Forest Service lands for particular regions. Column five in Table 19 presents their estimates for selected activities for Forest Service Region 3 (Arizona and New Mexico).

These literature estimates potentially can serve as sources for valid benefit transfers, thereby allowing us to estimate CS for recreation activities in the Mojave. As with any benefit transfer, however, the confidence in the results is a function of the similarity between the characteristics of the source study and those of the policy site to which the study values are transferred. For this reason, we chose the per-capita recreation CS values reported in McCollum *et al.* (1990) for the Southwest (AZ and NM) as the source for our benefit transfer. These values seem more appropriate than the average national CS values reported in Rosenberger and Loomis (2000) or the meta-analysis based CS values for Forest Service Regions 5 and 6 reported by the same authors, because generally the physical characteristics found in the Mojave are more similar to those of the U.S. Southwest than they are to those characterizing Forest Service Regions 5 or 6, or to those in most of the U.S. For those activities for which no CS values are reported in McCollum *et al.* (1990), we use the meta-analysis based values reported in Rosenberger and Loomis (2000) as the basis for our estimates for the Mojave. For OHV activities, we use average CS values reported for OHV recreationists in Arizona (Table 20).

Table 20: Estimated Consumer Surplus (CS) of OHV recreationists in Arizona

Vehicle Type	*CS per OHV Trip*	*CS per OHV Day*
	2003$	
All-terrain vehicle	106.20	51.36
4-Wheel Drive Truck	89.42	46.81
Sport Utility Vehicle	82.10	49.26
Motorcycle or Dune Buggy	120.38	56.75
Pooled sample, all vehicles	90.81	51.05

Note: The CS of OHV recreation users is the amount a user would be willing to pay above and beyond her expenditures on the OHV activity.
Source: Arizona State Parks, 2004 (Appendix).

The calculation of the estimated total CS for recreation activities practiced at a specific location or on land under particular ownership (NPS, BLM, etc.) is straightforward. The CS for a particular recreation activity i at the location (CS_i) during a set period (*e.g.*, a year) is derived as the average CS associated with that particular recreation activity per visitor day (12 hours), multiplied by the number of visitor days spent on that activity (V-Days_i):

$$CS_i = CS_{i,\text{ V-Day}} * \text{V-Days}_i . \qquad (1)$$

Summing over all recreation activities $i = 1,...., n$ practiced at the site, one obtains an estimate of the total consumer surplus (CS_T) at the site:

[37] In other words, the coefficients of these activities as estimated through the meta-analysis were found not to be statistically significant (at $p < 0.05$ or higher).

$$CS_T = \sum_{i=1}^{n} CS_i \; . \tag{2}$$

For the majority of the recreation activities practiced in the Mojave (see Table 9), no CS estimates are available. We do not include the CS associated with those activities in our estimate. This imparts a conservative bias to our estimates. For example, the CS estimates in Tables 19 and 20 cover only 16 out of the 47 recreation activities reported for BLM lands. On the other hand, only 16 percent of total visitor days on BLM lands are associated with activities not listed in Tables 19 and 20. Adding to the downward bias in our estimates is the fact that the CS of recreation in wilderness areas, which account for a substantial share of the study area, may be substantially higher than the values presented in Table 19. For example, Lutz *et al.* (2000) estimate the per-trip CS for overnight backcountry recreational hiking opportunities in wilderness areas in the Inyo and Lassen National Forest areas in the Sierra Nevada mountains in northern California at $70 to $181 (depending on the site), with an aggregate average of $154 (all 2003$). Finally, the fact that our CS estimates for OHV recreation are based on values for Arizona likely leads to a downward bias in these estimates, given that income is a primary driver of WTP and that average household income is higher (13 percent in 1999) in California than in Arizona.

For NPS lands, no information is available on the amount of visitor days by recreation activity. What is available from the visitor surveys, however, are the percentages of visitors who engage in various activities. Table 21 shows the most popular recreation activities for Death Valley and Joshua Tree National Parks and for Mojave National Preserve, with the percentage of visitors who engage in each of these activities.

Table 21: Activities of visitors to NPS lands in the Mojave desert

Death Valley National Park		*Joshua Tree National Park*		*Mojave National Preserve*	
Activity	*%*	*Activity*	*%*	*Activity*	*%*
Sightseeing	96%	Sightseeing	83%	Sightseeing	73%
Photography	92%	Visiting visitor center(s)	58%	Driving paved roads	64%
Hiking (<2 hrs)	42%	Day hiking	56%	Driving unpaved roads	43%
Visit mining ruins	37%	Walking nature trails	55%	Day hiking	28%
Visit Scotty's Castle	29%	Camping	36%	Nature study	27%
Drive unpaved road	26%	Bouldering	33%	Visit mine ruins/hist. sites	18%
Star gaze	18%	Stargaze/view night sky	29%	Camping-along roadside	17%
Tour Scotty's Castle	18%	Visit hist./ archeol. sites	22%	Camping-developed campgr.	15%
Tent camping	9%	Technical climbing	10%	Hunting	14%

Notes: Percentages do not add up to 100 because visitors could participate in more than one activity.
Sources: Littlejohn, 1997; Le *et al.*, 2004a and 2004b.

Given that the average length of time that visitors engage in these activities varies across the activities, and that information on this time is not available, the percentages of participants cannot be translated into visitor days. One way to get around this problem is to choose the average CS value for the most popular activities in each Park or Preserve.

Unfortunately, for some of the most popular activities in the NPS units in our study area no CS estimates are available. Examples are photography, visits to historic sites or mining ruins, and driving on paved roads. For this reason, we choose a different approach to estimating the CS of visitors to NPS land. Sightseeing is the most popular activity in all three NPS units, with between 73 percent (Mojave National Preserve) and 98 percent (Death Valley National Park) of all visitors engaging in sightseeing. It is also likely to occupy a substantial share of visitors total time spent in each unit.

Furthermore, the CS value associated with sightseeing that is reported in the literature lies between those reported for other time-intensive activities popular in the three units (see last column in Table 19). For example, the CS of hiking ($33.84) and camping ($20.25), both activities popular in Death Valley, are substantially higher and slightly lower, respectively, than that of sightseeing ($22.71). Hiking is even more popular in Joshua Tree National Park, where bouldering and technical climbing are also very popular. The CS value reported in the literature for rock climbing in the Southwest, $97.53, is much higher than that of sightseeing. Therefore, we choose the CV value of sightseeing as the average CV value at which we assess all recreation activities in the three NPS units. Since the sightseeing CS value we use was derived for Forest Service lands, one could probably conservatively assume that this value is likely to understate the sightseeing value on NPS lands, given the special standing that national parks have as recreation areas. Assuming a CS value of $22.71 for the average visitor day on NPS lands in the Mojave, total CS in 2003 is estimated at $12.7 million for Death Valley National Park, $17.3 million for Joshua Tree National Park, and $7.1 million for Mojave National Preserve. The sum of the three totals is equal to 26 percent of the estimated trip expenditures for visits to NPS lands.

On BLM lands, information is available on estimated total visitor days by recreation activity (Table 9). This allows the application of benefits transfer for individual recreation activities, and the use of the average per-capita CS estimates per recreation day reported by McCollum *et al.* (1990), Rosenberger and Loomis (2000), and Arizona State Parks (2004), as described above. Total CS of recreation activities on BLM lands in 2003 is estimated at $59.7 million, with the largest shares attributable to camping (40 percent) and various OHV activities (50 percent) (Table 22). On BLM lands, estimated total CS is equivalent to 70 percent of trip expenditures. The reasons this share is over twice as high as it is on NPS lands are the comparatively high CS values associated with OHV activities (compare CS values in Table 20 to those in Table 19) and the high volume of OHV-related activities in total recreation visitor days on BLM lands.

To estimate total CS associated with recreation in the State Parks in the Mojave, we apply McCollum *et al.*'s (1990) CS values to the primary activities practiced in the particular parks (wildlife viewing, hiking, and camping, except for the Antelope Valley California Poppy Preserve, in which there is no camping). Total CS in 2003 of recreation in those Park lands is estimated at $3.1 million.

Finally, our CS estimates for the two private lands included in the analysis are based on McCollum *et al.*'s CS values (wildlife viewing for the Desert Tortoise Natural Area), and Rosenberger and Loomis meta-analysis values for day hiking and horseback riding (Pipes Canyon Preserve). Due to the comparatively low level of visitor days, total CS of recreationists at these two sites in 2003 is estimated at $24,000.

Total CS of recreation on all lands in the Mojave examined in this study is estimated at $100 million in 2003 (Table 22), equivalent to 42 percent of total trip expenditures.

Table 22: Estimated total Consumer Surplus of selected recreation activities in the Mojave, by type of land ownership, in 2003

Land ownership		*CS, 2003$*			*Total*
NPS lands	*(by Park Unit)*	*DVNP*	*JTNP*	*MNP*	
		12,662,972	17,274,348	7,104,243	37,041,563
BLM lands	*(by Field Office)*	*Barstow*	*Needles*	*Ridgecrest*	
Camping		15,238,828	587,071	7,804,508	
Picnicking		243,818	59,171	30,460	
Hiking		202,409	130,427	3,633,274	
Biking		38,748	645	119,213	
Big game hunting		-	55,099	159,305	
Small game hunting		118,650	4,671	-	
Wildlife viewing		201,589	5,249	91,753	
Horseback riding		85,761	4,063	561,078	
Rock climbing		683	-	770,465	
OHV-ATV		4,524,508	567,528	2,906,000	
OHV-Cars/trucks/SUVs		4,126,412	294,476	2,796,244	
OHV-Dunebuggy		699,614	275,238	1,215,301	
OHV-Motorcycle		4,078,112	128,028	7,686,277	
Racing-Motorcycle		221,382	-	-	
Racing-OHV Cars/Trucks/Buggies		-	23,452	23,452	
Rock Crawling 4WD		11,822	-	-	
		29,792,334	2,135,118	27,797,329	59,724,781
State Parks				3,074,877	3,074,877
Private Lands				23,634	23,634
Total					99,864,855

Notes: Estimates for NPS lands are based on CS values for sightseeing reported in McCollum *et al.* (1990). Estimates for BLM lands are based on CS values reported by McCollum *et al.* (1990) except for activities not reported by those authors, for which CV values are based on Rosenberger and Loomis's (2000) meta-analysis CV estimates for FS Regions 5 and 6 (see Table 19), and on CS for OHV activities (see Table 20). CS estimates for State Parks and Private lands are derived using CS values from McCollum *et al.* (1990) for the primary uses of those parks and private areas listed in Table 6.

Pass-through "passive" recreation value of roadside scenic beauty

A large number of people travel through the Mojave each year for purposes other than engaging in recreation activities in the desert. As discussed in the introduction, a large share of the traffic volume through the Mojave is associated with recreation activities to the north of the desert (Mammoth Lakes, Inyo National Forest) or in Nevada (predominantly Las Vegas), as well as with travel for other purposes. In 2003 a total of almost 22 million vehicles crossed the state line to or from Nevada or Arizona or traveled north in the State on US 395 (see Figure 8).

Individuals passing through the Mojave on their way to other destinations cannot be counted as recreation visitors in the common sense, as they do not participate in recreation activities in the desert. Nevertheless, these individuals may value the scenic beauty and uniqueness of the landscape, engaging in the process of their travel in what may be described as "passive recreation" in the form of the use of visual amenities. The latter represents a direct use of the Mojave that carries an associated direct use value. In addition, some of these individuals may also attach existence and intrinsic values to the ecosystems and landscapes. The existence of the amenity benefits that travelers receive from the scenic beauty of the roadside is the central idea that inspired the creation of the National and State Scenic Byways Programs. Given the large number of individuals passing through the desert, the scenic amenity value is likely to be substantial.

Unfortunately, no study has been carried out to date that attempts to quantify scenic benefits to travelers of desert landscapes. Nevertheless, the potential magnitude of those values may be gauged by drawing on studies of the value of scenic beauty in other environments.

For example, a recent survey of users of North Carolina's Blue Ridge Parkway revealed that travelers' willingness to accept (WTA) a decline in roadside scenic quality was on average $519 annually (cash value) (Mathews *et al.*, 2005). Respondents also indicated that they were willing to pay (WTP) on average $151 per person per year to preserve the scenic quality of the northern North Carolina section of the Parkway.[38] [39] Of course, the difference in the valuation context, principally, the nature of the visual character of the landscape due to differences in vegetation, makes the North Carolina results inappropriate for transfer to the Mojave Desert. Nevertheless, if we assumed for hypothetical purposes that the average value transit travelers attach to the scenic beauty of the Mojave were only 1/10 that expressed by travelers on the Blue Ridge Parkway for preserving the scenic quality of the Parkway, or $15.1 per person per year, and if we assumed conservatively that the average occupancy of vehicles in the Mojave is only one person per car, and that those persons on average travel through the Mojave 10 times per year, the total "passive recreation" value associated with the traffic at only the four northern and eastern entrance/exit points of the Mojave shown in Figure 8 (21.8 million vehicles in 2003) would be $32.9 million per year. Doubling the occupancy rate and halving the number of times the average traveler crosses the Mojave would result in a four-times as large number of individuals passing through the desert and would quadruple that estimate to $131.6 million per year. By comparison, the total scenic value to North Carolina Parkway users, expressed as WTP to preserve the scenic quality of the North Carolina section of the Blue Ridge Parkway, is estimated at 350 million dollars per year (Mathews *et al.*, 2003:28). Especially the lower of the two estimates of the value of the Mojave's scenic beauty to passers-through likely is very conservative, because only part of the traffic is counted, and because an unrealistically low vehicle occupancy is assumed. Most importantly, however, the WTP elicited from respondents traveling on the Blue Ridge Parkway was for the prevention of a *reduction* in scenic roadside beauty, that is, a discrete (negative) change in visual amenities. It was not their WTP for preventing a *total loss* of the scenic roadside beauty, and hence it not a measure of the total value they attach to the visual amenity. The latter value, by

[38] By comparison, this amount, $151, represents only 0.25 percent of the respondents' average annual income (Mathews *et al.*, 2005).

[39] These results are consistent with the literature, which shows that for pubic goods (such as scenic views) WTA often is significantly larger than WTP, the difference between the two being a function of the substitutability (or lack thereof) between the public good and market goods, fear of non-reversibility of the action in question (the so-called commitment cost, a quasi option value), and the endowment effect (Hanemann, 1991; Kahnemann *et al.*, 1990; Shogren *et al.*, 1994; Zhao and Kling, 2004).

definition, is larger, and likely substantially so. By extension, our hypothetical WTP of Mojave travelers also represents only a fraction of the total value of visual amenities. Nevertheless, the lack of comparability between the Blue Ridge Parkway and the Mojave makes these estimates too unreliable for inclusion in our analysis. In other words, we cannot know whether our estimates are approximately correct, whether they are substantially lower, or whether they are substantially higher than the actual value. Nevertheless, this example should make clear the potentially large benefits, and hence economic value, that accrue to people passing through the Mojave.

Total recreation value of the Mojave

The sum of people's expenditures in 2003 on recreation in the Mojave and of their consumer surplus from recreation (that is, the additional amount they would have been willing to spend on that recreation beyond what they actually did spend) reveals the total value of recreation activities in the Mojave. Going back to our conceptual diagram of total economic value (Figure 1), the sum of expenditures and consumer surplus equals the total area under the demand curve, or areas CS, PS, and PC. In 2003, this total benefit is estimated at $338 million. Of these, $238 million were captured in market transactions involving products purchased by Mojave recreationists. The *net* benefit to recreationists of their activities in the Mojave is the difference between the value they received (the sum of areas CS, PS, and PC) from recreation activities and what they spent on these activities – the consumer surplus (CS). In 2003, the consumer surplus from recreation activities in the Mojave totaled an estimated $100 million. Finally, recreationists' expenditures on Mojave trips (the sum of areas PS and PC in Figure 1) generate earnings in the industries that directly or indirectly provide goods and services to recreationists.[40] These earnings are a proxy for the producer surplus, that is, for the net benefit of recreation activities to the recreation industry and industries interrelated with the latter.[41] Total earnings resulting from spending by recreationists on Mojave trips were estimated at $124 million in 2003. Total net benefit of recreation activities in the Mojave is the sum of the net benefit (the consumer surplus) received by recreationists and the net benefit (producer surplus, as imperfectly measured by earnings) received by the industries whose products are bought by recreationists. This total net benefit to society is estimated at $224 million in 2003.

Table 23: Total value and net benefit of recreation activities in the Mojave, 2003

	Benefits	*Net benefits*
	million 2003$	
Trip expenditures of recreationists	237.8	
Consumer surplus of recreationists	99.9	99.9
Total value of recreation activities	*337.7*	*99.9*
Total regional economic output generated by recreationists' spending	337.3	
Total regional earnings from spending-related economic output	124.1	124.1
Total net benefit to society		224.0

Notes: Regional refers to the area comprising Kern, Inyo, Riverside, and San Bernardino Counties.
Sources: Tables 15, 18, 22.

[40] The multiplier (*i.e.*, indirect and induced) output effect generated by the direct spending by recreationists are not shown in Figure 1, because these are not part of recreationists' expenditures.
[41] Recall that earnings include payments to capital and labor: wages, salaries, proprietors' income, and directors' fees.

The values and benefits shown in Table 23 are those that are associated with trip-related expenditures only. Recreation trips of course require equipment, which has its own associated expenditures. In the case of hunters in California, in 2001 average equipment expenditures were approximately equal to trip expenditures, while the average wildlife watcher spent twice as much on equipment as on trips (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2003). In the following, we consider only the economic impact of OHV equipment expenditures. Given that non-highway OHVs such as dirt bikes, ATVs, and dune buggies are less easy to transport than equipment associated with non-motorized recreation activities (wildlife watching, fishing, hunting), OHVs owned in the region are more likely to be primarily used in the region compared to other recreation equipment, so the expenditures associated with regionally registered OHVs can more justifiably be attributed to the Mojave than may be the case for other recreation equipment. Undoubtedly, however, there are many users who use their non-motorized recreation equipment primarily in the Mojave. By not including the economic impact associated with that equipment, we introduce a downward bias in our estimate of the economic impact of recreation in the region.

As of April 2006, a total of almost one million OHVs were registered in California. Of the ten counties with the most registered OHVs, eight are located in the southern part of the state, and counties within 75 miles of the Mojave accounted for 57 percent of all OHVs registered in the state (see Table 24).

Table 24: Number of OHVs registered in California, April 2006

California, total	993,920
Southern California counties:	
1) LA County	141,809
2) San Diego	103,471
3) Riverside	96,427
4) San Bernardino	88,837
5) Orange	70,634
6) Kern	32,135
7) Sacramento	29,154
8) Ventura	29,010
9) Santa Clara	23,187
10) Fresno	21,911

Source: Personal communication, Bill Jeffreys, business developer, Kern Economic Development Corporation, June 9, 2006.

According to the last statewide OHV user survey (California Department of Parks and Recreation, 1994), mean annual OHV related expenditures in California were $4,306 (in 2003$) per OHV owner, or $3,660 if trip expenditures are excluded (we already account for trip expenditures separately in our analysis). Based on the total number of registered OHVs and average OHV-related expenditures, total OHV expenditures, excluding trip expenditures, in the two counties were an estimated $443 million in 2006.[42] Using information on the composition of

[42] This assumes that the average real price of OHVs and related expenditure items has remained unchanged from 1992 levels.

OHV related expenditures (Table 25) and the RIMS II final demand output and earnings multipliers for the respective industries in our study area, total final regional demand and earnings from OHV related expenditures can be estimated (see Table 26).

Table 25: OHV-related expenditure breakdown, California (1992)

Expenditure category	*Share of total OHV related expenditures*
OHV purchases	38 %
Equipment and accessories	17 %
Operation (fuel, parts, repairs)	12 %
Misc. equipment (photo, hiking, fishing etc.)	7 %
Services (insurance)	6 %
Government (licenses, checks, permits)	4 %
Miscellaneous	1 %
Trip expenditures	15 %

Source: California Department of Parks and Recreation (1994).

Table 26: Estimates of OHV-related expenditures in Kern and San Bernardino counties, and associated total economic impact and earnings

Expenditure category	*Total direct expenditures 2003$*	*Final demand multipliers Output*	*Final demand multipliers Earnings*	*Final demand - Output 2003$*	*Final demand- Earnings 2003$*
OHV purchases	197,962,305	1.89	0.43	374,148,756	85,103,995
Equipment and accessories	88,562,084	1.87	0.46	165,735,083	40,906,826
Operation (fuel, parts, repairs)	62,514,412	1.83	0.69	114,476,391	42,966,155
Misc. equipment (photo, hiking, fishing etc.)	36,466,740	1.83	0.46	66,792,482	16,785,641
Services (insurance)	31,257,206	1.74	0.47	54,231,252	14,640,875
Government (licenses, checks, permits)	20,838,137	1.94	0.55	40,526,010	11,394,294
Miscellaneous	5,209,534	1.94	0.55	10,131,502	2,848,573
	442,810,419			826,041,477	214,646,359

The results indicate that in 2006, total final demand generated by OHV related activities, excluding trip expenditures, was estimated at $826 million in Kern and San Bernardino counties combined, while total final earnings approached an estimated $215 million.

Given that OHV ownership has been on the rise over the past two decades, it is likely that impacts in 2003 (the base year for our analysis) were somewhat lower. On the other hand, the above estimates do not take into account the undoubtedly large impacts on equipment, parts, and repair sales in the region caused by visiting OHV recreationists from other southern California counties. We therefore regard our estimates of $826 million in total final output and $215 million in final earnings as reasonable estimates of the economic impact from OHV related equipment expenditures in the Mojave region.[43]

Obviously, given that the Mojave is home to several of the counties who experience the most OHV miles traveled in California (California Department of Parks and Recreation, 1994), the OHV use opportunities it provides likely support a share of OHV-related sales in surrounding counties. Hence, the total OHV-related economic impact of the desert on southern California as a whole is larger than the estimates derived for Kern and San Bernardino counties.

The sum of earnings and consumer surplus associated with OHV recreation can serve as an appropriate indicator of the net benefits of OHV recreation as long as OHV activities do not generate negative impacts. If they do cause such negative impacts, the costs associated with these impacts need to be subtracted from earnings and consumer surplus in order to derive OHV net benefits. Indeed, OHV activity in the Mojave has been found to contribute to both human health impacts and reduced visibility via particulate pollution emissions (Lovich and Bainbridge, 1999), and to negative impacts on several desert species, directly in the form of increased mortality or morbidity, or indirectly via destruction or modification of their habitat (BLM, 2003a). Habitat destruction is principally due to illegal use of OHVs off designated trails or outside of designated OHV areas, a practice in which according to an informal user survey 15-20 percent of users occasionally engage.[44] Given the large numbers of OHV users and the high number of miles traveled annually in the Mojave, negative habitat impacts may be substantial. For reasons of scope, however, the present study does not attempt to develop quantitative estimates of the costs of these negative OHV impacts. It should therefore be kept in mind that the omission of negative OHV impacts from the analysis is biasing our net benefit estimates of OHV related activities upward.

As discussed in the preceding sections, the value estimates do not capture the value associated with recreation activities on the lands not included in this analysis, and the value of some activities for which no monetary value estimates are available. These include state lands other than State Parks; municipal lands; and private lands other than the Desert Tortoise Natural Area and the Pipes Canyon Preserve.[45] In addition, there are some recreation activities on BLM lands for which no value estimates were available. These activities account for an estimated 16 percent of all recreation visitor days on BLM lands.

In addition, these value estimates generally do not capture those equipment purchases related to Mojave recreation that are made outside of the Mojave. In the case of recreation activities on the three NPS units in the Mojave, they even exclude purchases made in the Mojave that occurred outside a radius of 50 miles from those units. For these reasons, we expect our value estimates to be low estimates of the value of Mojave recreation.

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[43] To put our estimates in perspective, in 1992 the total statewide economic impact of OHV-related activities was estimated at \$3.0 billion in output and \$1.65 billion in personal income (California Department of Parks and Recreation, 1994) - equivalent to \$3.7 billion and \$2.0 billion, respectively, in 2003 dollars. Since then, however, OHV use has increased markedly; green sticker registrations have shown an increase of 108 percent since 1980, while the number of street-licensed OHVs has increased by 74 percent since 1994 (California State Parks, 2002).

[44] Personal communication with Jason Fried, California Wilderness Coalition, June 2006.

[45] These activities include for example all use of the OHV area in California City *etc.*, which appears to receive tens of thousands of recreation visitor days per year, but for which no reliable use data are available.

Finally, we briefly discuss a methodological reason why our recreation value estimates are likely to be underestimates of the real recreation value provided by the Mojave. In our estimates of the total WTP of recreation users, the non-market portion of the total value (the CS) was derived through benefit transfer of CS values for particular recreation activities reported in the literature. For example, the average CS value per person of one OHV day in the Mojave was assumed to be the same as that of one OHV day in Arizona. The CS values reported in the literature are *marginal* values, that is, they represent the CS value to the average individual of one additional day of OHV use. By using these marginal values as the basis for valuing all OHV days in the Mojave, we in effect assume that OHV users in the Mojave value each OHV day the same. That however is likely not the case. For the average Mojave OHV user, one additional OHV day may indeed generate a CS equivalent to the CS value reported in the Arizona study, an average of $51 per person for all OHV vehicle types combined (see Table 20). However, to estimate the CS of all OHV days in the Mojave, we would need to know how total OHV recreation demand (*i.e.*, WTA) changes with reductions in total OHV days. In other words, we would need to know how the WTA for the next OHV day changes as overall OHV days are reduced. This information could be derived theoretically through an auction in which the total number of OHV days is reduced in increments of one, starting from the current number of OHV person-days, and OHV users could sell their rights to those individual OHV days. This thought experiment is the appropriate one as we try to determine the total CS value of OHV recreation in the Mojave, or the CS value that would be lost if no OHV recreation would occur in the Mojave. Plotting the bids for each lost OHV day would be expected to result in a downward sloping demand curve, indicating that WTA for each successive OHV day lost would be higher than for the last. This is graphically expressed in Figure 9.

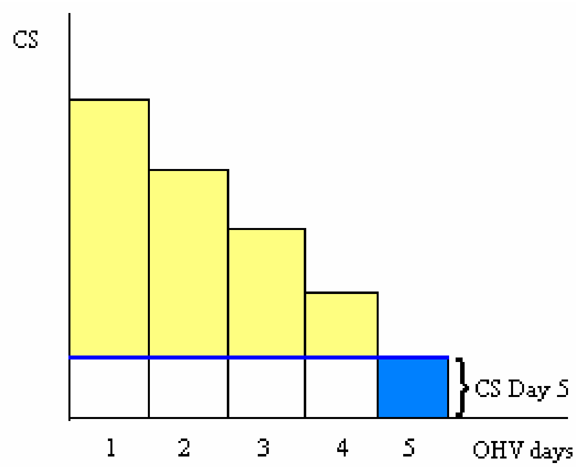

Figure 9: Change in CS with change in number of recreation days

The figure shows a person who spends, or plans to spend, five OHV days in the Mojave. The rectangles represent that person's CS for successive OHV days. For example, on the fifth day, that person's CS for OHV recreation is equivalent to the blue shaded square. The size of the CS decreases with increasing OHV days because successive OHV days become relatively less valuable to the individual. The reason behind the decreasing attractiveness of successive recreation days is the following. If an individual were asked how much she would be willing to pay for one day of OHV use in the Mojave per year, her WTP for that first day is likely to be higher than what she would be willing to pay to increase OHV recreation from, say, 20 to 21 days.

The value we use in estimating CS of OHV recreation in the Mojave is the average CS of people who engage in substantially more than one day of OHV use – the Arizona CS data are based on a survey showing that the average motorized trail user participated in 16 to 54 days of recreational OHV use (depending on vehicle category) (Arizona State Parks, 2004). Hence, the CS value that is the source of our benefit transfer represents the CS for one OHV day at a rather high level of total annual OHV days, exemplified by the CS marked in blue in Figure 9. Using that CS value for all OHV recreation days is likely to lead to a substantial underestimate of total CS of OHV recreation. For example, in Figure 9, applying the CS value for the fifth OHV day to all OHV days would ignore the area shaded yellow.

The same argument applies to our estimates of total CS of other, non-OHV recreation activities. As a result, our estimates of CS of recreation, and, by extension, our estimates of the total economic value of recreation in the Mojave, are likely to be substantial underestimates of the actual economic value of desert recreation.

Real estate value premiums of natural amenities

The Mojave Desert's attractiveness as a recreation destination derives from the area's high amenity values - its remoteness, its wide open spaces with scenic vistas, and its large number of major, permanently protected "natural" areas.

Naturally, the same amenities also have been attracting an increasing number of people who decide to relocate to the area, or to acquire second homes. As a result, the past decades have seen strong growth in new housing developments, especially in the southwestern sector of the study area. As a result of this influx of new residents, San Bernardino County has experienced increases in median house prices that are even larger than those observed in Los Angeles, Riverside, and Orange Counties (County of San Bernardino, 2004b).[46] Obviously, the natural amenities of the Mojave are not the only reason, and in most cases presumably are not the primary reason, for the high rate of migration into the area. Rather, the relative affordability and proximity to the Los Angeles metropolitan area is probably the single strongest driver of that growth, as evidenced by the high shares of residents in the largest population centers along the southwestern periphery (Palmdale, Lancaster, and Victorville) who commute to work in the metropolitan area (BLM, 2003a). However, natural amenities may be the dominant explanatory variable for inmigration in some parts of the study area too far from Los Angeles to allow daily commuting, which have witnessed a disproportionate increase in second homes and retirees. This is the case particularly along the southeastern periphery of the Mojave, in the vicinity of Joshua Tree National Park, where the landscape and remoteness are the primary attractors for homebuyers (King, 2005). As a result, developments with a combined total of up to 20,000 houses are currently planned in the vicinity of Joshua Tree (Spillman, 2006).

[46] Rising house prices have reduced housing affordability (as measured by the average wage earner's ability to afford the median priced home) in San Bernardino County from 49 percent in April 2003 to 22 percent in September 2005 (County of San Bernardino, 2004b; California Association of Realtors, 2005b).

The fact that natural amenities have economic value for residents is well documented in the economics literature. Evidence of people's appreciation of these amenities also is provided by the success of open space ballot measures. For example, in 1998, voters in 26 states approved 124 open space ballot measures (84 percent of all such measures put to the voters), with many of the approved referenda authorizing tax increases as the financing mechanism. The 124 approved open space measures raised $5.3 billion in funding, not counting ballot measures for which no funding totals were specified in the referenda (Land Trust Alliance, 1999). More recently, on November 8, 2005 voters in 17 states approved total new spending of more than $650 million for land conservation, bringing the 2005 total for new state and local conservation spending authorization to $1.7 billion (Trust for Public Land, 2005a).

The national-level observation of strong support for open space preservation also is evidenced in California. In that state, a total of almost two dozen local and county ballot measures have been approved between 1994 and 2005 that specifically aimed at the conservation of open space (Table 27).[47]

Table 27: Approved open space ballot measures in California, 1994-2005

Ballot Measures		*Conservation Funds Approved*
Municipal		
Albany, Nov. 1996	Measure R – establishment of an assessment district for open space	$5,000,000
Portola Valley, Nov. 1997	Measure B – 4-year, 2% Utility Tax Increase for Open Space	$608,539
Belmont, Nov. 1997	Measure E – advisory vote on preserving land in San Juan Canyon	
Santa Cruz, Nov. 1998	Measure G – bond for open space, recreation, parks	$2,700,000
San Francisco, Mar. 2000	Proposition C – Charter Amendment, 30-year property tax set aside for parks, recreation and open space	$150,000,000
Davis, Nov. 2000	Special Open Protection Tax for acquisition, improvements, and maintenance of open space	$17,500,000
Monrovia, July 2000	Special parcel tax for purchase and preservation of urban open space	$10,000,000
Portola Valley, Nov. 2001	4-year extension of 2% utility tax for open space acquisitions	$760,000
Oakland, Nov. 2002	Measure DD – bond measure for water quality projects and open space	$50,000,000
Portola Valley, Nov. 2005	4-year extension of 2% utility tax to acquire and preserve open space	$800,000

continued on next page.....

[47] In addition, in 1996, 2000 and 2002 state bond measures were approved in California that contained a total of $6.7 billion in conservation funds for the protection of water quality, coastal land, and parks (Trust for Public Land, 2005b).

Table 27 continued

County		
Santa Clara Co., June 1994	Measure A - $12 annual assessment on properties within the county for open space, watersheds, parks and recreation facilities	
Los Angeles Co., Nov. 1996	Proposition A – Safe Neighborhood Parks Act, 20-year assessment for parks, beaches, water quality, open space and recreation	$150,000,000
Santa Clara Co., Mar. 1996	Measure A – Charter amendment to dedicate 12-year $0.015 tax per $100 assessed property value for county park fund	$35,000,000
Santa Clara Co., Nov. 2001	Open Space Preservation Measure - $20 per parcel annual assessment for acquisition, preservation and development of open space, parks, trails, and waterways	$160,000,000
Sacramento Co., Nov. 2004	Measure A – 30-year renewal, ½ cent sales tax for transportation purposes with a portion to acquire open land	$48,000,000
Santa Clara Co., June 2006	12-year continuation of .01425 per $100 property tax for land acquisition, development, and maintenance of parkland	$73,680,000
Special Districts		
Marin Co. Open Space District, June 1997	Parcel tax to acquire peninsula properties for open space	$6,000,000
Placer Co. Park and Recreation District, Nov. 2001	$58 per parcel annual assessment for maintenance, acquisition and development of park land and recreation areas, and walking and biking trails	$8,388,000
Santa Monica Districts 1&2, Aug. 2002	Special assessment and bond to acquire and protect open space in the Santa Monica Mountains	$25,600,000
Monterey Peninsula Regional Park District, Aug. 2004	Parks, Open Space and Coastal Preservation Measure - proposed assessment for maintaining, improving and preserving parks and open space	$15,000,000
Marinwood Community Services District, Mar. 2005	Measure D - $75 dollar increase to $150 on each land parcel for parks, open space, and street landscape maintenance	$1,800,000

Note: The table does not show the total amounts approved in the ballot measures, but only the amounts specifically devoted to conservation.
Source: Trust for Public Land, 2005b.

Attractiveness of the landscape has a positive impact on property and home values. For example, a survey conducted for the National Association of Realtors (2001) revealed that 50 percent of the respondents would be willing to pay 10 percent more for a house located near a park or protected open space. Nearly 60 percent stated that if they were in the market for a new home, they would be likely to select one neighborhood over another if it was close to parks and open space.

Natural amenities such as open space and scenic vistas constitute attributes of a property, just as lot size, number of rooms, house age, and other attributes of the property do, and get factored into the home's or property's market value. Economists, based on the work of Rosen (1974), have devised an approach for estimating the value consumers assign to particular attributes of a good. These *hedonic* models infer the value of particular attributes (say, scenic views and open space) of a good (say, a house) from people's observed purchase behavior. Simply put, hedonic analysis is premised on the idea that people should have the same WTP for two goods that are identical, that is, that have the same attributes. Hence, if two goods differ only in one attribute, such as the size of open space surrounding them, but are otherwise identical, and if their prices differ, then the price difference must be caused by the difference in that one attribute. By comparing the prices of houses transacted in a particular geographical area and accounting for differences in all attributes that are expected to influence house prices, one can estimate the value of a unit of a particular natural amenity attribute, for example, an additional acre of open space within a 500 foot radius of a house or property.[48]

The positive impact of open space specifically on property values has been documented in a large number of studies. In the most comprehensive recent review of this literature, McConnell and Walls (2005) examined more than 60 published articles that analyze the economic impact of open space on house prices. The open space premiums in house prices reported in the literature vary substantially. This is due to a variety of factors. As Irwin (2002) points out, results of hedonic studies of property price impacts of open space are divergent because of the different kinds of open space considered, differences in the specification of the open space variable, and differences in preferences and relative scarcity of open space in different regions. The effects of proximity to natural open space also differ with the use of the open space. Positive impacts on property values are generally the greatest when the natural open space has some recreational access, limited use, few or no developed facilities, limited vehicular access, and effective maintenance and security (U.S. NPS, 1995).

In this study, we limit our estimates of the desert's natural amenities on house price values to a subset of properties located in the vicinity of National Park units in our study area. For these properties, due to their distance from major urban areas and their special protection status, the impact of natural amenities on house values is most pronounced, and least contaminated by other factors (such as lower house prices than in metropolitan areas). This exclusion of other Mojave properties from the analysis imparts a conservative bias on our estimates.

National Park lands are characterized by their status as permanently protected areas. Therefore, our focus on the impact of National Park lands on house values makes most relevant those studies that examine the impact of permanently protected lands, that is, lands in public ownership or under conservation easements. Those studies and their main findings are listed in Table 28.

Espey and Owusu-Edusei (2001) found that in Greenville, South Carolina, medium sized attractive parks raise property values by on average six percent for properties between 200 and 1500 feet of the park. Frech and Lafferty (1984) estimated that actions taken by the California Coastal Commission to preserve open spaces increased average home values in their study area by as much as 13.4 percent for properties located within half a mile of the protected area, and by at least 2.6 percent for properties located more than half a mile from the protected area.

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48 Hedonic house price models, however, do not capture the full value of the benefits of open space (Irwin, 2002; McConnell and Walls, 2005). Especially open space benefits with public goods character (such as some non-rival and non-exclusive ecosystem services, and recreational use by others than adjacent residents) are not fully captured by house prices. We therefore evaluate those benefits separately, as benefits to recreationists and benefits associated with ecosystem services.

Table 28: Impact of protected open space on house prices: selected literature findings

		Type of open space	*Average increase in house price*
Espey and Owusu-Edusei (2001)	Greenville, SC	Medium-size attractive urban park	6% in house prices between 200 and 1500 ft of park
Frech and Lafferty (1984)	CA coast	Protected coastal land	7.6%-13.4% <.5 mile from coast; 2.6%-4.5% >.5 mile from coast
Irwin (2002)	Central MD	Permanently protected open space	1.87% for each acre of developable pasture land converted to permanently protected open space
Irwin (2002)	Central MD	Public open space	0.57% for each acre of developable pasture land converted to public open space
Lutzenhiser and Netusil (2001)	Portland, OR	Natural area urban park*	16.1% within 1500 ft. of park
Phillips (2000)	Green Mountains,VT	Wilderness area	13% of parcel price
Pincetl *et al.* (2003)	L.A.	Green spaces	1.5% for each 10% increase in green space within 500 ft
Ready and Abdalla (2003)	Berks Co., PA	Open space - public	0.3% for each additional acre within 400 m of house
Ready and Abdalla (2003)	Berks Co., PA	Open space - public	0.02% for each additional acre within 400-1600 m of house
Thorsnes (2002)	Grand Rapids, MI	Forest preserve	2.9% - 6.8% for properties bordering the preserve; (19% - 35% of lot price)

Notes: * Lutzenhiser and Netusil (2001) define a "natural area park" as a park with > 50% preserved in native or natural vegetation, with park use balanced between preservation (including exclusion of human use from certain areas) and natural resource-based recreation.

Irwin's (2002) analysis shows that house prices increase with the proportion of surrounding lands under easements or in public, non-military open space. These results indicate that permamently protected open space has a premium attached to it over developable agricultural and forested lands. Irwin hypothesizes that this is attributable to the fact that open space is primarily valued for its absence of development rather than for a particular bundle of amenities it provides. This hypothesis seems to be confirmed by Earnhart (2006) who found permanence of protection to be an important criterion in the value derived from open space. Geoghegan (2002) finds that both developable and protected (under easements) open space increases house values, but that the latter inreases house values by more. Geoghegan *et al.* (2003) study four adjacent counties in central Maryland. Their results indicate that the value of open space is highly location specific. Also, it appears that open space value increases with development pressure, although their results in this respect are not conclusive (McConnell and Walls, 2005). Ready and Abdalla (2003) find that open space has the largest amenity value of all land uses examined by the authors within 400 meters of properties; within 400 to 1600 meters, only government-owned (local, state, federal) open space still has significant, if smaller, amenity value.[49] In his analysis of forested lands in

[49] See also Ready and Abdalla (2005).

Grand Rapids, Michigan, Thorsnes (2002) found that protected forest lands increase propery values, while merely vacant, unprotected ones do not. This result confirms the findings by both Irwin (2002) and Geoghegan (2002).

Lutzenhiser and Netusil (2001), in their analysis of open space in Portland, Oregon, found that natural area parks have the largest statistically significant (at the one percent level) effect on house prices for properties within 1500 feet of open space, increasing average house values by 16 percent. The authors define natural area parks as parks with more than 50 percent of their area preserved in native or natural vegetation, and with park use balanced between preservation (including exclusion of human use from certain areas) and natural resource-based recreation. Natural area parks also have the largest "reach" of all open space types examined by the authors: at 1200 to 1500 feet from the park, house prices are still 15 percent higher. Their results also show that, in general, house prices increase with the size of natural areas. Anderson and West (2003) also find that house values in proximity to parks increase with the size of the park. Lutzenhiser and Netusil's (2001) and Anderson and West's (2003) results suggest that parks do not just benefit houses in the immediate vicinity of parks.

Irwin's (2002), Lutzenhiser and Netusil's (2001), and Anderson and West's (2003) findings of a positive relationship between the size of house price impacts and the size of protected open space suggest that properties located in proximity to National Parks would receive even larger benefits than those found in the literature, which all were for substantially smaller open spaces.

Phillips (2000) examined the impact of wilderness areas on parcel prices in towns located in the Green Mountain Wilderness of Vermont. He found that, all other things being equal, the average parcel price in towns containing wilderness was 13 percent higher than in towns not containing wilderness. Phillips' results also showed that the price of parcels decreases by 0.8 percent per acre with each kilometer farther away from the nearest wilderness area.

Unfortunately, no hedonic analysis of house prices has been carried out in the California Desert. However, evidence suggests that the open space premium equally applies to desert lands. For example, Munro (2005), based on discussions with local realtors, reports that real estate "shoppers are looking for property in the middle of nowhere and up against BLM land," seeking "dark, starry nights, fresh air, and vistas."

As Table 28 shows, the economic literature indicates the importance of local context factors for the size of the open space premium. For this reason, it may not be appropriate to simply transfer to our study area the results of a study conducted in another location. To the extent feasible, local data should be used to derive estimates of the open space premiums for property values in the Mojave.

It is beyond the scope of this study to conduct a hedonic analysis of property values for the entire Mojave. Since the open space value premium is dependent on a variety of factors, such as price of real estate, proximity to protected open space, level of protection of open space, scenic beauty of open space, etc. that vary throughout the region, it is impossible to include the whole Mojave in our analysis, as this would require a number of separate, local analyses. Rather, we focus on one particular location and develop some first-approximation estimates of the property value premium of protected public land. The literature suggests that proximity to National Park land carries a particularly high premium for real estate prices, because of the size of the open space and its high level of permanent protection. For this reason, we chose Joshua Tree for our analysis. There are many other places in the Mojave that offer amenity values to residents, but none is as close to a major National Park as Joshua Tree.

House prices are a function of a number of attributes. These include the size, quality, and state of repair of the house and its ancillary structures, the size of the property, neighborhood characteristics, and environmental amenities (air quality, proximity to and attractiveness of protected open space, etc.), among others. A hedonic analysis of house prices would need to control for all of these variables in order to develop a statistically valid estimate of the size of the open space premium. Given that a full hedonic analysis was not possible within the scope of this study, we decided to assess the impact of proximity to Joshua Tree National Park on property values in Joshua Tree by examining price differences among building lots located at different distances from the Park. By focusing on building lots as opposed to properties with houses, we avoid the distorting influence on house prices from factors other than amenity values of Joshua Tree National Park.

With the help of several local realtors, we were able to identify six small to medium sized building lots for sale in Joshua Tree in September 2005 (see Table 29).[50] These are shown in Figure 10. We limited our sample to lots of roughly similar size because the per-acre price declines with increasing lot size. Overall, sizes of lots for sale ranged from less than one fifth of an acre to 80 acres. Our sample varies less in size than either the smaller lots (up to one and a quarter of an acre) or the larger lots that we excluded from the sample, and also shows a better distribution over various distances from the Park boundary than either of the two other size groups.

Table 29: Selected characteristics of a sample of small to medium sized building lots for sale in Joshua Tree, September 2005

No. on map	*Size*	*Price*	*Price/acre*
	acres	*dollars*	
1	6.9	189,000	27,431
2	2.5	95,000	38,000
3	2.1	125,000	59,524
4	2.5	85,000	34,000
5	5.0	45,000	9,000
6	2.5	115,000	46,000

Lots one through four are located closer to the Park, in the sense that they are situated at, or close to, the edge of developed land along the Park boundary. Lots five and six are located farther from the park. Unfortunately, our sample size is too small to allow valid inferences. Nevertheless, as Table 29 shows, the average price per acre of the lots closer to the Park,

[50] We focused on the part of Joshua Tree that is classified as Census Designated Place (CDP) in the 2000 Census. This part comprises the urban portion of Joshua Tree. Local realtors contacted in Joshua Tree were Joshua Tree Realty, Mel Benson Real Estate, and AFG Realty.

$39,739, is higher than that of the lots farther from the park, $27,500. Local realtors confirmed this finding, stating that, as a general rule, lot prices closer to the Park are higher. On average, the proximity premium of the lots in our sample that are closer to the Park is approximately $12,240 per acre, or 31 percent of the price of those lots.

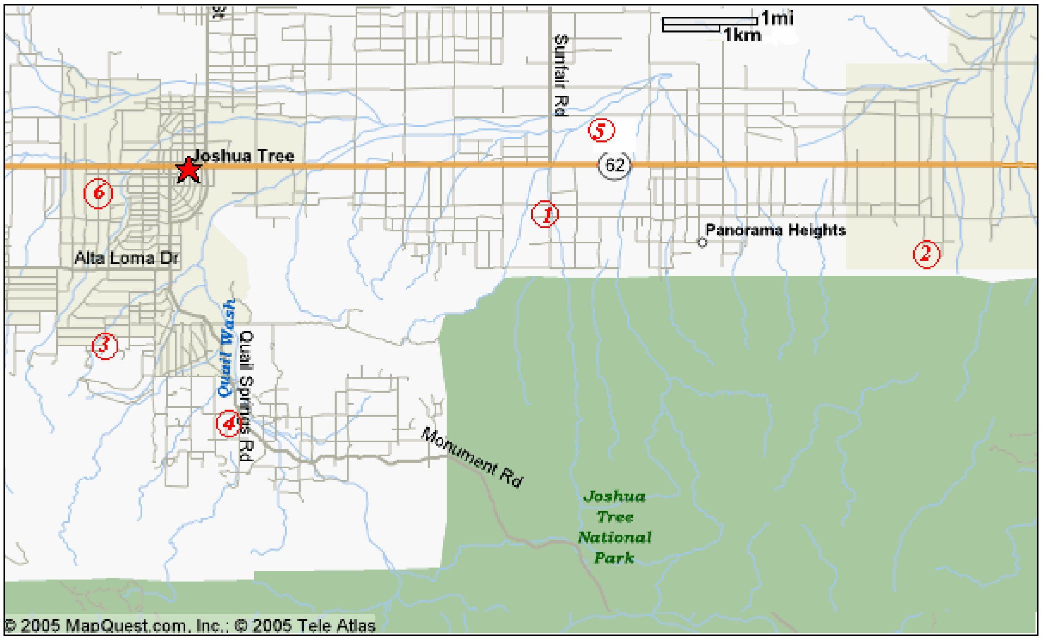

Figure 10: Map of Joshua Tree area properties included in analysis

This falls within the range of value premiums of 19 percent to 35 percent estimated by Thorsnes (2002) for lots bordering a forest preserve (see Table 28). All the other studies shown in Table 28 report value premiums for house prices, not lots. Given that the house price incorporates the price of the lot and hence commonly is several times as high as the lot price, value premiums measured in increases in house price necessarily are substantially smaller than when measured as increases in lot price. Of the studies that estimate house price premiums of open space, Frech and Lafferty (1984) is the study that arguably is most comparable to our case because the authors estimate value premiums associated with protected land that is larger in area than the protected lands in the other studies reported in Table 28. The authors find house price premiums of eight to 13 percent, which, given the relationship between property price and house price, appears to be very similar to Thorsnes' estimate. However, Joshua Tree arguably is different from the protected open lands examined in the cited studies, in that it is a well-known, and one of the most popular, National Parks, a designation that affords the highest possible level of continued protection of the open space resource. Due to the Park's geographic features, a portion of the visual amenity values accrues even to owners of properties located at a substantial distance from the park. In fact, all properties within the viewshed of the Park's hillsides are likely to receive some Park-related visual amenity values in the form of scenic vistas of the Park's hillsides. In addition, all residents in the vicinity of the Park derive amenity benefits in the form of easy access to the Park. Figure 11 shows a schematic representation of the total amenity value from scenic views of and easy access to the Park as reflected in property price premiums. Amenity value is higher in the viewshed than outside of it, and generally decreases with distance from the Park.

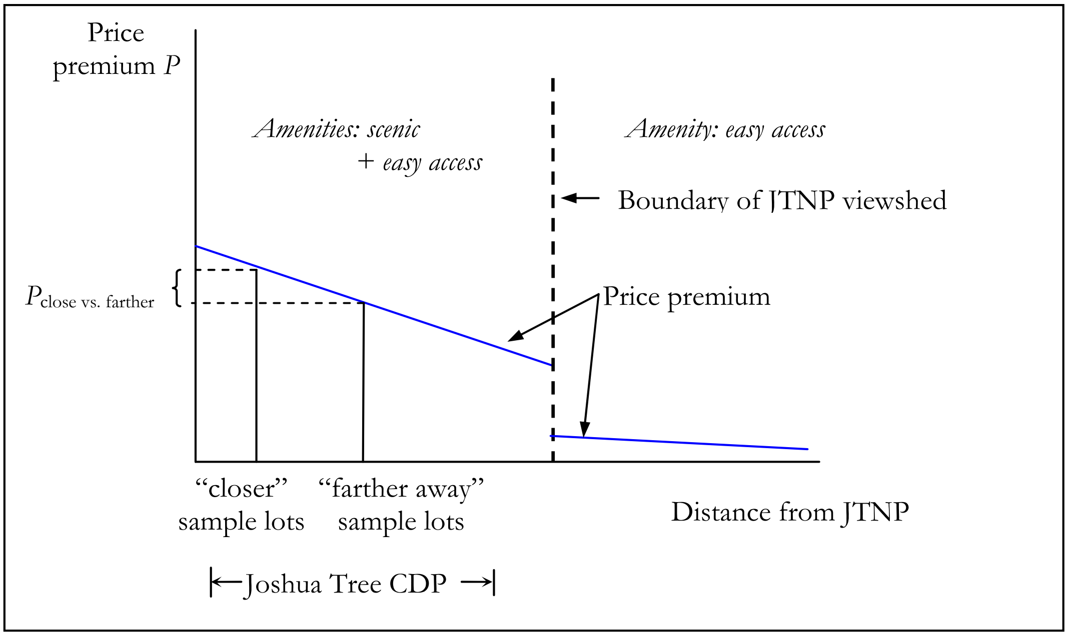

Figure 11: Simplified relationship between proximity to Joshua Tree National Park (JTNP) and associated property price premium

All six lots in our sample are in the viewshed of the park, so all receive amenity values. Our lot price comparison therefore simply identifies the *added* premium that lots very close to the Park's borders receive over those a bit farther away. It does not capture the total premium in lot prices associated with the Park. This added premium is the difference in average lot prices, labeled $P_{\text{close vs. farther}}$ in Figure 11. To obtain an estimate of the total premium, one would need to include lots outside of the Park's viewshed. Without a much more comprehensive lot price analysis, it is impossible to estimate the total premium in the price of a lot that is attributable to Joshua Tree National Park. For the line of properties closest to the Park, this total premium is larger than the $12,240 for the average small-to medium sized lot derived in our estimate. At a certain distance from the Park, the total premium becomes equal to our estimated premium; beyond that distance, it will be lower. However, all of Joshua Tree lies within the Park's viewshed, so all properties in the town are located in the left part of Figure 11, receiving both scenic and easy access amenities. It is not possible to determine from our limited analysis whether all properties in Joshua Tree receive total premiums larger than $12,240, or whether some receive premiums smaller than that amount. To derive an estimate of the combined total value premium for all properties in Joshua Tree as a whole, we make the simple assumption that the average value premium for a property in the town in September 2005 is equal to $12,240.[51] This amount is equivalent to nine percent of the median home price in Joshua Tree in May 2005 (the latest available information as of this writing) of $135,000 (California Association of Realtors, 2005a).

[51] Our estimate of $12,240 was derived for a sample of lots that measured 2.5-6.9 acres (Table 29), with a median value of 2.5 acres. No information is available on the average lot size of homes in Joshua Tree, but a visual examination of satellite photos suggests that the assumption of a median size of 1-2.5 acres for occupied lots (*i.e.*, with housing unit) is reasonable. With the price per acre increasing for smaller subdivided lots, we assume that the premium on smaller lots is not substantially smaller than that on the lots in our sample. Therefore, we assume that our calculated premium per lot represents a reasonable rough estimate of the average premium for built properties in Joshua Tree.

Given that the median home price in Joshua Tree has increased a total of 72 percent from the fourth quarter of 2003 (County of San Bernardino, 2004b) till May 2005, the estimated Joshua Tree National Park premium in late 2003 was $7,117.

Table 30: Selected population and housing characteristics of Joshua Tree

	2003	*2000*
Median house price	$78,500	$64,100
Population - total	13,000	8,137
Population – urban (CDP)	6,721 (est.)	4,207
Average urban household size	2.35 (est.)	2.35
Number of urban housing units *	2,860 (est.) [a]	2,112 [b]
Single units, percent of total urban units **	76.2 (est.)	76.2
Mean number of units per lot	1.13 (est.)	1.13
Estimated number of urban lots	2,537	1,582

Notes: CDP – Census designated place. Urban population in 2003 estimated based on rural/urban split in 2000. [a]Assumes no vacant units – this is likely to result in an underestimate of total housing units. [b]Includes vacant units. **Excludes mobile homes, boats, RVs, etc.
Sources: 2000 data: U.S. Census Bureau, Census 2000 Summary File 1 (SF 1) and Summary File 3 (SF 3); *www.city-data.com/zips/92252.html*. 2003 data: County of San Bernardino (2005), except where based on our estimates (est.).

The total premium for the estimated total 2,537 occupied urban lots (*i.e.*, in Joshua Tree CDP) in 2003 was an estimated $18.0 million.[52] The share of this total benefit that is attributable to the year 2003 is equivalent to the percent increase in the average house price in Joshua Tree over its 2002 level. Given a median house price increase in 2003 of 12.1 percent (County of San Bernardino, 2004b), and assuming the premium increased linearly with home prices, the increase in premium in 2003 was $2.18 million. For Joshua Tree as a whole, that is, including urban and rural areas, the total premium is larger, because most rural parts of Joshua Tree lie in the viewshed of the Park and offer easy access to it.

Although open space premiums in Joshua Tree and Twentynine Palms may be particularly high because of the proximity of the two places to Joshua Tree National Park and their remoteness, properties in many of the other High Desert towns and cities are likely to receive substantial premiums as well. For example, many settlements to the east of Apple Valley along routes 18 and 247 South offer scenic views of the mountains of San Bernardino National Forest, as well as proximity to the highly valued recreation sites of Big Bear Lake and Lake Arrowhead. Properties along the peripheries of the Mojave's larger towns like Apple Valley, Hesperia, Lancaster, and Palmdale can also be expected to receive open space value premiums, to the extent that they provide scenic vistas and comparatively easy access to recreation sites in the area's National Forests. The open space premiums may vary considerably across different locations, not least because of sizeable differences in the underlying real estate price levels. The premiums in Joshua Tree may be comparatively high as a percentage of the property value, because of the special nature of the open space resource in that locale. Nevertheless, given the higher real estate price levels in Lancaster and Palmdale, even a smaller percentage open space premium could result in

[52] Given the sharp rise in property prices, in late 2005 the total premium, at nine percent of the average house price, is estimated to have increased to $31 million.

larger absolute dollar values of open space premiums along the periphery of those places. Unfortunately, it is beyond the scope of this study to conduct a comprehensive analysis for the Mojave as a whole. But given that properties in Joshua Tree account for only a small fraction of all properties in the Mojave likely to capture open space premiums, the total value of the open space premium in the Mojave is likely to be in the several hundreds of millions of dollars. Richardson (2004), in his study of the economic benefits generated by wildlands in the Mojave, develops an estimate of the environmental amenity value captured by private properties in communities adjacent to wildland areas. Using Census data to identify the number and median value of housing units in communities near wildlands, assuming a wilderness amenity premium of 13 percent of the median house value (based on Phillips, 2000), and excluding the urban centers, Richardson estimates the total private property amenity benefits or wildlands. Total benefits are $100.7 million for the 5,076 housing units in communities in Inyo County located near wildlands; $355 million for the 20,768 such housing units in San Bernardino County; and $113.3 million for the 5,950 units near wilderness in Riverside County. Given that most of Riverside County lies outside of our study area, Richardson's (2004) estimate of Riverside wildlands amenity premiums captured by house prices is of limited relevance for this analysis. Nevertheless, the wildlands amenity benefits for properties in San Bernardino and Inyo counties alone totaled an estimated $455.7 million. These values result from an amenity premium assumed to be 13 percent, substantially lower than the 31 percent premium found in our samples in Joshua Tree. Given Joshua Tree's particular attractiveness, the premiums found there may not be representative of the area as a whole. Assuming an average premium of 13 percent for all properties near wildlands in the Mojave is perhaps a more reasonable assumption. However, it should be emphasized that the wilderness amenity value premium of $455.7 million does not include open space premiums received by properties close to protected non-wilderness lands in the Mojave. The true open space premium in the Mojave therefore likely is larger than $456 million.

Of course, this amount is the current value of the space premiums received by private properties in the Mojave, as incorporated into property prices. It is not an annual value, and as such is not comparable with the other benefits quantified in this report, which are expressed in terms of an annual (2003) benefit. To derive the total open space premium received in 2003, Richardson's estimate, which is based on data for the year 2000, must first be updated to the year 2002. Based on data from the California Association of realtors, median home prices in San Bernardino County increased by 20.5 percent between 2000 and 2002. At the end of 2002, therefore, the total wildlands premium received by private properties in San Bernardino County had increased to an estimated $428 million. In 2003, the cumulative unweighted increase in median home values in the San Bernardino county cities and towns in our study area (see Table 4) was a further 19.6 percent (County of San Bernardino, 2004b). Correspondingly, in 2003 the gain in total open space premiums received by private properties near wildlands in San Bernardino County was an estimated $84.0 million. This represents the combined annual benefit stream received by all such properties in 2003. This figure still is an underestimate, however, as it only captures the increase in open space premiums on houses built as of 2000, thereby ignoring the amenity premiums gained by the sizeable number of homes constructed between 2000 and 2003.

For Inyo county, no information on changes in median house value since 2000 is available.

The increased development of the Mojave will at some point lead to a reduction in the open space premium on individual properties, and development beyond a certain level may actually reduce the total value of the open space premium in the settled areas, as the increasingly smaller gain received by additional housing units is overcompensated by a loss in value on existing units from increased crowding.

Military uses of the Mojave

The Mojave is home to five military bases: the Twentynine Palms Marine Corps Air Ground Combat Center, the Marine Corps Logistics Base and Fort Irwin in Barstow, Edwards Air Force Base in Lancaster, and the China Lake Naval Air Weapons Station in Ridgecrest. The combined number of military personnel and their families, civilian employees, and on-site contractors at these installations is approximately fifty thousand, not counting retired military personnel residing in the area.[53] The economic impact of these installations on the surrounding areas, and on southern California in general, is substantial.

The total value of salaries, service, and construction and maintenance contracts of the Twentynine Palms Marine Corps base amounted to approximately $533 million in 2004 (see Table 31). Of these expenditures, over $363 million accrued to the Mojave region in the form of salaries or construction and maintenance contracts to companies in the area.

Table 31: Twenty-nine Palms Marine Corps base 2004 expenditures

Expenditure category	*Expenditures in million $, by region*		
	U.S.	*California*	*Bakersfield-Riverside-San Bernardino RIMS area*
Utilities (telephone, natural gas, electricity)	19.53	19.53	n.a.
Service contracts	24.56	14.56	n.a.
Construction and maintenance contracts	138.86	118.39	11.83
Salaries	350.90	350.90	350.90
Aid to Morongo School District	1.40	1.4	1.4
Contribution to local charitable orgs.	0.05	0.05	0.05
City of 29 Palms - vehicle licensing fees and gas tax	0.6	0.6	0.6
Total	535.84	505.38	364.73

Source: Marine Air Ground Task Force Training Command (2005). n.a. – not available.

This number does not include the value of service contracts received by local companies,[54] or the share of utility expenditures that accrued to the area. In addition, the base contributes to the local school district and charitable organizations, and generates local tax and fee revenues (see Table 31).

[53] Based on Marine Air Ground Task Force Training Command (2005), Department of Defense (2004), and National Training Center Fort Irwin (2006).

[54] Unlike for construction and maintenance contracts, the economic impact statement for the base does not identify the location of the recipients of service contracts.

Table 31 only shows direct expenditures, not the total economic impact of the base. A large number of the contractors operating on the base are located in the Mojave itself or in neighboring counties, and most are located in California. Hence, some of the economic impact of the base is captured in the Mojave itself or in the surrounding region. Service, construction and maintenance expenditures generate multiplier impacts that increase the total economic impact of the base. Construction and maintenance contracts with suppliers located in the four county area generated an estimated additional (indirect and induced) output of $12 million in the area. Unfortunately, it is impossible to assess the extent to which contractors located outside of the four county area increased area output, as this would require information on the inputs for the respective projects that were sourced locally. Nevertheless, the total local economic impact of base contracts certainly was larger than the $24 million total impact associated with direct contracts with local companies. The majority of the base's contracts with out-of-area suppliers are with companies located in southern California. Overall, 81 percent of the total contract value (59 percent of the value of all service contracts and 85 percent of that of all construction and maintenance contracts) was received by companies located in the state (Marine Air Ground Task Force Training Command, 2005). At the state level, the total final demand output effect of the base contracts likely surpassed $265 million in 2004.[55]

In addition to contracts generating economic multiplier impacts, salaries of military and civilian personnel generate multiplier effects as well. The indirect and induced output effect of the salaries can be estimated using information on the composition of average household expenditures.[56] Based on these expenditure shares, after-tax salaries paid by the base can be translated into output of particular industries.[57] Deriving estimates of the output effect of base salaries for the Mojave region would require information on the share of expenditures in each category that is supplied by producers in the region. Unfortunately, such information is not available. Therefore, we derive output estimates for California as a whole, making the assumption that all salaries paid by the base are spent in the state.[58] To estimate the output effect associated with base salaries, we use the RIMS II final demand output multipliers for the Bakersfield-Riverside-San Bernardino area for the respective industries.[59] These state-level output effect estimates also can serve as high-end estimates of the output effect that base salaries have in the Mojave region. The actual output effect in the region likely is substantially smaller as a sizeable share of salaries likely is spent outside of the region.

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[55] This number is based on the value of contracts that went to in-state contract recipients and on the RIMS II construction (2.05) and service multipliers (1.95) for the four-county Bakersfield-Riverside-San Bernardino BEA area. Since statewide multipliers are likely to be larger (Hughes, 2003), the total output impact estimate of $265 million likely is conservative.

[56] We use the expenditure shares reported for the U.S. West region (see table 52 in Bureau of Labor Statistics, 2006).

[57] The average state and local tax burden in California was 10.6 percent in 2002 (Johnson et al., 2006), while the average federal tax burden was 20.7 percent (Congressional Budget Office, 2005). The tax burden on base salary recipients was likely lower due to the progressive nature of both state and federal income taxes. As a result of this bias, our output estimates likely are underestimates.

[58] Undoubtedly, a part of salaries paid by the base is spent outside of California. Our assuming otherwise will therefore bias upward our estimated output effect of base salaries.

[59] Because multipliers increase in size with the expansion of the geographical boundaries of analysis (Hughes, 2003), the multipliers for California are larger than those for our four-county RIMS II area. Hence, using the latter to estimate statewide output effects will tend to underestimate output effects. This bias therefore counteracts the upward bias we introduce through our assumption that all salaries are spent within the state.

Finally, additional earnings generated by the salaries can be estimated with the help of RIMS II direct effects earnings multipliers. The $351 million paid out in salaries in 2004 represented earnings of $321 million.[60] These earnings generated additional earnings in the four-county area of an estimated $257 million, resulting in total regional earnings associated with salaries paid by the base of over $578 million.[61] Since part of the salaries is spent outside of the four-county area, the total earnings associated with the base salaries for the state as a whole is even larger than these $578 million.

Table 32 summarizes the direct economic effects associated with base salaries and contracts as well as the indirect and induced effects, both for the Mojave region as well as for the state as a whole. For the Mojave region, the Twentynine Palms base is estimated to have generated net benefits in the form of earnings of over $580 million in 2004.

Table 32: Estimates of total economic impact of Twentynine Palms Marine Corps base

	Direct effects		*Indirect and induced effects*		*Total effects*	
	Output	*Earnings*	*Output*	*Earnings*	*Output*	*Earnings*
			Million $			
California						
Contracts	133	-	132 [1]	77 [1]	265 [1]	77 [1]
Salaries	-	321	424 [1]	257 [1]	424 [1]	578 [1]
Bakersfield-Riverside-San Bernardino RIMS area						
Contracts	12 [2]	-	12 [3]	7 [3]	24 [3]	7 [3]
Salaries	-	321	424 [4]	257	424 [4]	578

Notes: [1] Likely to be an underestimate. [2] Does not include the value of service contracts. [3] Does not include impacts associated with service contracts. [4] Likely to be an overestimate. See text for explanation.

The remaining bases in the Mojave do not publish economic impact reports. However, an internal assessment at Edwards Air Force Base indicated that the total economic impact of that base was estimated at approximately $1.5 billion per year, with most contracts going to companies in the state.[62]

The low population density and the large contiguous open areas found in the Mojave, together with climate, weather, and topography, have made the region attractive as a location for military aircraft operations since the 1950s. The central portion of the Mojave is home to the largest dedicated air space in the United States, the R-2508 Special Use Airspace Complex. The R-2508 complex is composed of a number of internal restricted areas, military operations areas, Air Traffic Control assigned airspace, and other special airspace.[63] Currently, this area is used for

[60] Private contributions to social insurance must be subtracted from salaries to derive earnings. In 2002, the social insurance tax averaged 8.6 percent (Congressional Budget Office, 2005).

[61] The RIMS II direct effect earnings multiplier for "other services" (including federal government enterprises) for the Bakersfield-Riverside-San Bernardino BEA area is 1.80.

[62] Personal communication, Dennis Schaffner, Edwards Air Force Base community relations officer, 23 May 2006.

[63] See *http://r2508.edwards.af.mil/* The complex presently is used and managed by the three principal military installations in the upper Mojave region: the Air Force Flight Test Center at Edwards Air Force Base, the National Training Center at Fort Irwin, and the Naval Air Warfare Center Weapons Division at China Lake.

aircraft research and development in all stages of flight, operational weapons test and evaluation flights, student pilot training, air combat maneuvering and proficiency flights, and civilian test aircraft in direct support of Department of Defense (DoD) or defense testing. As a consequence, the region shows a high concentration of companies in the aircraft and defense related industries. In FY 2002, the top 40 DoD contractors alone received contracts totaling $262 million for work performed in San Bernardino and Kern counties (California Office of Military and Aerospace Support, 2004).[64]

Beyond the commercial value associated with military uses of the Mojave in general and the R-2508 Complex in particular, both also contribute to military readiness, the value of which is at best difficult to quantify in economic terms. In addition, by providing large, open and sparsely populated areas for military uses, the Mojave also helps avoid the conflicts and negative impacts that would occur if these activities had to be conducted in other, more densely settled areas.

Beyond military aerospace activities, the Mojave also provides an ideal location for the civilian aerospace industry and, most recently, the private space industry. These activities center around Mojave airport, which has evolved into a flight research and civilian aerospace test center and is home to the first FAA licensed inland spaceport.[65]

Military uses in the Mojave do not necessarily stand in conflict with the conservation of the Mojave ecosystem. On the actual surface areas that are used in operations on the ground, compatibility of military use and conservation may be limited, depending on the extent to which restrictions are instituted and effectively implemented to protect sensitive and priority conservation areas and critical species habitat. However, military and conservation interests align closely with respect to the areas surrounding the active military ground operation sites. Specifically, both military and conservation objectives are threatened by encroaching development. Such development eventually may lead to restrictions on certain military uses as well as reductions in the quantity and quality of many of the ecosystem functions provided by the Mojave. In other words, the current levels of ecosystem services and military use opportunities found in the Mojave both are coproducts of the wide open spaces, that is, of the current low state of development of much of the desert.

Film industry in the Mojave

At least partly because of its unique, varied scenery and remoteness, the Mojave has served as a source of background locations since the beginnings of the U.S. film industry. In more recent times, hundreds of feature films, commercials, print ads, music videos and television shows have been shot in the region. What makes the region so attractive is that its 27,000 square miles represent the "'world in a nutshell…' with such look-a-like locations as the Pacific Ocean (Salton Sea), Middle Eastern Sand Dunes, Northwest forests, New England towns, Western Towns, Midwestern Farms, French vineyards, Arizona deserts, mines and wet and dry lakes. It is why the

[64] Note that this amount includes only the largest DoD contractors. For example, none of the companies that in FY 2004 received a total of $139 million worth of contracts from the Twentynine Palms Marine Corps Base are among the DoD's top-40 contractors.
[65] See *http://www.mojaveairport.com/*

region is able to bill itself as 'Hollywood's Largest Backlot'" (Inland Empire Economic Partnership, 2005). The region also attracts a large number of professional photographers each year.

The value the Mojave holds for the respective film and photography companies is not easily measured. It could be approximated as the loss of profits that would result from replacing the Mojave with the next-best setting. This loss in profits may result from higher production costs or from reduced sales, in the case that the alternative location yields an inferior product and results in reduced demand for the product. The value of film and photography in the Mojave further includes the earnings in the economy that result from multiplier effects in the economy. For example, film crews patronize local hotels and restaurants, shop at local groceries and convenience stores, and buy gasoline at local gas stations. All of these activities boost the local economy (Inland Empire Economic Partnership, 2005). The net benefits for the affected companies are the respective profits they earn from supplying inputs to the film and photography industry. The net benefit to households is the sum of the additional earnings they obtain through employment attributable to the film and photography business. The film and photography-related economic value of the Mojave also includes the consumer surplus received by the consumers of the products, for example moviegoers (as well as people watching the films on DVD or other media), viewers of Mojave photography, and others.

Due to the lack of information on the local expenditures by film crews and others, and the difficulty of determining the cost of substitute locations, it is not possible to develop a comprehensive estimate of the total economic value generated with filming and photography in the Mojave. Nevertheless, below we provide some information on the level of film and photography activity that took place in the Mojave in 2003.

As Table 33 shows, in 2003 a total of several dozen documentaries, educational films and feature films were shot on federal lands in the Mojave, along with music videos, commercials, and television shows. The total economic impact generated by these activities alone is likely to have been substantial, as are the related earnings for companies and households. Although the quantification of this value is beyond the scope of this study, it is clear that filming and photography in the Mojave generate substantial economic benefits.

In addition, the Antelope Valley Film Office (2003) reports that they tracked over 220 productions that were carried out in the Antelope Valley area in FY 2002-03, with a total estimated local economic impact of $3.3 million. The same report (Antelope Valley Film Office, 2003) also cites Motion Picture Association of America data that put the film industry related payroll in the Antelope Valley at $96 million in 2000, with an additional $4 million in vendor services. It must be noted, however, that it is unclear how many of these productions were attracted specifically by Mojave Desert features (scenery, open space). Hence, it is impossible to ascertain what share of the economic benefits can be attributed to the desert.

Nevertheless, it is clear that it is the desert's features that attract a number of productions that generate economic impacts of major local significance. For example, in 2003, Kill Bill Vol. 2, was filmed near Barstow, Lancaster and Victorville, with a production budget of $30 million; Hulk was filmed near China Dry Lake and Victorville, with a production budget of $120 million; and

Jarhead was filmed at the Southern California Logistics Airport, with a production budget of $70 million.[66] All of these brought local revenues in the form of lodging and restaurant sales, as well as direct employment in the production, and associated multiplier effects on output and earnings.

Table 33: Film and photography permits and revenues on public lands in the Mojave, 2003

	Number of permits	*Revenue from fees*
NPS lands		
Death Valley NP	~30	~$5,000 [1]
Joshua Tree NP [2]	36	$11,110
Mojave NPr	1	$1,675
BLM lands [3]		
Inyo County	28	$20,458
Kern County	4	$4,225
Los Angeles County	0	0
San Bernardino County	184	$115,644
Department of Defense		
Edwards AFB [4]	~31 [5]	n.a.[6]
Total		$158,112

Notes: [1]Death Valley National Park issued about 30 permits at a $210 application fee each. Many films were educational, and fees were waived. [2] Film and photography permits. [3]Film and still photography shoots, including feature films, television commercials, television shows, student projects, music videos, still photography, art and music workshops, and a film festival. Fees include processing and monitoring fees. Some permits may have been cancelled but application fees were still paid. [4]Over the years, Edwards AFB has supported several major films such as *Deep Impact* (1998), *Race to Space* (2001), and *Armageddon* (1998), television shows such as *Monk* and *JAG*, music videos, and military documentaries. [5]About 30 documentaries and one music video were supported at Edwards AFB in 2003. [6]The Department of Defense does not charge film or photography permit fees.
Sources: Personal communication with: Don Roberts, Special Programs Ranger at Joshua Tree National Park, September 8, 2005; Danette Woo, Mojave National Preserve, July 15, 2005; Dave Rhinehard, Business Manager of Death Valley National Park, July 19, 2005; Sonia Santillan, California BLM, July 14, 2005; and John Haire, NH III DAF, Director of Media and Entertainment Liaison at the USAF Flight Test Center at Edwards Air Force Base, August 1, 2005.

Other direct use values of the Mojave

The preceding sections of Part III of this report have highlighted the most commonly considered and the most easily quantifiable benefits the Mojave provides to humans. However, as indicated in Table 1, the Mojave serves a number of additional activities. Two of these are its use for educational and scientific research purposes. These are heavily concentrated in the wilderness areas of the Mojave. Although the economic value of the educational and scientific research benefits of wilderness areas in the U.S. has not received much attention, several studies exist that have attempted to put a monetary value on these benefits (see for example Loomis and Richardson, 2000, 2001; Richardson, 2004). Richardson (2004) documents the extent of use of

[66] Internet Movie Database, *www.imdb.com*.

the Mojave by high school classes, California State University courses, and others, and estimates that total educational use amounts to some 24,000 education user days. Mojave ecosystems also provide sometimes unique opportunities for scientific research. The University of California and California State University both operate research and study centers in the Mojave that are used for research purposes by independent scientists and university groups, with a total annual use of more than 7,500 user days, of which average of 50 percent are spent on wildland-related activities. The economic value of scientific research in the Mojave is difficult to quantify, although one can probably safely assume that it is positive. At a very minimum, the expenditures of researchers in the Mojave inject dollars into the local economy. In addition, to the extent that the researchers spend at least part of their stay in the desert outdoors, they also receive some recreation benefits. However, here we do not attempt to quantify these benefits in monetary terms.

Option value of the Mojave Desert

The values discussed in the preceding sections all correspond to the direct use of the Mojave in the form of extractive or non-extractive recreation, living, renewable energy generation, agriculture, and film and photography. More specifically, the value estimates we have developed up to this point measure the economic value that present users of the Mojave assign to their specific uses. However, the economic literature shows that people also attach value to the availability of resources for potential future use, even though they may not presently be using those resources or are uncertain of whether or not they will do so in the future. Although this so-called option value applies to all potential direct uses of the Mojave, the theoretical (Weisbrod, 1964; Krutilla, 1967) and empirical literature (see for example Walsh *et al.* [1984] and Barrick and Beazley [1990]) have suggested and confirmed, respectively, its importance in the case of the preservation of scenic, undeveloped areas such as National Parks and Wilderness areas. These studies also showed that, although option value is generally decreasing with distance from the locale and is often small on a per-capita level, it accounts for a non-negligible portion of the total economic value of protected natural areas.[67]

Richer (1995), in his 1993 study elicited Californians' willingness to pay for increased protection of desert lands in the Mojave. His WTP estimates include the option value of future recreation and other uses in the Mojave. Unfortunately, that study did not decompose total economic value into its direct use, indirect use, option, and non-use components. In addition, what Richer examined was not the value of potential future desert uses, but rather the *increase* in the value of changes in potential future uses of the desert that would come about through strengthening of the protected status of a large portion of the Mojave.[68] Richer estimated the total WTP in 1993 of

[67] For example, Barrick and Beazley (1990) estimated that the total option value of preventing oil and natural gas development in the Washakie Wilderness area in Wyoming's Shoshone National Forest (adjoining the southeastern portion of Yellowstone National Park) to people in the U.S. not residing in the area was $3.6 billion at 1983 prices. Walsh *et al.*'s (1984) study indicates that the option value to Colorado households of additional Wilderness designations in that state accounts for between eleven and 14 percent of the total annual recreation and preservation value generated by the additional designations, or between $6.0 million and $10.2 million per year at 1980 prices, depending on the size of the additional designations.

[68] Richer (1995) examined the WTP of California residents for the protections proposed in California's Desert Protection Act of 1993, which included the establishment of three new National Parks (upgraded in status from National Monuments and National Scenic Areas, respectively) and 76 new wilderness areas in the California Desert.

California residents for the *increased* protection at $312.9 million per year, or $374.7 million per year in 2003 Dollars.[69, 70] For these reasons, it is not possible to estimate the option value of the Mojave desert based on existing local data. Nevertheless, an order-of-magnitude estimate can be constructed using a benefit transfer approach. Richer (1995) estimated that per-capita WTP for increased protection of the Mojave, from pre-California Desert Act levels to the level proposed in that Act (which is close to the present level), was an average of $101.4 for California residents in 1993, or $121.4 at 2003 prices. Taking into account that Richer's value estimate is for an *increment* in the protection of those desert areas, not for the *total* value of the desert, his WTP estimate is likely to underestimate the total value of the desert for the average California household. On the other hand, his estimate is likely to capture most of the option value because the proposed measure for which his study elicited respondents' WTP would lead to the permanent protection of the lands in the three new National Park units and would lead to a strongly increased protection of the lands proposed for wilderness status.

In their study of Colorado residents' total WTP for wilderness areas, Walsh *et al.* (1984) found that option value accounted for 15.4 percent of the total annual recreation use and preservation value that Colorado residents held for the State's wilderness areas. Given that the lands in Richer's study were proposed for designation as wilderness areas and National Parks, and that these lands account for a large share (6.9 million acres) of the total area of the Mojave, let us assume for the moment that Californians' option value for the Mojave accounts for the same share of their total WTP for desert protection as Colorado residents' option value of their total WTP for their state's wilderness areas, namely 15.4 percent. This would imply that the option value of the Mojave to the average Californian household is $18.7 per year in 2003 dollars.

To estimate the total option value of Californians who did not visit the Mojave in 2003, we need to subtract from the total population of the state's households those households that engaged in recreation activities in the Mojave in 2003. This leaves an estimated 10.26 million households in the state who did not engage in recreation in the desert in that year and whose WTP for the Mojave therefore is not captured in our recreation value estimates.[71] Multiplying this number by the average estimated annual option value of $18.7 per California household yields a total option

[69] Richer followed standard conservative value aggregation procedure by assuming that WTP of non-respondents and protest respondents was zero. In other words, the estimated total WTP of California households for the increased desert protection aggregates the mean per-capita WTP of $101 (1993 dollars) over only 28.6 percent of all California households.

[70] At the current (2003) population level, total WTP would be $429.8 million per year in 2003 dollars, assuming that per-capita WTP remained unchanged from its 1993 level.

[71] Available data on the origin of visitors (Le *et al.*, 2004a, 2004b; Littlejohn, 1997) indicate that the three NPS units in the Mojave received an estimated total of 1.59 million visitors from California in 2003. No information on place of residence is available for recreation visitors of BLM, State, and private lands in the Mojave. We assume that all of these visitors are from California, and that all of them only made one recreation trip to the Mojave in 2003. Both of these assumptions introduce downward biases into our estimate of the total passive use value of Californians who did not engage in recreation in the Mojave in 2003. Finally, to convert our estimate of Mojave recreation visitors from individuals to households, we assume that the visitors from California overall mirrored the structure of the average Californian household. We therefore divide the total number of Mojave visitors from California by the average California household size, which was 2.87 in 2000.

value of $55.1 million in 2003 for California households that did not engage in recreation activities in the Mojave.[72]

Obviously, this estimate is the result of several assumptions that are entirely reasonable, but nevertheless arbitrary. One can be fairly certain, however, that the true option value of those Californian households not visiting the Mojave in 2003 at the very minimum is of the same order of magnitude as our estimate. More likely, given the conservative nature in our choice of assumptions, our estimate of $55.1 million in 2003 understates the true magnitude of the option value of the Mojave to nonvisiting California households.

The Mojave is known nationally for its scenic beauty and its particular, unique attractions such as Death Valley, the Joshua tree and the National Park named after it, to name but a few.[73] For this reason, it is obvious that people beyond California appreciate the special nature of the Mojave. For precisely this reason the area attracts large numbers of visitors from the rest of the country. For example, in 2003, Death Valley National Park, Joshua Tree National Park, and Mojave National Preserve together attracted an estimated 454,700 U.S. visitors from states other than California. This is evidence of the fact that there exists WTP for the Mojave throughout the U.S. Estimates of the option value of U.S. residents not visiting the Mojave could be constructed analogously to our estimates for non-visiting California households. Before deriving such estimates one would need to determine whether, and to what extent, a person's option value for landscapes of special significance is a function of the distance of her place of residence from those landscapes.[74] In this study we do not attempt to construct estimates of the option value for the Mojave of U.S. households outside of California that are not visiting the area. We merely point out that these values exist, that they are likely to be large in aggregate even if they are small at the level of the individual, and that they should be included in a full economic analysis of the benefits provided by the Mojave (Richer, 1995).

2. Indirect use values of the Mojave Desert

Many of the ecosystem service values produced by the ecosystems in the Mojave (see Table 2) are already captured at least in part in our estimates of the economic value of recreation, agriculture, property open space premiums, filming, generation of renewable energy, and education. For example, the economic value of wildlife-based recreation is contingent upon the production of wildlife by the ecosystems in the Mojave. Likewise, the production of some agricultural produce depends on the pollination services provided by these ecosystems. Therefore, the value of these

[72] In deriving this estimate we made the very conservative assumption that only 28.6 percent of all California households hold non-use values for the Mojave. This was the percentage of all the state's households that Richer (1995) found to have a positive WTP for *increased* protection of the Mojave. It is reasonable to assume that at least some of those households who did not express a willingness to pay for *additional* protection of the Mojave nevertheless value the existence of the Mojave or the fact that this unique region is available for their children to experience.

[73] In fact, Death Valley and Joshua Tree National Park in particular are known internationally, as confirmed by the large number of international visitors to those locations. In 1996, over two-thirds of all visitors of then Death Valley National Monument were from outside of the U.S. (Littlejohn, 1997).

[74] Such "distance decay" has been observed for people's WTP for the protection of threatened and endangered species (Loomis, 2000).

services is embodied in the value of the outputs they help produce, in this case recreation and agricultural products.[75] [76] Of the remaining services, erosion control, or more specifically, the reduced ambient concentrations of airborne respirable particulate matter, and provision of water are the only ones for which monetary estimates can be compiled for our study area.

Human health benefits of erosion control by Mojave wildlands

Richardson (2004), in his study of the economic benefits provided by "wildlands" in the California Desert (including designated wilderness areas as well as BLM wilderness study areas, or WSA's) derives estimates of the erosion control services of desert wildlands. Unpaved desert roads are a significant source of airborne particulate matter. When inhaled, the smaller-sized fraction of these airborne particles has the potential to penetrate deeply into the lungs where it can cause a variety of negative health impacts.[77] In addition to premature mortality from cardiopulmonary causes, PM_{10} causes asthma attacks and may significantly reduce lung function growth in children (Avol *et al*., 2001; Gauderman *et al*., 2002; Peters *et al*., 2001; Pope *et al*., 2002; Samet *et al.,* 2000). In California, respirable airborne particulate matter (PM_{10}) is a serious health threat. The California Air Resources Board estimates that premature deaths from PM have reached levels comparable to those caused by traffic accidents and second-hand smoke (CARB, 2002). PM concentrations in California's desert region are particularly high because of the problem of wind-blown dust from natural, non-point sources, especially unpaved roads (Alexis *et al*., 2002). Wildlands in the Mojave reduce particulate emissions because they do not experience traffic on unpaved road surfaces. Traffic on unpaved desert roads destroys the fragile surface crust found on desert soils and leads to high rates of wind erosion of fine dust particles from those roads (Webb and Wilshire, 1980). Richardson (2004) estimates the value of the avoided health effects associated with the reduced emission rates of PM_{10} from wildlands at a total of $23.7 million (2003$) per year for Imperial, San Bernardino, Riverside, and Inyo Counties. Excluding Imperial County, which is not included in our analysis area, the total value of erosion control services provided by wildlands in our area is $23.0 million per year. This estimate includes the value of PM_{10}-related avoided hospital and emergency room admissions and avoided work loss days. It does not include the value of other avoided PM_{10} related health effects such as acute and chronic bronchitis and cardiovascular diseases, among others. Moreover, Richardson derives these health benefit estimates based on a study (Sharp and Walker, 2002) that employs a cost-of-illness approach to value health impacts. That approach does not include the value of the avoided suffering and inconvenience that result from avoided health impacts, or the cost of averting

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[75] Note however that generally, the value of the outputs is larger than the value of the ecosystem service inputs, because the latter are just one of several inputs. Labor, capital, and energy are needed in addition to ecosystem service inputs in order to produce the respective outputs.

[76] Even though some of the benefits generated by ecosystem services can conveniently be captured through valuation of the final products into which the ecosystem services have become incorporated (wildlife-based recreation activities, agricultural products, etc.), it is important to keep in mind that the value of these outputs is in fact due in part to the underlying ecosystem services.

[77] The environmental health and medical literature commonly identifies particles with an aerial diameter of less than ten microns (µm) as those of concern for human health. These particles are referred to as respirable particles PM_{10}.

behavior, and therefore results in a low estimate of the health benefits of avoided particulate-related negative health impacts.[78]

Some of the ecosystem services provided by the Mojave are not captured in our estimates. These include carbon sequestration and biodiversity maintenance. The value of carbon sequestration could be estimated on the basis of the increase in 2003 in the carbon stored in the Mojave's biota and soils.[79] The total increase in the carbon stored in the Mojave bioregion can then be valued. This valuation ideally should be based on the marginal contribution of the removed carbon to the avoided future damages from increased atmospheric carbon concentrations. Alternatively, and much less demanding, it could be estimated on the basis of the value the associated carbon credits could fetch on carbon markets.[80] Putting a monetary value on biodiversity is far less straightforward. Preservation of biodiversity carries a number of potential economic values. These can be distinguished into the market value of biological resources used as raw materials and of wildlife-based extractive and non-extractive recreation, including the value of future drugs based on animal or plant species; the value of the reduced risk of major agricultural losses from insects or pathogens developing resistance to pesticides[81]; the passive use value people assign to intact ecosystems and particular species; and the value of the ecosystem services provided by biodiversity (Gowdy, 1997; Millennium Ecosystem Assessment, 2003; United Nations Environment Programme, 2005).

Some of the values of the *present* direct and indirect uses of biodiversity are captured in our direct use and passive use value estimates. However, many are not, and their quantification is challenging due to limitations in humans' knowledge of the importance of biodiversity to individual and societal welfare (Vatn and Bromley, 1995; Gowdy, 1997). In particular, the total value of the ecosystem services provided by biodiversity is largely unknown, and is perhaps unknowable, due to a lack of knowledge, the presence of fundamental uncertainties and irreversibilities, and the inability of valuation methodologies to overcome these challenges (Vatn and Bromley, 1995).[82] This certainly also applies to the value of the biodiversity maintenance services provided by the Mojave.

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78 In most instances, the WTP of the affected individuals is a superior indicator of the value of avoided negative health impacts (U.S. Environmental Protection Agency, 2000). Valuing the benefits of avoided health effects using WTP generally leads to higher benefit estimates (see for example Cesar *et al*., 2002; Kroeger, 2002).

79 The carbon sequestered in the agricultural products produced in the Mojave should not be included in this analysis. It is not truly removed from the carbon cycle because it reenters this cycle within a relatively short period.

80 This approach is not contingent upon the ratification by the U.S. of international carbon agreements. Carbon markets in the U.S. already exist, and credits can already be traded on the Chicago Stock Exchange.

81 Agricultural pest control and the development by the pests of resistance to those controls has been a continuous process since the development of large-scale agriculture. Major components of the world's food base such as commercially dominant varieties of rice and corn at various times have benefited heavily from the incorporation of particular disease resistance genes found in their wild varieties.

82 The presence of large uncertainties and of irreversibilities of changes in ecological systems has led many economists to call for the use of the Safe Minimum Standard (SMS) in biological diversity policymaking instead of the use of cost-benefit-based analyses. See for example Bishop (1978, 1993), Bulte and Van Kooten (2000), Ciriacy-Wantrup (1952), and Pagiola *et al.* (2004).

Benefits of human uses of Mojave water

Although a semi-arid to arid environment, the Mojave does represent an important source of water for many local communities. In-basin withdrawals of water come primarily from underground aquifers. These aquifers are replenished by rainwater that percolates through the soil and by the surface and subsurface flows that enter the area. For example, Barstow is dependent for its water on an aquifer that is fed primarily by the north flowing Mojave River, while California City is dependent for its withdrawals on rain-fed aquifers.[83] In addition to natural percolation-based replenishment, water from the California aqueduct is injected into aquifers for temporary storage (water banking) and replenishment. For example, the Kern Water Bank manages one of the largest active recharge projects in the United States (Meillier et al., 2001). Temporary water storage in aquifers carries an economic benefit because it allows improved management of water flows through time and thereby improves allocation of scarce water to different uses. It is beyond the scope of the present study to attempt to quantify the benefits associated with water banking.

An assessment of the value of the water provisioning services of the Mojave requires an analysis of the marginal contribution that Mojave water is making to the economic net benefits of the various end uses to which it is put (Hanemann, 2005).

Water use

Our estimate of total water use in our study area is derived from information provided in the California Water Plan Update 2005 (California Department of Water Resources, 2005). The most recent water budget reported in that plan is for the year 2001. We base our estimates of the value of human uses of Mojave water in 2003 on these 2001 data. Given the increase in population in the Mojave between 2001 and 2003, total water use likely was higher in 2003 than in 2001. This introduces a downward bias into out value estimates.

The Mojave Bioregion is roughly coextensive with California's South Lahontan Hydrologic Region (see Figure 12), which comprises five planning areas. The major part of one of those areas, the Mono-Owens Planning Area, lies predominantly outside of our study area. On the other hand, the Mojave Bioregion comprises the Twentynine Palms Planning Area located in the Colorado River Hydrologic Region. We subtract and add, respectively, the water use in these two areas from that of the South Lahontan Hydrologic Region to derive total water use for the Mojave Bioregion.

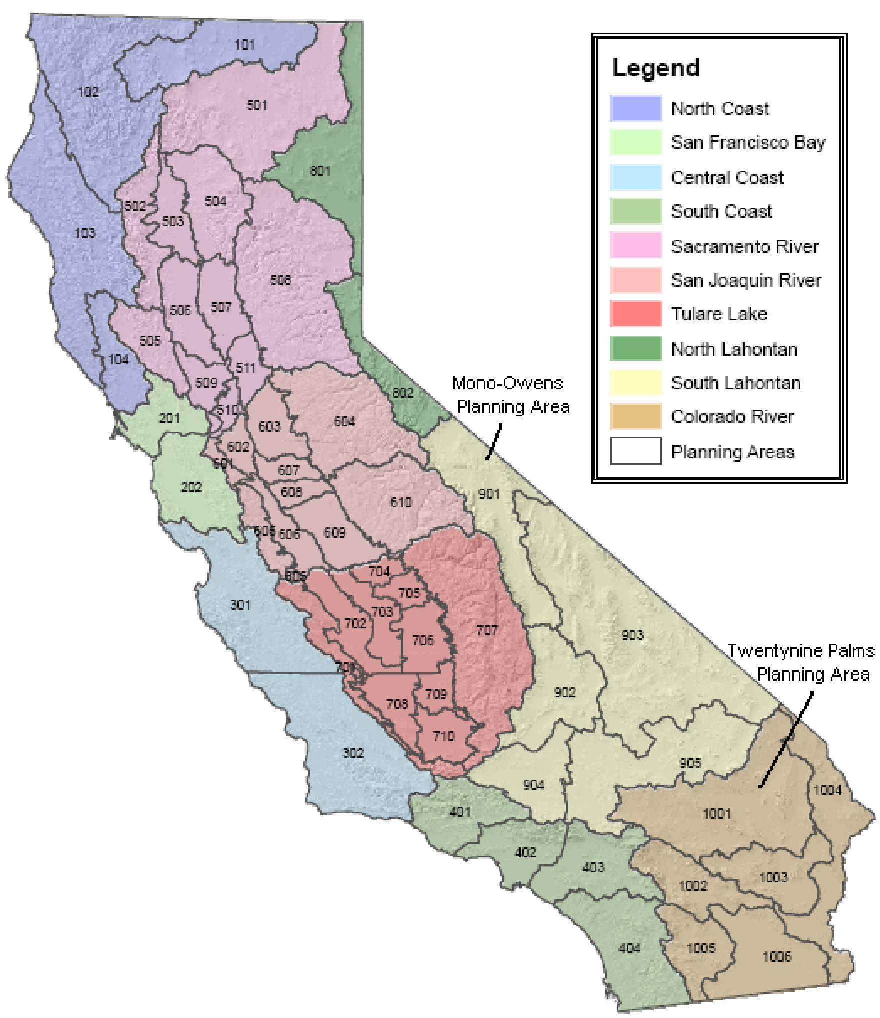
In 2001, the latest year for which data are available, total net use of ground and local surface water in the Mojave Bioregion was an estimated 207,100 acre feet, with groundwater accounting for almost 97 percent of the total (see Table 34).[84] This number does not include any use of

[83] Pers. comm. with Scott Priester, Chief City Planner, Barstow, 21 April, 2005; pers. comm. with Mike Edmiston, City Council, California City, and William Way, Jr., City Manager, California City, 24 March 2005.

[84] The California Water Plan (California Department of Water Resources, 2005) defines net water use or demand as "the amount of water needed in a water service area to meet all requirements or demands. It is the sum of several components including evapotranspiration of applied water in an area, the irrecoverable water from the distribution system, and the outflow leaving the service area; does not include reuse of water within a service area."

California State Water Project (SWP) water, which amounted to 81,900 acre feet in 2001. SWP water is used primarily in the southwestern part of the Mojave Bioregion and is distributed by the Antelope Valley East Kern Water Agency.

Urban and agricultural use each accounted for approximately half of total net water use in the Mojave Bioregion in 2001, with shares of 49 percent and 51 percent, respectively, of total net use (Table 35).



Source: Scott Hayes, 31. Oct. 2005, *http://landwateruse.water.ca.gov*

Figure 12: Hydrological regions and water planning areas in Southern California

In addition to ground and surface water, California SWP water is used in some water planning areas in the region. However, SWP water is a significant share of total net water use only in the Antelope Valley planning area, where it accounts for slightly over half of all net water use (Table 36).

Table 34: Dedicated net ground and surface water supplies in the Mojave Bioregion, 2001 (includes no SWP water)

Hydrologic Region/Planning Area	*Groundwater use (acre-feet)*	*Surface water use (acre-feet) **
South Lahontan Hydrologic Region	299,000	46,800
- Mono-Owens Planning Area	-114,900	-40,000
+ Twentynine Palms Planning Area	16,200	0
Total	200,300	6,800

Note: * Does not include environmental instream flows or recycled water.
Sources: California Department of Water Resources (2005a, 2005b, 2005c).

Table 35: Urban and agricultural net water use in the Mojave Bioregion, 2001

Hydrologic Region/Planning Area	*Urban use (acre-feet)*	*Agricultural use (acre-feet)*
South Lahontan Hydrologic Region	155,500	301,700
- Mono-Owens Planning Area	-7,500	-148,400
+ Twentynine Palms Planning Area	8,500	9,800
Total	156,500	163,100

Sources: California Department of Water Resources (2005a, 2005b, 2005c).

Table 36: Urban and agricultural use and SWP deliveries in Mojave Bioregion in 2001, by water planning area

Water Planning Area	*Urban use*	*Agriculture use*	*SWP*	*SWP as % of total urban and agricultural net use*
	1000 ac.ft	*1000 ac.ft*	*1000 ac.ft*	
Antelope Valley	78.2	60.7	76	55%
Mojave River	59.6	79.1	5.6	4%
Death Valley	0.3	7.8	0	0%
Indian Wells	10	5.7	0.3	2%
Twentynine Palms	8.5	9.8	0	0%
Total	156.6	163.1	81.9	26%

Sources: California Department of Water Resources (2005a, 2005b, 2005c).

In the absence of specific information on the allocation of SWP water to the various uses, we assume that SWP water is devoted evenly to urban and agricultural uses. For each Planning Area, we therefore reduce the quantities of total water used in urban and agricultural uses shown in Table 36 by half of the amount of SWP water used in the Area. We make this adjustment because SWP water is not generated in the Mojave and as such the value associated with it cannot be attributed to the latter.

The value of Mojave water

We use the market prices of water to construct our estimate of the value of water in urban and agricultural uses in the Mojave. We realize that because of the special nature of water (Hanemann, 2005) market prices often may not reflect the true value of water for society. Nevertheless, they allow us to generate a lower bound estimate of that value. In addition to urban and agricultural uses, Mojave water also contributes to a variety of environmental uses, such as instream flow and wetland maintenance. The value of these environmental uses to a large extent already is captured in our estimates of the value of water-related recreational activities.

The prices of urban and agricultural water vary throughout the study area. For urban uses, the cost of water is composed of a fixed monthly charge and a quantity charge, with the quantity charge either flat or increased block type. We were able to obtain information on the cost of municipal water uses for the major towns and cities in the study area (Table 37). In order to derive an estimate of the total user cost of urban water use in our study area, we multiply the quantity of water used in each Water Planning Area (see Table 36) by the population-weighted average of the quantity charges of the towns and cities in the respective Area for which that information was available. Using the average rates reported by Black and Veatch (2004) inevitably leads to errors in our total water user cost estimate. The average rates reported by the source are based on an assumed consumption of 1,500 cubic feet per month. Given that in several cities and towns increasing block rates are employed and that actual individual and average consumption in most cases is not 1500 cubit feet, multiplying total water consumption by these average rates inevitably leads to errors. Nevertheless, there exists no alternative to our approach when the goal is to estimate total water user cost.

Table 37: User cost of urban water use in the Mojave Bioregion, 2003

Service area	*Rate type*	*Fixed monthly service charge ($)*	*Incremental cost ($/ac. ft)**	*Average monthly residential usage (hcf)*
Apple Valley	R2	23.00	204	27
Barstow	R5	13.75	541	28
Hesperia	R7	13.20	240	24
Joshua Tree	R5	22.00	900	10
Needles	R2	23.00	0	16
Palmdale	R4	11.67	314 [a]	n.a.
Ridgecrest	R7	11.77	146	29
Twentynine Palms	R5	11.03	671	12
Victorville	R7	13.50	191	29
Yucca Valley	R7	21.50	1406	10

Notes: ac.ft. – acre foot; hcf – hundred cubic feet; n.a. – not available; R2 - base charge includes water allowance, plus uniform rate; R4 - base charge includes water allowance, plus tiered rate; R5 - Base charge excludes water allowance, plus uniform rate; R7 - Base rate excludes water allowance, plus tiered rate. Urban use includes residential, commercial, and industrial uses. [a] Assumes base rate, not higher elevation rates. *Based on a use of 1500 cubic feet per month.
Sources: Black and Veatch (2004); Palmdale Water District (2005).

We derive fixed costs by multiplying the number of households in each city or town in the study area by the applicable service charge. In calculating fixed water charges for cities and towns for which no information was available, we use the lowest fixed water cost found in our study area.

Total estimated quantity charges for urban water users in our study area in 2003 were $34.24 million. Total service charges were an estimated $33.69 million. The combined total cost to urban water users was $67.90 million, or approximately an average of $28 per household per month. These estimates exclude inhabitants of unincorporated areas.

The average cost of water for agricultural users in the Mojave is impossible to determine. This is due to the fact that some users operate their own groundwater wells, that both treated and untreated water are used, and the scarcity of available up to date data on agricultural water rates in the South Lahontan Hydrologic Region (Table 38).[85]

Users pumping their own groundwater potentially may have substantially lower water costs. However, using those costs when estimating the agricultural value of water would be misleading. The market price of agricultural water is a superior indicator of the value of water for agriculture, because it more closely reflects the WTP of agricultural users.

Table 38: Selected water rates for agricultural users

Supplier	*Rate ($/ac.ft)*	*Rate type*
Metropolitan Water District of Southern California	443	Full service rate
Metropolitan Water District of Southern California	329	Interruptible agricultural water program (IAWP) wholesale rate
Antelope Valley East Kern Water Agency	351 [*280*]	First priority, treated [*untreated*], delivered under terms of water service agreements from agency-owned facilities
Antelope Valley East Kern Water Agency	251 [*182*]	Second priority, treated [*untreated*], delivered under terms of water service agreements from agency-owned facilities
Antelope Valley East Kern Water Agency	251 [*182*]	Second priority, treated [*untreated*], surplus water delivered under terms of irrigation water service agreements from agency owned facilities

Sources: Metropolitan Water District of Southern California (2005); Antelope Valley East Kern Water Agency (2006).

Most of the agricultural production in the Mojave Bioregion is taking place in the Antelope Valley. We therefore use the Antelope Valley East Kern Water Agency rates for our estimates. Due to the price difference between treated and untreated water and the lack of information on the share of each, we develop two scenarios. The first uses the rate for first priority, treated water

85 The 1994 California Water Plan Update did list an average cost of $20 per acre foot for groundwater in the South Lahontan Hydrologic Region in 1991. However, the current Plan (California Department of Water Resources, 2005a) does not include the South Lahontan Region.

of $351 per acre foot as the average cost of water to agricultural users in the Mojave. The second uses the rate for second priority, untreated surplus water of $182 per acre foot (see Table 38).

The total value of Mojave ground and surface water to agricultural users was an estimated $42.87 $million in 2003 under scenario 1, and $22.23 million under scenario 2. Even though these values are substantial, they do not reflect the full value of water used in agriculture, because agricultural water in California in many instances is subsidized. According to one estimate, these subsidies for agricultural water amounted to an average of $30 per acre foot of water in 1997 in the South Lahontan Region (Sumner and Hart, 1997). Using Sumner and Hart's subsidy estimate adjusted to 2003 prices, the total value of the agricultural water subsidy in the Mojave was en estimated $4.06 million in 2003.

The combined value of Mojave water to urban and agricultural uses in 2003 is estimated at between $90.2 million and $110.8 million (Table 39). These values represent the gross value of water to urban and agricultural uses. In order to derive the net value of Mojave water to society one needs to subtract from these values the costs associated with using that water, that is, the cost of installing, maintaining and operating the water delivery infrastructure.

Table 39: Total estimated value of surface and groundwater used in the Mojave Bioregion in 2003

Type of use	*Value (Million $)*	
Urban uses	67.9	
Agricultural uses	Low estimate: 22.3	High estimate: 42.9
Total	90.2	110.8

No estimates of these costs are available for the Mojave Bioregion. However, our gross value estimates are likely to be substantial underestimates of the total value of water in the Mojave in 2003, given that water currently is priced too low in the region and that our value estimates are based on market prices and therefore do not capture the consumer surplus (CS) of Mojave water for users. Our estimates therefore reasonably could be expected to be approximations of the net value of water to Mojave users rather than the gross value, or at least to fall in between the two.

The current rate of groundwater use in the Mojave is not sustainable, as is evidenced clearly by the dramatic depletion of groundwater aquifers in the region (California Department of Water Resources, 2005a). The strong growth in residential development in the Mojave has the potential to exacerbate this problem. From an economic perspective, water currently is priced too low in the region, leading to large volumes of water devoted to non-essential uses such as landscaping.[86] Current prices therefore underrepresent the true value of water. This situation inevitably will change as natural constraints are being approached. Already in the last several years, water prices in the South Lahontan Region have been rising faster than overall prices.

[86] In 2001, an estimated 40 percent of total residential water use in the South Lahontan Hydrologic Region was used in exteriors (California Department of Water Resources, 2005a).

3. Non-use values of the Mojave Desert

As shown in Table 1, non-use values are the final remaining component of the Mojave's Total Economic Value. Estimates of the existence, stewardship, and bequest values received by people recreating in the Mojave are captured in the WTP estimates of recreationists (sum of travel costs and consumer surplus). However, many people who do not visit the Mojave nevertheless are familiar with it to a lesser or higher degree, and may value it for its visual beauty and unique character. The non-use values of these people are not captured in any of our value estimates presented in the preceding sections, and need to be estimated separately.

As with option values of future Mojave uses, Richer (1995) captures the non-use values of California residents (see above). However, the non-use values of residents in the remainder of the country who do not visit the Mojave landscape and its ecosystems are likely to be substantial as well. For example, the findings of a study by Champ *et al.* (1997) indicate that there exists a substantial WTP among Wisconsin residents to improve the scenic attractiveness and wilderness character of the North Rim of the Grand Canyon.[87]

An order-of-magnitude estimate of the passive use value of the Mojave for residents in the rest of the state can be constructed by combining Richer's (1995) findings with those of Walsh *et al.* (1984). Richer estimated that per-capita WTP for increased protection of the Mojave, from pre-California Desert Act levels to the level proposed in that Act (which is close to the present level), was an average of $101.4 for California residents in 1993. Adjusting for inflation, this translates into $121.4 at 2003 prices. Taking into account that Richer's value estimate is for an *increment* in the protection of those desert areas, not for the *total* value of the desert, his WTP estimate is likely to underestimate the total value of the desert for the average California household. On the other hand, his estimate is likely to capture most of the bequest and stewardship values because the proposed measure for which his study elicited respondents' WTP would lead to the permanent protection of the lands in the three new National Park units and would lead to a strongly increased protection of the lands proposed for wilderness status. As already mentioned, Richer does not decompose this total WTP into the different components of economic value. However, Walsh *et al.* (1984) did just that in their study of Colorado residents' total WTP for wilderness areas. They found that existence and bequest value together accounted for 38.2 percent of the total annual recreation use and preservation value that Colorado residents held for the State's wilderness areas. Given that the lands in Richer's study were proposed for designation as wilderness areas and National Parks, and that these lands account for a large share (6.9 million acres) of the total area of the Mojave, let us assume for the moment that Californians' non-use value for the Mojave accounts for the same share of their total WTP for desert protection as Colorado residents' non-use value of their total WTP for their state's wilderness areas, namely 38.2 percent. This would imply that the non-use value of the Mojave to the average Californian household is $46.4 per year in 2003 dollars. Obviously, this is an average – some people who do not visit the Mojave are likely to have a zero WTP for the desert, while others may value it at substantially more than $46 per year.

[87] The proposed measure presented to respondents was a road removal program along the North Rim before designating the area as a wilderness area (Champ *et al.*, 1997). The estimated willingness to donate for this program was $9 per capita (1994 dollars) for the average Wisconsin resident. Assuming a zero WTP for non-responses, this translated into a total WTP of Wisconsin residents for the proposed measure of $7 million.

To estimate the total passive use value of Californians who did not visit the Mojave in 2003, we need to subtract from the total population of the state's households those households that engaged in recreation activities in the Mojave in 2003. This leaves an estimated 10.26 million households in the state who did not engage in recreation in the desert in that year and whose WTP for the Mojave therefore is not captured in our recreation value estimates.[88] Multiplying this number by the average estimated annual passive use value of $46.4 per California household yields a total passive use value of $136.3 million in 2003 for California households that did not engage in recreation activities in the Mojave.[89]

As in the case of our option value estimate, this estimate is the result of several assumptions that are reasonable but to some degree arbitrary. Again, one can be fairly certain that the true passive use value of those Californian households not visiting the Mojave in 2003 at the very minimum is of the same order of magnitude as our estimate. More likely, given the conservative nature in our choice of assumptions, our estimate of $136.3 million in 2003 likely understates the true non-use value of the Mojave to nonvisiting California households.

As is the case with the option value of the Mojave, it is clear that people throughout the country also assign existence and stewardship values to the Mojave or to particular components of it. These values are not captured in the value estimates presented in the preceding parts of this report. We briefly outlined a possible approach for the estimation of these passive use values in our discussion of the option value of the Mojave for households not residing in California. As with option value, do not attempt to quantify existence and stewardship values of the Mojave for households in the rest of the country that do not visit the Mojave, but merely emphasize that these values exist, are likely to be substantial, and would need to be included in a complete analysis of the economic value of the Mojave.

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[88] Available data on the origin of visitors (Le *et al.*, 2004a, 2004b; Littlejohn, 1997) indicate that the three NPS units in the Mojave received an estimated total of 1.59 million visitors from California in 2003. No information on place of residence is available for recreation visitors of BLM, State, and private lands in the Mojave. We assume that all of these visitors are from California, and that all of them only made one recreation trip to the Mojave in 2003. Both of these assumptions introduce downward biases into our estimate of the total passive use value of Californians who did not engage in recreation in the Mojave in 2003. Finally, to convert our estimate of Mojave recreation visitors from individuals to households, we assume that the visitors from California overall mirrored the structure of the average Californian household. We therefore divide the total number of Mojave visitors from California by the average California household size, which was 2.87 in 2000.

[89] In deriving this estimate we made the very conservative assumption that only 28.6 percent of all California households hold non-use values for the Mojave. This was the percentage of all the state's households that Richer (1995) found to have a positive WTP for *increased* protection of the Mojave. It is reasonable to assume that at least some of those households who did not express a willingness to pay for *additional* protection of the Mojave nevertheless value the existence of the Mojave or the fact that this unique region is available for their children to experience.

IV. Conclusion

The Mojave Desert in California is a region that provides a wide variety of benefits to human society. Some of the uses that produce these benefits take a direct form, such as recreational activities, housing, production of renewable energy, agriculture, and filming and photography, among others. Other uses occur indirectly, as in the case of erosion control services performed by wildlands that lead to the avoidance of negative health impacts from increased concentrations of airborne particulate matter. Finally, some uses take a passive form, in the sense that they do not actually involve any physical presence of the users in the Mojave. The values associated with such passive use are commonly referred to as existence, stewardship, and bequest values, which represent the benefits people obtain from knowing that treasured species, ecosystems, or landscapes exist, and are maintained and passed on to future generations. All of these uses contribute to human well-being and generate associated economic benefits. Some of these benefits are reflected in market values while others are not. Unfortunately, those benefits that involve products and services not directly bought and sold in markets are often not included in economic analyses. The omission of these benefits from economic analyses and public policy deliberations carries the danger that the uses that produce these benefits often are not considered economically valuable, when in fact they can be very valuable.

The goal of this report is to provide an assessment of the full range of economic benefits provided by the Mojave Desert. Evidently, as with any analysis of this scope, our efforts were constrained by the limited resources available for the task at hand. Given these limitations, one of our objectives was to outline the conceptual framework for a truly comprehensive assessment of the economic benefits produced by the Mojave. Based on this framework, the unavoidable gaps in the benefits quantified in the present study can be filled in by future research.

Our analysis considers the complete range of the different types of economic values associated with the various human uses of the Mojave. Although all of these value types, that is, direct use, indirect use, and passive use values, are of equivalent importance from an economist's perspective, different users of this report may be interested more in some of these values than in others. For this reason, our aim was to discuss the use values, indirect use values, and passive use values of the Mojave separately. In addition, we distinguish between those benefits associated with uses of the Mojave that are reflected in market transactions, and those that are not. Some uses are not reflected in markets because they are not tied to goods or services that are bought or sold. The lack of a market for a particular use in no way implies a lack of value of the respective use (Hanemann, 2005).

In order to derive an estimate of the contribution that human use of the Mojave makes to people's well-being, we first derived estimates of the total benefits associated with that use. However, these gross benefits are not an adequate measure of the net benefits, or increase in human well-being, brought about by human activities in the Mojave, because they include the value of the inputs that went into the "production" of these total benefits.[90] Rather, in order to

[90] For example, let us assume that someone engaging in a recreation trip in the Mojave values that experience at $100. This then is her gross benefit associated with that trip. If she spends $60 on inputs that make that trip possible, then her net benefit, or what commonly is referred to as her consumer surplus, from the trip is only $40. This $40 is the true measure of the benefits she receives from the trip.

derive net benefits, the costs associated with those uses of the Mojave need to be subtracted from the gross benefits. Table 40 presents both gross benefits and net benefits, differentiated by type of value and by whether or not the respective benefits are reflected in markets (indicated in blue in the table) or not. The table also indicates what measure was used to estimate net benefits: consumer surplus, producer surplus, earnings, profits, and WTP.

Total (gross) benefits include the monetary values that people assign to direct, indirect, and passive uses of the Mojave. They also include the multiplier impacts these uses cause in the regional economy. For example, recreational users who visited the Mojave in 2003 valued their recreation activities in the Desert at an estimated $338 million. This total value comprises their trip expenditures and the consumer surplus, or net benefit, they received from visiting the Mojave. The trip expenditures enter the regional economy and produce direct, indirect and induced effects on output and earnings. These impacts on the regional economy in turn produce net benefits for firms (in the form of increased profits) and households (in the form of increased utility). Output is not a meaningful indicator of benefits, therefore the respective gross benefits expressed in the form of output are placed in square brackets in Table 40. They are included in the Table solely for purposes of indicating the total volume of market activity generated by the different uses of the Mojave. As already indicated, the relevant measure of the economic value of the uses of the Mojave are the net benefits provided by the various uses, that is, consumer surpluses and producer surpluses.

An estimation of the true net benefits of the regional economic activity that is generated by the expenditures associated with the direct uses of the Mojave would require information on the WTP of the affected individuals to obtain the additional earnings derived from that activity, or, alternatively, information on the utility functions of the affected households. In the absence of either of these, the earnings themselves can serve as an upward-biased estimate of the monetary value of the net benefits produced by the multiplier effect. Using earnings results in an upward biased estimate of net benefits because earnings do not account for the costs households incur in the process of obtaining these earnings, that is, of the opportunity cost of work and capital.[91]

The examined uses of the Mojave in 2003 generated total net benefits of an estimated $1.4 billion. The largest net benefits at the regional level were produced by military uses, (41 percent), recreation (31 percent), passive use and option values to California households (10 percent and 4 percent, respectively), ecosystem services (9 percent), and open space premiums on house prices (6 percent). Of these total net benefits, $1.1 billion, or approximately 80 percent, were captured in markets, in the form of profits, earnings, property value increases, or avoided medical costs.[92] The absolute and especially the relative size of these benefits should be interpreted with caution, however, given that in many cases we were not able to fully quantify benefits associated with a given use, and that benefits of some uses were not quantified at all.

[91] This opportunity cost includes the value of leisure as well as the required inputs for work, such as work-related travel expenses.
[92] Earnings comprise wages and salaries, proprietors' income, directors' fees, and employer contributions for health insurance less personal contributions for social insurance.

Table 40: Total monetary value of regional benefits generated by Mojave uses in 2003*

	Benefits	*Net Benefits*		
	Million 2003$	*Million 2003$*	*%*	*measure*
Direct use values				
Recreation value				
- to recreationists	337.7	99.9	7.0	CS
- to regional economy [1]	[1,163.4]	338.8	23.8	Earnings
Open space house price premiums near wilderness areas[2]	84.0	84.0	5.9	Price
Military uses [3]	n.a.	>585.0	41.1	Earnings
Agricultural value	[214.0]	>0 [4]		Price
- multiplier effects of agricultural inputs	>0 [5]	>0 [5]		
Film industry				
- fee and permit revenue only	0.2	0.2	0.0	Earnings
- avoided costs of alternative "settings"	>0 [5]	>0 [5]		
- local earnings from productions	>0 [5]	>0 [5]		
Option value of CA households not visiting the Mojave	55.1	55.1	3.9	WTP
Option value of rest of U.S. households not visiting the Mojave	>0 [5]	>0 [5]		
Indirect use values				
Ecosystem service value:				
- health benefits of erosion control by wildlands	23.0	23.0	1.6	Avoided cost
- benefits of water use				
- urban	> 67.9	67.9	4.8	Price
- agricultural [6]	>22.2-42.9	22.2-42.9	2.3	Price
- biodiversity maintenance, crop pollination, etc.	>0 [5]	>0 [5]		
Passive use values				
Existence and stewardship values of CA households not visiting the Mojave	136.3	136.3	9.6	WTP
Existence and stewardship values of U.S. households not visiting the Mojave	>0 [5]	>0 [5]		
Total		1,422.7 [7]	100	
...of which reflected in markets:		1,131.5 [7]	79.5	

Notes: *For a discussion of the value of the renewable energy produced in the Mojave, please refer to the appendix. All values are for benefit flows produced in 2003. Benefits of non-market values represent total economic value; benefits of market values represent output. Net benefits of non-market values represent consumer surplus; net benefits of market values represent earnings. Benefits highlighted in blue are those registered in market transactions and values. [1] Earnings from trip expenditures and OHV related equipment expenditures. [2]This is the gain in open space premiums accruing to private properties in San Bernardino County in 2003. Rather, it represents the total value of the open-space premium in 2003. [3]Twentynine Palms Marine Corps Base only. [4]Not calculated due to lack of input cost estimates. [5]Not quantified. [6]These values do not include the value of subsidies for agricultural water. [7]Based on the average of the agricultural water values.

In most cases, our estimates are lower bound values, due to the generally conservative nature of the assumptions made in generating them. This, in combination with the benefits omitted from our analysis, makes our total benefit estimate very conservative. Even so, our analysis indicates that the net benefits generated by human use of the Mojave are substantial. Switching from an economic value to an economic impact perspective, the uses of the Mojave analyzed in this report in 2003 generated a total output in the regional economy of close to $1.5 billion (excluding the economic impact associated with base salaries), and total earnings of $339 million from recreation activities alone. Furthermore, in 2003 the gain in property value from open-space amenity premiums received by properties close to wildlands amounted to an estimated $84 million in San Bernardino County alone.

It is important to note that the benefits listed in Table 40 do not include the option and passive use values that people outside of California hold for the Mojave. In addition, activities in the Mojave generate economic impacts beyond the artificial boundary we chose in our economic impact analysis, namely, the four-county area composed on Inyo, Kern, Riverside, and San Bernardino Counties. Furthermore, we only estimated the value of open-space premiums on house prices in one location, Joshua Tree; the total premium across all cities, towns, and unincorporated places in the Mojave is far higher than this value. We also lack estimates of the net benefits produced by agriculture and the film industry, as well as those associated with scientific and educational, military, and space-related uses of the Mojave. Finally, the value of a number of ecosystem services provided by the Mojave are not captured in these results. Of these values not captured in our total net benefit estimate, the option and passive use values of individuals residing outside of California are likely to represent the single largest benefit omitted.

Several results emerge from this analysis that are worth emphasizing. Foremost among these is that the total economic value of the human uses of the Mojave is quite substantial, with an annual net benefit flow of $1.4 billion in 2003. Second, four fifths ($1.1 billion) of this total net value is captured in markets in the form of profits or earnings generated by the direct or indirect impacts of the human activities in the Mojave. However, of equal importance is the finding that a large part of the total net benefits society derives from the Mojave is not reflected in markets. In other words, markets are a poor indicator of the overall well-being individuals obtain from the Mojave. Although this is not a surprising finding - indeed, it is a common characteristic of large and spectacular ecosystems or landscapes – it does underscore the critical importance of including non-market impacts in any analysis of the effects that a change in the ecosystem could bring about. In the Mojave, such changes could take the form of increased development for residential, commercial, or industrial purposes, or an increase in recreation activities that may lead to a reduction in ecosystem health and resilience, such as increased motorized recreation off designated roads. Such changes may produce benefits to some individuals (the additional homeowners or off-road participant), but they may also reduce the benefits the other users of the Mojave receive. In fact, at some point, the next additional unit of increases in such rival uses may cause a reduction in net benefits to society as a whole, because the combined gains to the additional users are less than the combined losses in benefits to existing users. As human pressures on the Mojave keep increasing, development strategies for the desert face the challenge to maximize the desert's net benefits for society as a whole. This may require tough choices, as individually desirable behaviors increasingly impinge on the common good.

Several opportunities exist for future research to fill the gaps in the benefits assessment presented in this study. Important targets for quantification are the total value of real estate environmental amenity premiums across all towns and cities in the Mojave; the net benefits associated with the agricultural outputs produced in the Mojave, that is, producer surplus and consumer surplus, and net earnings of the multiplier effects of agricultural production; the benefits of scientific and educational uses of the Mojave; and finally, the value of the option and passive uses of the Mojave by U.S. households outside of California.

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Appendix

A. Agricultural uses of the Mojave

As explained in part III of the report, we discuss the economic value of agricultural uses of the Mojave separately for several reasons. First, we lack information on input costs of the various crops produced in the region. In addition, agricultural production in the Mojave generates environmental costs the quantification of which is beyond the scope of this report. These costs include an unsustainable use of groundwater from Mojave aquifers, or of scarce regional water resources in general. Agriculture is the main water consumer in the Mojave, and in 2001 accounted for more water use than urban (residential, commercial, landscape, industrial) uses (California Department of Water Resources, 2005a). Agriculture also contributes to the particulate pollution problem present in much of the Mojave (Lovich and Bainbridge, 1999), with negative impacts on human health and visibility. In the absence of information on the size of the costs of these negative impacts, it is impossible to generate net benefit estimates for agriculture in the Mojave.

Because of the Mojave's semiarid climate, agricultural production in the region is concentrated in a few locations (see Figure A1), and generally is dominated by specialty crops. For some of the counties in our study area it was not possible to determine the value of the share of the agricultural production that took place in the area. For example, estimates of agricultural production value in the study area for Inyo and Kern Counties could not be determined because the Crop and Livestock Reports do not disaggregate values by regions within the counties (Counties of Inyo and Mono Agriculture Department, 2004; County of Kern, 2004).[93] By contrast, the San Bernardino County Crop and Livestock Report (San Bernardino County, 2004c) delineates regions within the county and their production values, which allows the identification of the county's agricultural production in the Mojave Desert.

The Mojave Desert Resource Conservation District, encompassing San Bernardino County lands in the Mojave, contains approximately 30,000 acres of irrigated land, with principal crops in the region including alfalfa, alternate crops such as barley, oats, and hay, row crops, fruits and nuts, and pistachios. In addition, cattle ranches and leases exist throughout the desert where rainfall is sufficient, such as near Providence, Kingston, and New York mountain ranges (Mojave Desert RCD, no date).

The major zone of agricultural production in the Los Angeles County portion of our study area is located in the Antelope Valley. With the help of the Los Angeles County Deputy Commissioner and the UC cooperative extension farm advisor, we were able to develop an estimate of the agricultural production value for the Antelope Valley (see Table A1). The primary crops grown in the valley include onions, root vegetables, alfalfa, fruit trees, and grain (County of Los Angeles, 2004).

[93] The Eastern Kern County Resource Conservation District (no date) states that two ostrich farms exist in the region, as well as production of hay, onions, pistachios, almonds, peaces, apricots, pecans, and some irrigated pasturelands.

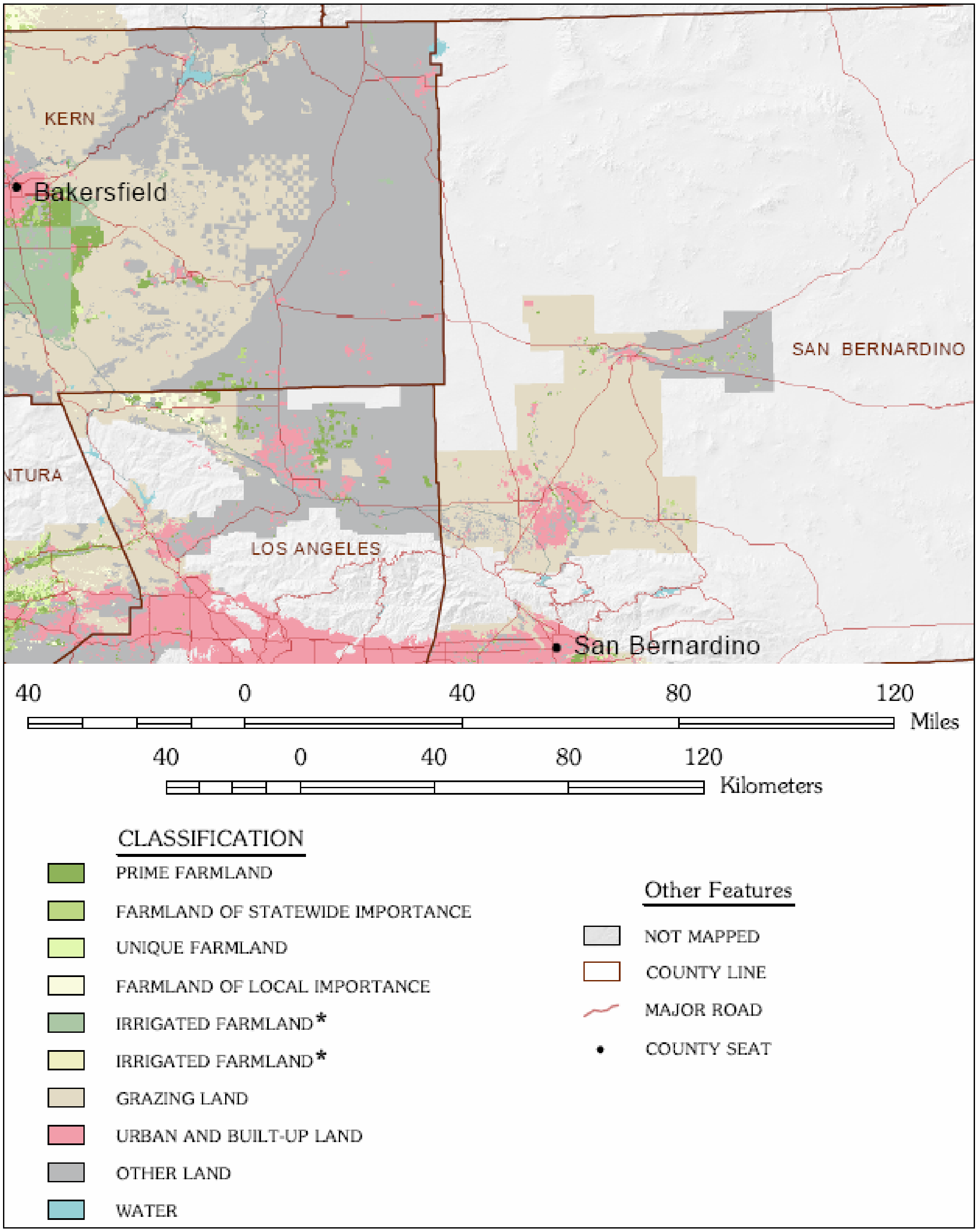

Figure A1: Farmland in the Mojave
Source: California Department of Conservation, 2004.

The Antelope Valley estimate excludes a number of agricultural areas in Los Angeles County, the which also lie along the Mojave's periphery, except for the agricultural lands located between the Angeles National Forest and the outskirts of the L.A. metropolitan area (see Figure A1), which are mostly used for grazing. Therefore, our estimate of the county's agricultural production value is likely to represent an underestimate of the total agricultural production value in the Los Angeles County portion of our study area.

Table A1: Agricultural Production Values, Antelope Valley, Los Angeles County, 2003

Commodity	*L.A. County Total*	*Antelope Valley*
	Dollars	
Cherries	390,000	-
Apples	720,000	-
Grapes	354,000	-
Miscellaneous[1]	3,952,000	-
Dry onions	18,212,000	16,390,800[2]
Root vegetables	74,834,000	67,350,600[2]
Field crops	8,535,000	-
Dairy & livestock	8,249,000	4,124,500[3]
Apiary[5]	767,000	-
Total	116,013,000	87,865,900

[1]Mostly nectarines, peaches, pears, plums, oranges, pistachios, tangerines, apricots; some lemon and grapefruits. [2]Pers. comm. (September 8, 2005) with Richard Sokulsky, L.A. County Deputy Commissioner, and Grant Poole (August 24, 2005), UCCE farm advisor, who estimate that over 90 percent of the total county production of these crops is in the Antelope Valley. [3]Pers. comm. with Richard Sokulsky, who estimates that 70 percent of diary and 50 percent of the county's total livestock production take place in the Antelope Valley. We use a low estimate of 50 percent for the combined dairy and livestock production value. [5]Production evenly distributed throughout the county.

Based on the available information for Los Angeles and San Bernardino Counties, the minimum value of the agricultural production in the Mojave was an estimated $214 million in 2003 (Table A2). As already discussed, this value excludes any production in the Mojave portion of Kern and Inyo Counties. However, given that only a minor share of Kern County's agricultural lands is located in the Mojave, and that agricultural production in Inyo County is comparatively small, the downward bias in our estimate is not expected to be very large.

Table A2: Value of agricultural production in the Mojave

County	*County-wide production*	*Production in study area*
	Million dollars	
Inyo	40.6	n.a.
Kern	2,477.5	n.a.
Los Angeles	322.6	87.9
San Bernardino	645.9	126.1
Total	3,486.6	214.0

Notes: Values are for 2003. n.a. – data not available

The estimation of the net benefits associated with these revenues from agricultural activities would require information on the value of agricultural inputs used in the production of the crops grown in the Mojave. It would further require accounting for the environmental costs associated with crop production. The generation of such cost estimates is beyond the scope of this study.

B. Renewable energy industry in the Mojave

As in the case of agriculture, we analyze the value of renewable energy produced in the Mojave separately from the other benefits provided by the Mojave, for two reasons. Assessing the net benefits of renewable energy production in our study area would require a taking into account of the costs associated with that production. These costs can be distinguished into two main components. The first of these is the cost at the plant level of producing electricity, commonly expressed as levelized generation cost. Most available detailed estimates of the production costs of renewable energy are for state-of-the-art, current technology projects (see for example California Energy Commission, 2003a; Price, 2002). By contrast, the large majority of the renewable energy production installations found in the Mojave are rather old. For example, the Coso Hot Springs geothermal plant units have been in operation since 1987-1989, and the SEGS solar plants were built between 1985 and 1990. Likewise, many of the wind turbines found in the region are of the older, comparatively small type. Given the dramatic decline in renewable generation costs that has come with advances in generation efficiency and economies of scale (see Table B1), cost data for state-of-the-art facilities are not applicable to older plants. In addition, many of the installations have been expanded over time. As a result, different units of the various plants are likely to have different electricity production costs. Given that it is not possible to obtain location-specific cost data at the unit level for the renewable installations in our study area, developing estimates of the electricity generation cost in our study area necessarily would run the risk of substantial errors.

Table B1: Average levelized generation costs of renewable electricity generation technologies currently operating in the Mojave

	1985	*1990*	*2003*
		Cents/KWh	
Geothermal	7	5-6	4.5 [1]
Solar thermal	~30	~20	11 - 13.5 [2]
Wind	~15	~10	4.6 [3]

Notes: [1] Geothermal flash (50 MWe). [2] Solar-parabolic/natural gas hybrid (50 MWe). [3] 100 MWe.
Sources: California Energy Commission (2003a); Burtraw *et al.* (1999); National Renewable Energy Laboratory (2002); Price (2002).

The second cost associated with renewable energy production is their negative impact on competing uses, especially in the case of wind energy installations. These impacts include reduced values of properties and potentially reduced enjoyment by recreationists, both due to the visual disamenities associated with large wind power plants. It is beyond the scope of the present analysis to attempt to construct estimates of these costs associated with the renewable energy installations found in the Mojave. Rather, we develop estimates only of the gross value (electricity sales) of the renewable energy installations operating in the Mojave.

Its geographic and climatic characteristics make the Mojave an ideal location for the application of several renewable energy technologies. Not surprisingly, the Mojave is the site of a substantial number of renewable energy installations. These harness geothermal, wind, and solar energy flows and convert them to electricity. The quantity and value of the electricity generated by these installations are shown in Table B2.[94]

Table B2: Selected characteristics of renewable energy plants in the Mojave

	Total net installed capacity	*Power generation*	*Total value of produced electricity*
	MWe	*MWh*	*Dollars*
Geothermal			
Coso Hot Springs, China Lake	270	2,082,714	242,011,367
Solar			
Daggett SEGS I&II	43.8	39,339	4,689,209
Kramer Junction SEGS III-VII	150	397,332	46,169,978
Harper Lake SEGS VIII&IX	200.2	328,376	38,157,271
Wind			
Tehachapi Wind Farms	656	1,650,606	191,800,417
Total	1,320	4,498,367	522,710,226

Notes: Data for power generation and price of electricity (¢11.62 per kWh) are for 2003.
Sources: California Energy Commission (2003a); California Wind Energy Collaborative (2005); Energy Information Administration (1997, 2004a, 2004b).

For example, in the case of solar concentrating plants, operation and maintenance require inputs of labor, spare parts, equipment, administration, operation, power block and solar field maintenance, drafting and supervision of service contracts, and water (Price, 2003). Many of these inputs, which are registered as costs by the plant, are provided by the regional economy. The earnings (revenue minus costs) of the suppliers (households and companies) of these inputs, in addition to the plants' profits, are a measure of the consumer and producer surplus generated by the plants. The operation and maintenance associated with the renewable energy plants generated an estimated total of 1,165 jobs in the regional economy (Table B3). These include direct jobs at the plant facilities as well as indirect jobs created in the industries that provide inputs to the plants. These employees spend a share of their income in the local economy, thereby generating induced effects. All of these direct, indirect, and induced impacts can be estimated using input-output analysis.

Multiplier effects of operation and maintenance of renewable power plants

The net benefit that these installations produce for society is the sum of the plant profits and the earnings in the regional economy that are generated through the multiplier effects of the operation and maintenance of the plants.[95] We do not have information on the operation and maintenance (O&M) costs for the renewable energy plants in the Mojave. However, we can construct estimates for the solar plants in our study area based on comparable plants in the Nevada desert for which such information is available.

[94] For a detailed list of installations, see Appendix C in California Energy Commission (2003b).
[95] All of the plants were constructed before 2003, so no multiplier effects associated with their construction occurred in that year.

Table B3: Employment impact of the renewable energy plants in the Mojave

	Employment (est., 2003)
Geothermal	
Coso Hot Springs, China Lake	429
Solar	
Daggett SEGS I & II	61
Kramer Junction SEGS III - VII	210
Harper Lake SEGS VIII - IX	280
Wind	
Tehachapi Wind Farms	184
Total	1,165

Sources: Heavner and Del Chiaro (2003), except solar, which is from Schwer and Riddel (2004).

Schwer and Riddel (2004) provide estimates of the annual O&M costs for a 100MWe solar trough plant in Nevada. By scaling up their cost estimates to the total combined capacity of the three solar plants in the Mojave (394 MWe), we can derive an estimate of the annual O&M costs of those plants (Table B4).[96] The regional capture rate for the labor inputs is assumed to be 100 percent, that is, all O&M related labor is assumed to be provided by residents in the Bakersfield-Riverside-San Bernardino RIMS II area.[97] For capital inputs for O&M activities we assume a regional capture rate of only 60 percent. We chose this rather low rate because we assume that at least some of the solar technology replacement parts may be produced outside of our RIMS area. Multiplying the various O&M expenditures by their respective capture rates yields the effective regional spending associated with the O&M activities in the solar plants. These direct regional output effects are shown in Table B4.

Table B4: Estimated operation and maintenance costs of the solar power plants in the Mojave, and associated total regional economic output and earnings

O&M inputs	*O&M costs*	*Direct regional output effect*	*Total regional output*	*Total regional earnings*
		Million 2003$/yr		
Administrative labor	1.122	1.221	2.329	0.779
Technical labor	9.707	9.707	18.657	6.280
O&M capital expenditures	21.281	12.769	23.387	5.877
Total	32.209	23.697	44.373	12.937

Notes: For administrative labor inputs we use the RIMS II final demand output and earnings multipliers for "Administrative and support services"; for technical labor we use the multipliers for "Professional, scientific, and technical services"; for O&M capital expenditures we use the multipliers for "Miscellaneous manufacturing".

[96] This estimate is likely to be conservative because the three Mojave plants are older than the state-of-the-art facility examined by Schwer and Riddel (2004). They are therefore likely to require higher maintenance expenditures.
[97] This area comprises Inyo, Kern, Riverside, and San Bernardino Counties.

The direct spending on O&M inputs generates indirect and induced effects in the regional economy. To estimate these multiplier effects, we multiply expenditures on the three O&M inputs (administrative labor, technical labor, and capital expenditures) by their respective RIMS II final demand output and earnings multipliers for the Bakersfield-Riverside-San Bernardino County economic area. The total estimated annual output and earnings in the Mojave region from solar power plant O&M activities are substantial (Table B4).[98] Total regional output due to solar plant O&M is estimated at $44.4 million per year; total regional earnings, at $12.9 million per year.

We do not estimate total regional output and earnings for the other renewable power plants in the Mojave. However, given that solar power accounts for approximately half of all renewable energy plant employment in the Mojave, it would be reasonable to presume that the impacts of O&M activities at geothermal and wind power plants are of a similar magnitude as those of the solar plants.

Future development of renewable energy in the Mojave

Although already substantial, the value of the Mojave for renewable energy generation is likely to increase considerably in the next decades. California's Renewable Portfolio Standard or RPS (California Senate Bill 1078, 2002) is steering the State's development of renewable resources. The RPS requires retail electricity sellers to increase their sales of electricity from renewable sources by at least one percent per year and achieve an increase of 20 percent by 2017 at the latest. The California Energy Commission (CEC), the California Public Utilities Commission, and the California Power Authority have adopted the Energy Action Plan, setting a goal of 20 percent of the State's electricity to be produced from renewables by 2010 (California Energy Commission, 2003b). The CEC has developed scenarios for meeting the renewable portfolio standard, based on known proposed renewable energy projects. A number of the proposed and planned projects are located in the West Mojave Desert bioregion (California Energy Commission, 2003b). According to the Commission's assessment, the Kern County wind resource area could fulfill much, if not all, of the perceived renewable energy demand through 2008. San Bernardino County offers smaller but nevertheless important wind resources, and the essential sufficiency of the existing transmission infrastructure makes the development of these resources economically very attractive (Yen-Nakafuji, 2005). In the 2008-2017 timeframe, concentrating solar power will be important in distributed generation.[99]

Given the potential for long-term increases in natural gas prices as a result of supply shortages, an increase in renewable energy capacity can contribute to energy diversity and thus economic security by reducing reliance on natural gas. Therefore, the value of renewable electricity increases with rising natural gas prices. This increased value is equivalent to the avoided increase in electricity generation costs that would result from higher natural gas prices.

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[98] The final demand output multipliers for our four-county area range from 1.8316 for capital expenditures to 1.9220 for technical labor. The earnings multipliers range from 0.4623 to 0.6470.

[99] Distributed generation, that is, small, modular electricity generators sited close to the point of use, reduces retail electricity sales, thus reducing the amount required to meet the 20 percent of sales.