

Efficacy of the California Bureau of Land Management Community Assistance and Hazardous Fuels Programs

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Abstract—This study provides a framework for assessing the social and environmental benefits and public education outcomes associated with the U.S. Department of the Interior, Bureau of Land Management's Community Assistance and Hazardous Fuel Programs in California. Evaluations of fire hazard mitigation programs tend to focus primarily on the number of acres treated and treatment costs associated with mitigation without adequately assessing the benefits of these treatments. While some evaluations account for the value of protected structures or the avoided costs of suppression, few account for the ecosystem service value of protected natural capital. Examples include the water purification and flood abatement functions of wetlands, the hydrologic regulation functions of forests, and the recreational value of various natural landscapes. The total economic value approach to environmental assessment used in this study includes both the market-based and nonmarket values that are at risk from wildfire, particularly ecosystem goods and services. Using a decision support methodology, the data allows the BLM to more effectively quantify and account for the social and environmental benefits derived from fire mitigation treatments. Suggestions are provided for how this approach could effectively be scaled up and used at a national, regional, or Statewide level to analyze the efficacy of all BLM programs. Although this approach is currently compatible with BLM current reporting system, the assessment provides recommendations on how to augment the evaluation system so that future program elements or "system" elements that enable (or prevent) communities to take part in raising awareness and taking action for themselves are evaluated at the broader BLM program level for the Community Assistance and Hazardous Fuel Programs in California.

Introduction

Not all fire is harmful, and it is important to differentiate between harmful and beneficial fires (Ganz and Moore 2002). Federal fire policy has been significantly modified since 1995 to recognize and embrace the role of fire as an essential ecological process (USDA 1995; USDI–USDA 1995; NWCG 2001). The value of ecosystem goods and services should be recognized when considering the positive and negative effects of fire on a landscape. Traditionally, economic assessment methodologies such as Cost-Benefit Analysis have not accounted for the value of many ecosystem services because the tools and techniques to evaluate ecological goods and services in a cost-effective manner were not widely available (EPA 2000; National Research Council 2004). When tradeoffs are made between alternative land use and fire management decisions, the best available information is needed to avoid systematic biases in the resulting decision.

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If hidden costs or benefits are not fully accounted for, people will tend to make uninformed choices leading to inefficient outcomes. For example, as witnessed in the Katrina hurricane, the valuation literature has long shown that offshore barrier islands and near shore saltwater wetlands in the Gulf Coast region do tend to provide significant benefits to coastal communities in the form of alleviating flooding and hurricane storm surge (Farber 1987). Yet, when these ecological benefits are not adequately quantified and incorporated into short-term land use development decisions, critical information is left outside of the market calculus and inefficiencies arise with sometimes disastrous results. The same quantification needs to be applied when evaluating the significant benefits to communities living in a fire adapted ecosystem. While this assessment focuses on the avoided costs of losing these benefits to an unwanted fire, we recognize that some ecological goods and services may benefit from periodic low intensity fires. To assist the U.S. Department of the Interior, Bureau of Land Management (BLM) in California gather such knowledge, we have developed a conservative, baseline ecological-economic assessment of the ecosystem goods and services for three selected counties in that State. Counties were selected based upon the frequency of BLM projects, the availability of land cover data, and the landscape heterogeneity and transferability. Our goal has been to use the best available methods, data sources, and spatial analysis techniques to generate defensible value estimates that can then be integrated into better land use planning and environmental decisionmaking throughout the region.

Study Objectives

This study provides the basis for a quantified assessment of the benefits, cost effectiveness as related to National Fire Plan (NFP) funded projects administered by the California BLM. The projects evaluated cover those implemented during the 2002 through 2004 study period. Primary objectives of the study are:

- Quantification of the economic values associated with the Community Assistance and Hazardous Fuels Programs (HFP) in three counties that are representative of California's heterogeneous landscapes.
- Providing a framework and analysis of which BLM fuel reduction projects offer the highest return on the investment when considering the ecosystem goods and services included as part of the HFP.

The assessment differs from previous ones in that it takes into consideration *both* the market-based and nonmarket values likely to be impacted by a catastrophic fire. Specifically, it provides a first-order baseline estimate of the ecosystem goods and services provide by California's natural landscapes that might be threatened by catastrophic fire. Using a decision support methodology developed by Spatial Informatics Group LLC, the NaturalAssets™ Information System, the study presents data that will allow the BLM to more effectively quantify and account for the social and environmental benefits derived from fire mitigation treatments.

Study Site Selection

Study sites were chosen by first generating a query map of the concentrations of community assistance grants, and fuels projects funded by the BLM and the Rural Fire Assistance Program (RFA) from 2002 through 2004.

A density analysis map (fig. 1) was created by the BLM with data generated from the National Fire Plan Operations and Reporting System (NFPORS). The purpose of this first level of analysis was to determine those locations in California that have been targeted for receiving the most funding through these Federal programs; three counties were chosen that had high concentrations of grant recipients. The three counties selected for performing the NaturalAssets™ Information System evaluation were Napa, Humboldt, and San Bernardino. They were selected because:

- These counties represent a good cross section of vegetative communities, latitude, and development patterns.
- All three have significant BLM lands within their boundaries.
- All three counties have a diverse number of land cover types and hazardous fuel treatments.
- All three counties are covered by the 1997 to 2001 California Land Cover Mapping and Monitoring Program.

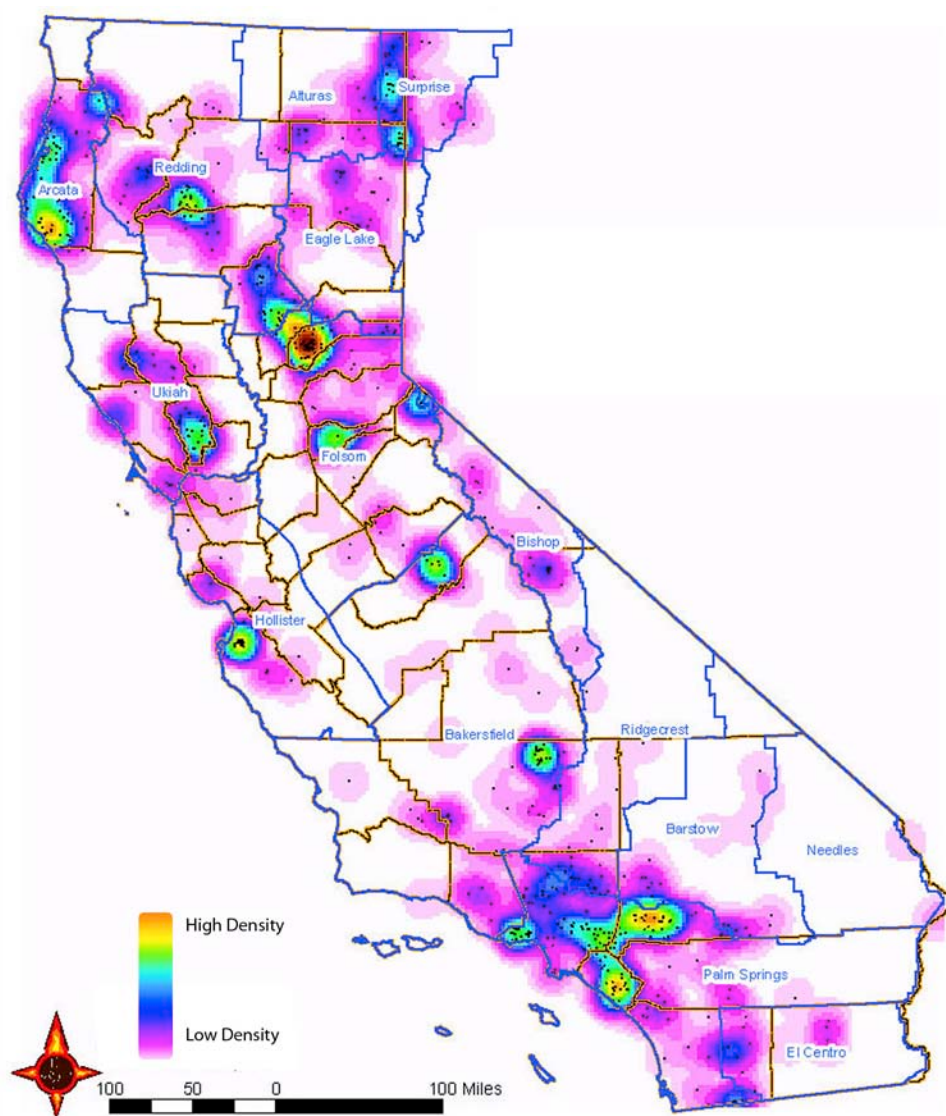


Figure 1—Density analysis of BLM funded projects in California (adapted from BLM 2004). The density analysis was conducted by BLM using the following data (in a point format): 2002 to 2004 Fuels Treatments (NFPORS), 2002 to 2004 Rural Fire Assistance Grants, 2002 to 2004 Community Assistance Activities only from the following counties: Humboldt, Butte, Nevada, Napa, Madera, Kern, Los Angeles, San Bernardino, and Orange.

We also provided the BLM with two case studies: the town of Petrolia in Humboldt County and Morongo Valley in San Bernardino County (fig. 2). These two case studies are used to compare the costs of treatment to the estimated benefits from those treatments, including both protected structures and Ecosystem Service Valuations (ESVs). Morongo Valley is a highly developed part of San Bernardino County while Petrolia is in a rural part of Humboldt County. Both of these communities are in the wildland urban interface with Petrolia listed as a Community at Risk and Morongo Valley listed as a Community of Interest.

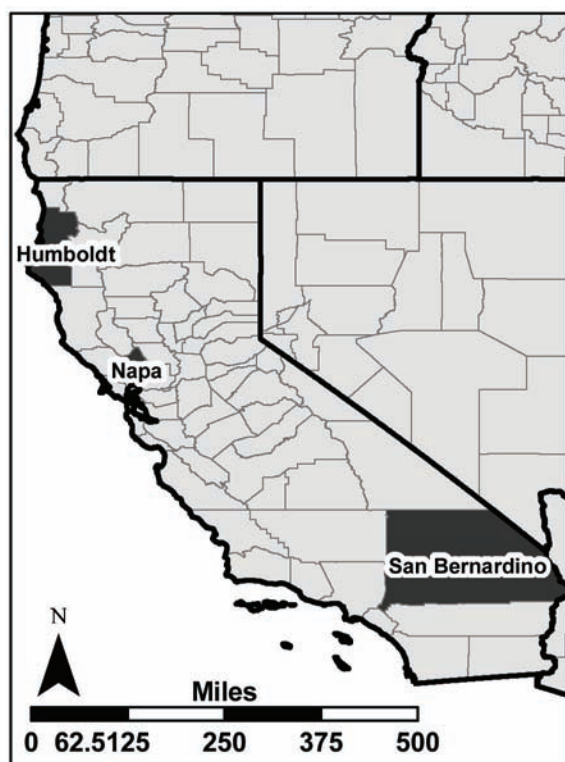


Figure 2—Case study locations include Napa, Humboldt, and San Bernardino Counties.

Methods

Economic valuation can help to ensure that ecosystem services that are not traded in markets and do not have market prices receive explicit treatment in economic assessments. Our goal is not to “create” values for ecosystems. Rather, our purpose is to generate a conservative baseline estimate of the values that people already hold with respect to these ecosystems through an assessment of the best available literature. Such information will in turn assist in our assessments of the benefits provided by community assistance and hazardous fuels programs in California. This approach is consistent with that being taken in the international Millennium Ecosystem Assessment, which focuses international policymakers’ attention on the contributions of ecosystems to human wellbeing (Millennium Ecosystem Assessment 2003;

Argady and others 2005). Due to the lack of credible metrics for evaluating the effectiveness of the BLM projects, we have made a series of assumptions for this study including:

- Hazardous fuel treatments, irrespective of size, will have an impact on reducing the fire hazard on a landscape scale. Although the focus of this assessment is not to model (spatially or temporally) how much of an impact these treatments might have on fire behavior, there is credible research to indicate that strategically placed treatments can change fire behavior (Finney 2001; Knapp and others 2004). We assume that all BLM funded hazardous fuels projects have a beneficial impact on protecting market and nonmarket assets regardless of the probability of burning or the level of changes to fire behavior.
- Communities value their structures more than any other market asset. The research to date on community perceptions of fire support this assumption (Hodgson 1994; Winter and Fried 2000; Everett 2002). As far as generating monetary values for marketable assets, this assessment focuses on parcels and the improvement values (generated from the Grand list) and not other market assets. While the market value of standing timber is clearly high in Humboldt County, we chose not to attempt to quantify it due to the lack of data on forest accessibility, size, and age structure.
- Environmental aesthetics and recreational opportunities are important services provided by forests in the urban/wildland interface. The natural landscape in and around communities has amenity and recreational values that tend to be quite high in California. In California's Sierran foothills, for example, Hodgson (1994) did a survey of residences and found that one in five respondents considered protection of the landscape more important than the protection of structures. Californians value their natural landscape and are willing to pay for the costs associated with living in a fire-prone area for the other natural amenities that these surroundings provide.
- There are additional ecosystem goods and services from which local California residents benefit even though they may not be as aware of them. These include flood avoidance, wildlife habitat refugia, and clean water provision, all of which provide real benefits to society. This assessment includes value estimates for those ecosystem goods and services that have been quantified in the peer-reviewed literature.
- If hazardous fuel treatments are going to be effective in California, they need to be coordinated with an outreach effort to raise awareness of why landscape scale treatments are needed. This is especially important in California where the environmental assessments (performed under the National Environmental Protection Act and/or the California Environmental Quality Act) require public input and often turn into legal battles over whether fuel treatments are appropriate in certain ecological and socio-political systems. Although it is not within this assessment's scope to address or resolve these conflicts, we should be aware that they exist in the State and contribute to the costs of implementing a hazardous fuel treatment program.

Building on these assumptions, we recognize that the protection of forests from fire damage can generate real benefits to society—benefits that go beyond the protection of market goods and structural assets. Scenic views, recreational opportunities, flood control, wildlife habitat protection, sediment retention, and water supply all contribute to the wellbeing of people

and the communities they live in. The challenge is that currently many of the economic values associated with fire mitigation efforts remain unaccounted for because they are not easily quantified in conventional policy assessments or cost-benefit analyses.

Value Transfer of Nonmarket, Nonuse Estimates

One of the primary goals in this the study is to shed light on the nonmarket economic benefits of ecosystem goods and services associated with the landscapes that are affected by fire hazard mitigation efforts. While a fair amount of research has been done on the economic value of ecosystem services globally (Costanza and others 1997; Millennium Ecosystem Assessment 2003), relatively limited peer-reviewed work has been done to estimate the specific economic values of ecosystem services located in San Bernardino, Napa, and Humboldt Counties. Because limited empirical ecosystem service valuation research has been done at the study sites, we were required to “transfer” values from other sites.

Measuring the use values associated with marketed goods and services simply requires monitoring market data for observable trades; but the nonmarket values of goods and services are much more difficult to measure (Bingham and others 1995). When there are no explicit markets for ecosystem goods and services, more indirect means of assessing economic values must therefore be used. A subset of economic valuation techniques commonly used to establish values when market values do not exist are identified in table 1. (This list of nonmarket valuation techniques is not intended to be all-inclusive. Rather, it is intended to reveal the breadth of available empirical techniques that have been and are currently being explored in the field of ecosystem service valuation.)

Table 1—Conventional nonmarket valuation techniques.

Avoided Cost (AC): services allow society to avoid costs that would have been incurred in the absence of those services; flood control (barrier islands) avoids property damages, and waste treatment by wetlands avoids incurred health costs.
Marginal Product Estimation (MP): Service demand is generated in a dynamic modeling environment using production function (that is, Cobb-Douglas) to estimate value of output in response to corresponding material input.
Factor Income (FI): services provide for the enhancement of incomes; water quality improvements increase commercial fisheries harvest and, thus, incomes of fishermen.
Travel Cost (TC): service demand may require travel, whose costs can reflect the implied value of the service; recreation areas attract distant visitors whose value placed on that area must be at least what they were willing to pay to travel to it.
Hedonic Pricing (HP): service demand may be reflected in the prices people will pay for associated goods: For example, housing prices along the shore of pristine freshwater lakes tend to exceed the prices of inland homes.
Contingent Valuation (CV): service demand may be elicited by posing hypothetical scenarios that involve some valuation of alternatives; people would be willing to pay for increased water quality in freshwater lakes and streams.

As the descriptions in table 1 suggest, each nonmarket valuation methodology represented in the NaturalAssets™ information system (NAIS) has its own strengths and limitations, often limiting its use to a select range of ecosystem goods and services within a given landscape. For example, the economic value generated by a naturally functioning ecological system can be estimated using avoided cost (AC), based on the estimated cost of damages due to lost services. However, because these estimates are highly sensitive to market conditions used to estimate costs, they must be used with great caution. While rigorous and well established in the field, travel cost (TC) is primarily limited to estimating recreation values, while hedonic pricing (HP) is used for estimating property values associated with aesthetic qualities of natural ecosystems. On the other hand, contingent valuation (CV) surveys are often widely used to estimate the economic value of less tangible services such as critical wildlife habitat or biodiversity. The challenge with CV and related methods such as choice modeling is that estimated values are highly sensitive to the survey format and context of valuation (Heberlein and others 2005).

In this study, the full suite of ecosystem valuation techniques is used to account for the economic value of goods and services provided by natural landscapes in San Bernardino, Napa, and Humboldt Counties.

Value transfer by definition involves the adaptation of existing valuation information or data to new policy contexts with little or no data. (Following Desvousges and others [1998], the term “value transfer” is used instead of the more commonly used term “benefit transfer” to reflect the fact that the transfer method is not restricted to economic benefits, but can also be extended to include the analysis of potential economic costs, as well as welfare functions more generally.) The transfer involves obtaining an estimate for the economic value of nonmarket goods or services through the analysis of a single study, or group of studies, that have been previously carried out to value similar goods or services. The transfer itself refers to the application of estimated point values, derived utility functions, and other information from the original “study site” to a “policy site” (Loomis 1992; Desvousges and others 1998).

While we accept the fundamental premise that primary valuation research will always be a “first-best” strategy for gathering information about the value of ecosystem goods and services (Smith 1992; Downing and Ozuna 1996; Kirchhoff and others 1997), we also recognize that value transfer has become an increasingly practical way to inform policy decisions when primary data collection is not feasible due to budget and time constraints, or when expected payoffs are small (EPA 2000; National Research Council 2004).

In other words, value transfers will always represent a policy-relevant compromise solution. When primary valuation research is not possible or plausible, then value transfer, as a “second-best” strategy, is important to consider as a source of meaningful baselines for the evaluation of management and policy impacts on ecosystem goods and services. However, the real-world alternative is to treat the economic values of ecosystem services as zero; a status quo solution that, based on the weight of the empirical evidence, will often be more error prone than value transfer itself.

Ecosystem Service Valuation (ESV) Data

The raw material for the value transfer exercise comes from previously published studies that empirically measured the economic value of environmental goods and services. Three types of valuation research exist in the literature today:

- Peer-reviewed journal articles, books and book chapters, proceedings, and technical reports that use conventional environmental economic valuation techniques and that are restricted to an analysis of social and economic values.
- Non peer-reviewed publications that include PhD dissertations, non peer-reviewed technical reports and proceedings, as well as raw data available on the Internet.
- Secondary analysis (for example, meta analysis) of peer-reviewed and/or non peer-reviewed studies that use both conventional and nonconventional valuation methods.

The critical underlying assumption of NAIS is that the ESVs for ecosystem goods or services can be inferred with sufficient accuracy from the analysis of existing nonmarket valuation studies. Clearly, as the level of information increases within the source literature (in other words, more studies are done), the accuracy of the value transfer likewise improves. The research team developed a set of explicit decision rules for querying economic results from the raw data contained in NAIS that would allow us to estimate with sufficient accuracy the economic value of ecosystem services in San Bernardino, Napa, and Humboldt Counties. The research team selected valuation studies that were:

- Peer reviewed and published in recognized journals
- Focused on temperate regions in either North America, Canada, or Europe
- Focused primarily on nonconsumptive use

Using these search criteria, we were able to obtain data from a set of viable studies (n=84) whose results were then standardized to 2004 U.S. dollar equivalents per acre to provide a consistent basis for comparison. (All dollar values are standardized to 2004 using Consumer Price Index tables published by the U.S. Department of Labor; <http://www.bls.gov/cpi/home.htm>.) Because each study may contain more than one estimate of value, the end result is a collection of valuation data points that are coded by temporal (that is, time of study), spatial (place where study was done), and methodological (method used) criteria, thereby allowing the research team to derive a lower bound and upper bound estimate of dollar values for the study site. For this study, we were able to generate a total of (n=205) individual point estimates for reviewed land cover types. Given the aforementioned restrictions and gaps in the available literature, this approach yields conservative, baseline economic values for San Bernardino, Napa, and Humboldt Counties.

In sum, the transfer method adopted in this report involves obtaining an estimate for the value of ecosystem goods or services through the analysis of peer-reviewed research that has been previously collected and stored in NAIS in a standardized format so that it can further be augmented with site-specific GIS data (that is, land cover, socioeconomic characteristics) to ensure reliable valuation estimates at the study site.

Spatial Analysis Methods

Another principal goal in this study is to link the ESV estimates for ecosystem goods and service to available land cover/land use data in San Bernardino, Napa, and Humboldt Counties. Thanks to the increased ease of using GIS and the availability of land cover data sets derived from satellite images, ecological and geographic entities can more easily be attributed with ecosystem services and the values they provide to people (Wilson and others 2004; Wilson and Troy 2005). In simplified terms, the technique discussed here involves combining one land cover layer with another layer representing the geography to which ecosystem services are aggregated—that is, a watershed. While the aggregation units themselves are likely to be in vector format, because vector boundaries are most precise, the land cover layer may be either raster or vector. (The vector data model represents spatial entities with points, lines and polygons. The raster model uses grid cells to represent quantities or qualities across space.) Spatial disaggregation increases the contextual specificity of ecosystem value transfer by allowing us to visualize the exact location of ecologically important landscape elements and overlay them with other relevant themes for analysis—biogeophysical or socioeconomic. A common principle in geography is that spatially aggregated measures of geographic phenomena tend to obscure local patterns of heterogeneity (Openshaw and others 1987; Fotheringham and others 2000).

Development of Land Cover Typology

Two types of values were spatially mapped for this project: ecosystem service values and structural improvement values. These require accurate, high resolution, and categorically meaningful depictions of land cover. Before developing these maps, a land cover typology was created. To do this, we assessed available data coverages to determine which land cover classes at what level of categorical precision could be mapped at a usable scale and with acceptable levels of accuracy. Table 2 shows the resulting typology with the code name for each cover class, its description and the counties in which it was present.

Table 2—Land cover typology with applicable counties.

Code	Description	Counties
AGR	Agriculture	All
CON	Conifer	All
DSHB	Desert scrubland	San Bernardino
DWLD	Desert woodland	San Bernardino
EST	Estuary and tidal bay	Napa, Humboldt
FWET	Fresh wetland	All
HDW	Hardwood oak woodland	All
HEB	Herbaceous	All
MIX	Mixed hardwood, conifer	All
OWLF	Forested areas suitable for spotted owl habitat	Humboldt
RIPF	Riparian forests (50 m buffer)	All
RW2	Redwood-second growth	Napa, Humboldt
RWOG	Redwood-old growth	Humboldt
SHB	Shrubs	All
SWET	Salt wetland	Napa, Humboldt
URB	Urban and barren	All
URBG	Urban green (forest and grass)	All
VIN	Vineyard	Napa
WAT	Open water	All

Spatially Explicit ESV Calculation Methods

Ecosystem service values were then determined by multiplying areas of each cover type, in acres, by the dollar per acre ecosystem service value for that cover type. The economic values used to estimate the values associated with each ecosystem good or service are drawn from the NAIS ESV data. The total ESV of a given cover type for a given watershed can thus be determined by adding up the individual, nonsubstitutable ecosystem service values associated with that cover type. The following formula is used:

$$V(ES_k) = \sum_{i=1}^n A(LU_i) \times V(ES_{ki})$$

Where $A(LU_i)$ = area of land use (i)

and $V(ES_{ki})$ = annual value of ecosystem services (k) for each land use (i).

Resulting values were estimated for the entire study area using value transfer methods. Following that, the ESVs were aggregated by county study area, broken down for each county by land cover, and cross-tabulated for each study site by (1) land cover and watershed and (2) land cover and zip code. Assessed structural improvements were also summarized to generate a total economic value estimate for critical human-modified land uses.

Results

Using the value-transfer search criteria, the research team obtained data from a set of 84 viable empirical studies, whose results were then standardized to 2004 U.S. dollar equivalents per acre/per year to provide a consistent basis for comparison in the tables in this section. (All economic valuation data in this report are have been standardized to represent total net present values, not discounted. This allows for the results to be incorporated into forward-looking scenarios that might weight future costs and benefits differently than current costs and benefits when summing over time using specific discount rates; Heal 2004.) The aggregated baseline ESV results for all land cover types represented within the study area are presented in table 3.

The ESV data in table 3 show the minimum, the maximum, and the average nonmarket ecosystem service valuation estimates aggregated across all land cover types contained in the study. (Not all land cover types generated for the spatial analysis of San Bernardino, Napa, and Humboldt Counties by the Spatial Informatics Group team could effectively be matched with equivalent ESV estimates as denoted in table 4.) Clearly, not all land cover types represented in this report provide benefits to society equally. Rather, consistent with previously published literature (Daily 1997; Wilson and Carpenter 1999), the data reveal how land cover types in the study area that are associated with water (wetlands, estuaries, and riparian forest) tend to yield the largest ecosystem service values per area unit. Also consistent with previous findings, it also appears that both agricultural systems (in this report, the same ESVs were assigned to agricultural and vineyard land cover types) and urban greenspace tend to yield fairly large values per unit of measurement (Pretty and others 2000; Ricketts and others 2004). While nonriparian forest systems tend to be less valuable per acre unit, there is still a range of variability evidenced among different forest types, with old growth and spotted owl habitat yielding the highest values per unit and oak woodland yielding the least.

Table 3—Aggregate ecosystem services for all available land cover types.

Code	Description	Min \$ acre/yr	Max \$ acre/yr	Avg \$ acre/yr
AGR	Agriculture	\$83.47	\$1,689.04	\$887.06
CON	Forest-conifer	\$32.48	\$999.79	\$332.35
DSHB	Desert shrub	NA	NA	NA
DWLD	Desert woodland	NA	NA	NA
EST	Estuary	\$1,483.90	\$5,239.01	\$2,386.75
FWET	Fresh wetland	\$1,761.07	\$9,180.73	\$4,440.73
HDW	Hardwood oak woodland	\$61.68	\$486.84	\$177.82
HEB	Herbaceous	NA	NA	NA
MIX	Mixed hardwood, conifer	\$34.32	\$1,001.63	\$334.19
OWLF	Spotted owl habitat	\$100.53	\$1,113.86	\$403.86
RIPF	Riparian forest	\$122.17	\$15,126.99	\$3,558.03
RW2	Redwood second growth	\$29.89	\$997.20	\$329.76
RWOG	Redwood old growth	\$84.63	\$1,051.94	\$384.50
SHB	Shrubs	NA	NA	NA
SWET	Saltwater wetland	\$229.18	\$8,845.04	\$2,446.06
URB	Urban and barren	NA	NA	NA
URBG	Urban green	\$602.29	\$4,289.91	\$2,268.21
VIN*	Vineyards	\$83.47	\$1,689.04	\$887.06
WAT	Open fresh water	\$227.79	\$13,073.87	\$2,928.72

*Note: Assumption that AGR and VIN ESVs are equivalent as both are intensively managed and represent human dominated systems.

Spatially Explicit Ecosystem Service Valuation Results

Building on the ESV data generated with NAIS, the research team was able to use the spatially explicit ESV calculation methods, to generate ESV results. Tables 4 and 5 provide summaries of total ESVs by land cover class and reveal that significant differences exist between the three counties in the study.

Significant economic benefits clearly accrue to society from forests in Humboldt County. As the data in table 4 show, forest-related land cover types account for an overwhelming proportion (almost 80 percent) of total ESV delivered by naturally functioning ecological systems in the study area. Thus, while on a per-unit basis, forest land types may tend to provide less economic value than nonforested systems, the large study area currently under forested cover brings the total economic value associated with forests to the foreground. After forests, it appears that freshwater wetlands (FWET) and open water (WAT) provide the next most significant ESVs in the study area.

In contrast to Humboldt County, forested systems appear to account for only approximately 30 percent of the total ESV delivered by functioning ecological systems in Napa County. Napa's open freshwater (WAT) alone in the form of streams, lakes, and rivers appears to provide a significant economic benefit to society (31 percent). And as might be expected, both agricultural land (AGR) and vineyards (VIN) also provide a substantial positive impact on the economic value associated with ecosystem services in the region (approximately 20 percent). For Napa County, the zip codes of high value (both structural and ESV) are within Napa and St. Helena.

The data in table 6 reveal that similar to Napa County, forested systems deliver approximately 31 percent of the total ESV delivered by ecological systems in San Bernardino County. Freshwater wetlands (FWET) account

Table 4—Humboldt County study areas land cover and ESV estimates.

Class	Study area zip codes			Entire county		
	Acres	ESV/acre	Total ESV	Acres	ESV/acre	Total ESV
AGR	38,973	887	34,571,513	39,380	887	34,932,508
CON	271,121	332	90,107,174	282,303	332	93,823,306
EST	4	2,387	10,085	4	2,387	10,085
FWET	23,676	4,441	105,140,399	23,704	4,441	105,261,803
HDW	272,587	178	48,471,365	277,209	178	49,293,301
HEB	201,869	NA	-	205,292	NA	-
MIX	628,282	334	209,965,524	647,218	334	216,293,687
OWLF	221,523	404	89,464,211	221,580	404	89,487,414
RIPF	117,270	3,558	417,250,658	122,248	3,558	434,960,966
RW2	230,466	330	75,998,467	246,197	330	81,185,900
RWOG	90,604	385	34,837,363	98,005	385	37,682,967
SHB	53,085	NA	-	55,556	NA	-
SWET	1,344	2,446	3,287,882	1,356	2,446	3,317,256
URB	41,821	NA	-	42,944	NA	-
URBG	8,042	2,268	18,239,981	8,043	2,268	18,242,491
WAT	17,266	2,929	50,566,177	17,655	2,929	51,707,928
	TOTAL ESV		1,177,910,801	TOTAL ESV		1,216,199,612

Known market values	
improvement value of structures	\$4,376,522,485
TOTAL	\$5,554,433,286

Known market values	
improvement value of structures	\$4,499,321,899
TOTAL	\$5,715,521,511

Table 5—Napa County study areas land cover and ESV estimates.

Class	Study area zip codes			Entire county		
	Acres	ESV/acre	Total ESV	Acres	ESV/acre	Total ESV
AGR	26,265	887	23,298,875	27,700	887	24,571,316
CON	16,891	332	5,613,779	17,327	332	5,758,593
EST	1,110	2,387	2,648,298	1,115	2,387	2,661,834
FWET	4,409	4,441	19,577,352	4,412	4,441	19,592,412
HDW	141,771	178	25,209,687	145,867	178	25,938,010
HEB	64,207	-	-	66,148	-	-
MIX	11,704	334	3,911,425	13,619	334	4,551,190
RIPF	16,880	3,558	60,060,503	17,479	3,558	62,189,858
RW2	1,257	330	414,390	1,262	330	416,315
SHB	113,065	-	-	119,967	-	-
SWET	3,438	2,446	8,409,695	3,450	2,446	8,438,390
URB	18,408	-	-	18,462	-	-
URBG	1,808	2,268	4,099,948	1,808	2,268	4,099,948
VIN*	35,032	887	31,073,702	35,034	887	31,075,280
WAT	29,688	2,929	86,947,804	29,918	2,929	87,621,444
	TOTAL ESV		271,265,459	TOTAL ESV		276,914,591

Known market values	
improvement value of structures	\$10,957,341,955
TOTAL	\$11,228,607,414

Known market values	
improvement value of structures	\$11,256,915,849
TOTAL	\$11,533,830,440

Table 6—San Bernardino study areas land cover and ESV estimates.

Class	Study area zip codes			Entire county		
	Acres	ESV/acre	Total ESV	Acres	ESV/acre	Total ESV
AGR	39596.26	\$887	\$35,124,255	71,762	\$35,124,255	\$63,657,272
CON	282191.6	\$332	\$93,786,377	333,674	\$93,786,377	\$110,896,564
DSHB	5260821			10,189,383		
DWLD	596696.3			606,121		
FWET	113840.5	\$4,441	\$505,534,805	185,251	\$505,534,805	\$822,650,494
HDW	37049.87	\$178	\$6,588,207	47,948	\$6,588,207	\$8,526,125
HEB	34444.69			55,833		
MIX	69668.12	\$334	\$23,282,391	85,968	\$23,282,391	\$28,729,641
RIPF	84104.76	\$3,558	\$299,247,244	93,540	\$299,247,244	\$332,816,821
SHB	384160.9			482,529		
URB	441379.6			660,011		
URBG	121.74	\$2,268	\$276,129	152	\$276,129	\$344,531
WAT	27602.46	\$2,929	\$80,839,872	42,117	\$80,839,872	\$123,347,887
	TOTAL ESV		\$1,044,679,280	TOTAL ESV		\$1,490,969,334

Known market values	
improvement value of structures	\$35,770,650,855
TOTAL	\$36,815,330,135

Known market values	
improvement value of structures	\$68,941,985,365
TOTAL	\$70,432,954,699

for the majority of ecosystem service benefits delivered to society (55 percent)—by far the single most important ecosystem type in the study area from an ecosystem services perspective. Given that desert shrub is the most predominant land cover type in the county and that no ESVs were estimated for desert land cover types in this study, we anticipate that fire-related ESVs would be forthcoming for these critical ecosystem types as this information is gathered and included in this type of analysis.

An overwhelming proportion of ecosystem service values in Humboldt County comes from its forests. Humboldt's relatively large area of forested cover accounted for nearly 80 percent of total ESV delivery by naturally functioning ecological systems in the study area. On a per-unit basis, some forest types provide a lower stream of benefits than many non-forested types, but the size of forested area in Humboldt County means that ESV benefits from forests dominate. For instance, the Six Rivers National Forest contributes \$293 million in ESV to Humboldt County with an additional \$19 million in market values (such as structures). This contribution is primarily due to its size, and to the dominance of redwood old growth and spotted owl habitat.

In Napa County, forested systems only accounted for 30 percent of ESVs delivered by functioning ecological systems. Napa's open freshwater, in the form of streams, lakes and rivers, provided 31 percent of measured economic benefits to society. Both agricultural land and vineyards also provide a substantial positive impact on the economic value associated with ecosystem services in the region (approximately 20 percent). The communities of Napa (zip codes 94558 and 94559) and Saint Helena (94574) have the highest estimated quantities of ESVs and structural values within Napa County (fig. 3).

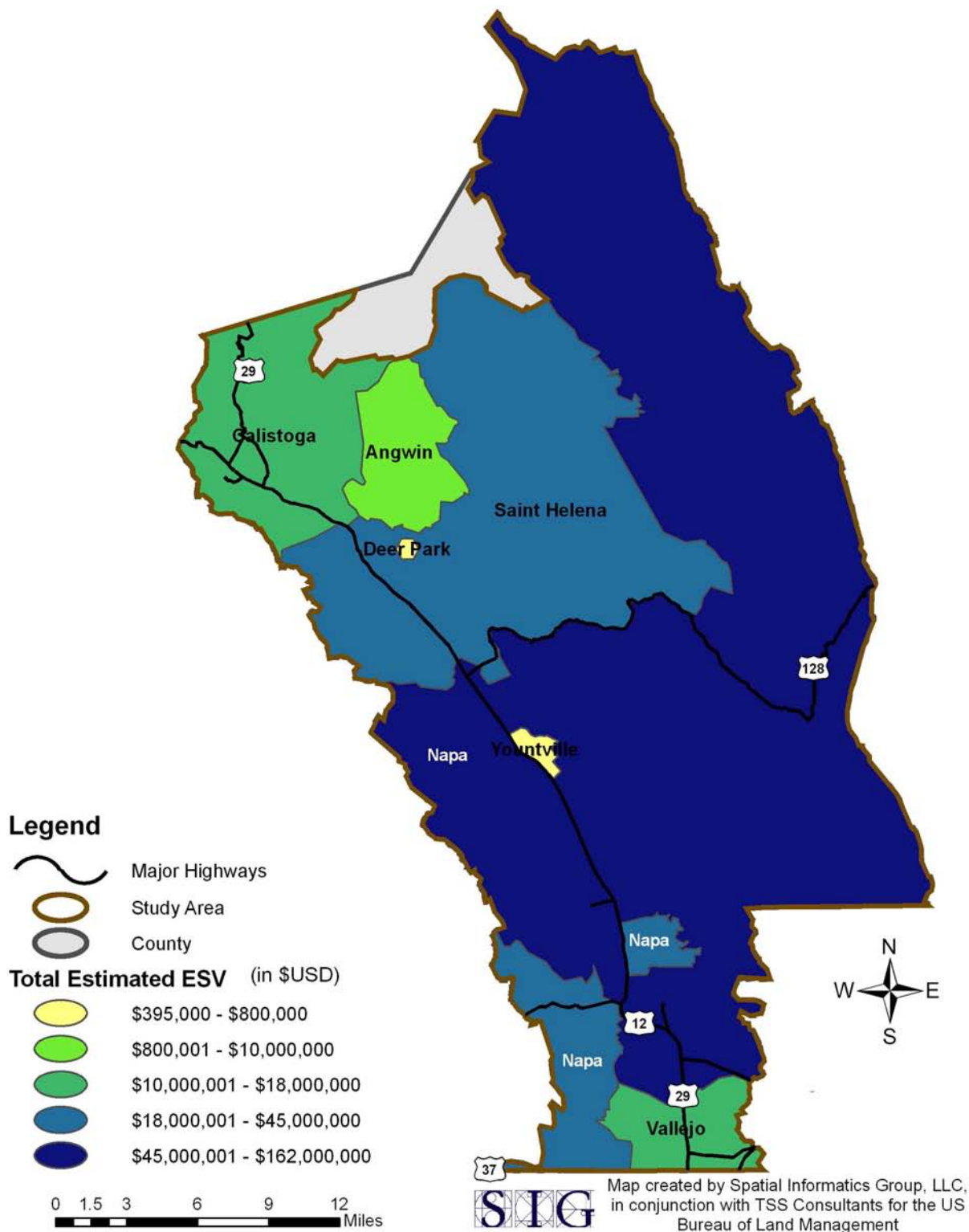


Figure 3—Total estimated ecosystem service valuation by zip code for Napa County study area.

Similar to Napa County, forested systems delivered approximately 31 percent of the total ESVs delivered by ecological systems in San Bernardino County. From an ecosystem services perspective, freshwater wetlands accounted for the majority (55 percent) of ecosystem service benefits delivered to society. For instance, the community of Twenty Nine Palms (zip codes 92277 and 92278) has low assessed structural values relative to other communities in San Bernardino County, but the freshwater resources of this community yield considerable ESVs compared with the rest of the communities within this county (fig. 4). Desert shrub is the most predominant land cover type in San Bernardino County. However, there are two reasons why this land cover shows few societal benefits in this study. First, this desert-related land cover type tends not to burn, and second, the value transfer analysis did not yield any ESV studies that estimated economic values for desert cover types.

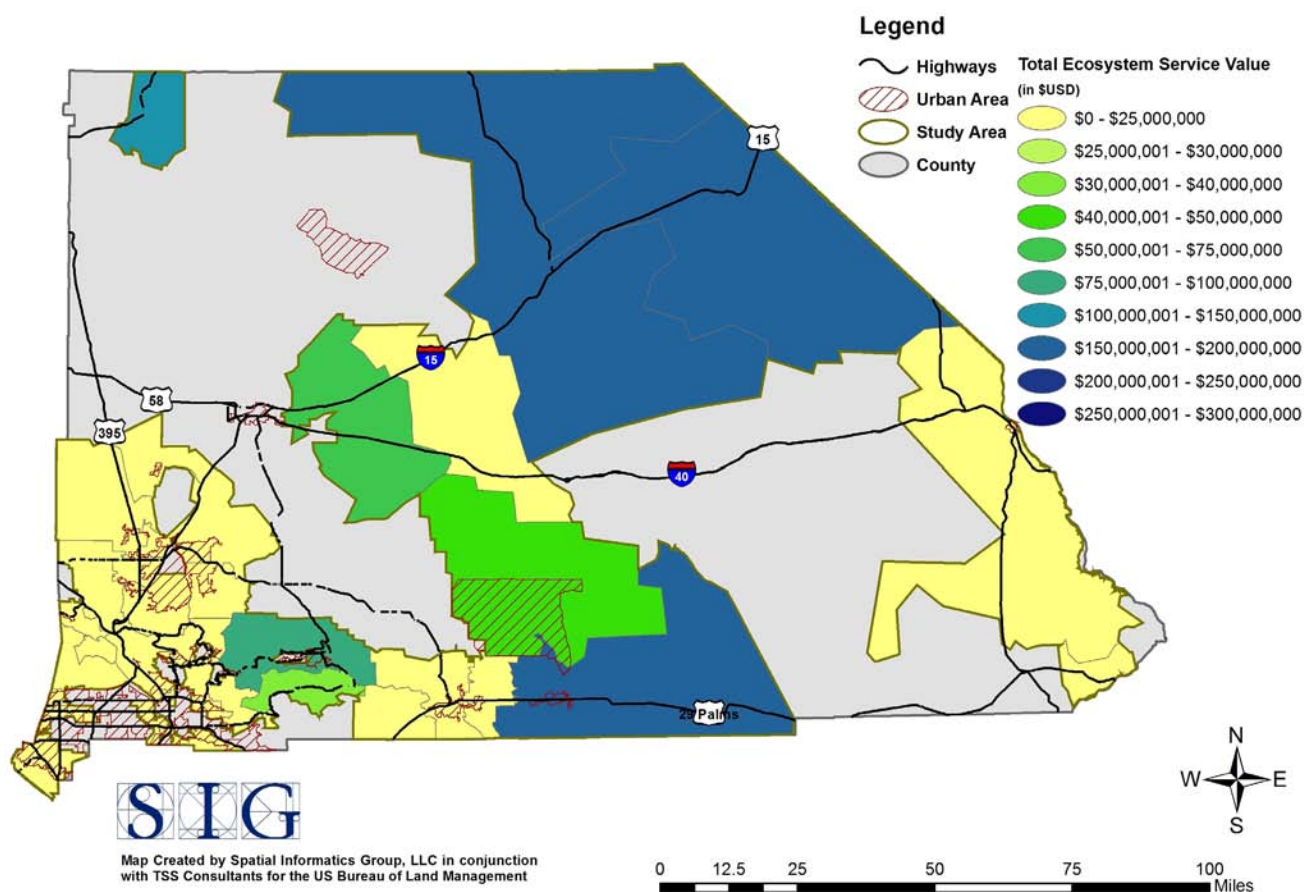


Figure 4—Total estimated ecosystem service valuation by zip code for San Bernardino County study area.

Cost Effectiveness of Fire Hazard Mitigation Efforts

In this section, we provide a cost effectiveness framework by which the BLM fuel hazard mitigation programs can be evaluated relative to their return on investment and agency management goals. This framework takes into consideration both the capital costs and the avoided losses to ecosystem services associated with fire mitigation. This will allow the BLM and other agencies to consider the real losses to ecosystem goods and services that might occur in the event that such fuel treatments were not implemented. For example, in Humboldt or Napa Counties, the treatment costs per acre range from \$306

to \$600/acre but the estimated benefits of fire mitigation are conservatively between \$117 to \$4,440/acre (using the lower range average ESV for hard-wood oak woodland and higher range average ESV for fresh water wetland). Regardless of whether the proposed fuel treatment uses prescribed burning or mechanical treatment (in either of these two counties), the costs per acre to benefit ratio will be higher when we include the accounting of avoided losses of ESVs. This application is further explained in two case studies of Morongo Valley and Petrolia. Using these case studies, we compared the costs of treatment to the estimated benefits from those treatments, including both protected structures and ESVs.

An additional analysis was used to evaluate the cost effectiveness of all projects within these three counties by agency and by treatment. NFPORS is an interagency system designed to assist field personnel in managing and reporting accomplishments for work conducted under the National Fire Plan. As it is spatially explicit, NFPORS allows for the accounting of natural assets surrounding BLM projects using both artificial boundaries (like zip codes or parcels) and natural boundaries (watershed boundaries and tributaries). The NFPORS system also allows us to evaluate the contribution of the BLM projects to the overall fire mitigation framework within these three counties and compare their efficiencies with metrics such as per acre treatment costs and their ESV avoided costs. For instance, in Humboldt County, of all the money spent by Federal agencies on fuel hazard reduction treatments, BLM spent 5.6 percent of the total on fire treatments and 29 percent on mechanical treatments. For Humboldt County, the BLM spent \$306/acre on fire treatments and \$377/acre on mechanical treatments. In Napa County where all of the treatments were performed by the BLM, 63 percent of the treatment costs were mechanical (at \$600/acre), nearly 4 percent went for fire treatments, and the remaining 33.5 percent went toward other treatments (biological and chemical). While these may seem high compared with the national averages for fire mitigation treatment, they are comparable with other parts of California. (The Congressional Research Service Report for Congress on Forest Fires and Forest Health reported a national average of treatment costs at \$250/acre. On the Shasta Trinity National Forest, treatment costs for slopes <30 percent ranged from \$250 to \$600/acre and average \$400/acre.) This would indicate that statements made about the transferability of these three counties generally apply to these treatment costs.

In an area like Humboldt County, where 6,043 acres were treated in a variety of ways by the four Federal agencies and their local partners, ESVs are estimated at \$1,177,910,801 while structural values are assessed at \$4,376,522,485, for a total accounting within the Humboldt study area zip codes of \$5,554,433,286. Given the modeling assumptions, the net benefit of performing these treatments and protecting market and nonmarket assets on the landscape level from wildfire is \$2,504/acre in Humboldt County. Using the same cost effectiveness approach, we can state that the net benefit from treatments that protect market and nonmarket assets in San Bernardino and Napa Counties are \$4,994/acre and \$22,904/acre, respectively. Compared with the \$2,504/acre “avoided costs” of protecting market and nonmarket assets in Humboldt, we can easily see that there would be a greater net loss to society resulting from a major wildfire in Napa County. Yet by reviewing the overall treatment acreages for Napa across all Federal agencies, the numbers of acres treated are substantially less than Humboldt and San Bernardino. This is probably due to the lack of Federal agency land, the overall socio-political climate for accepting fuel reduction treatments, and the costs of doing business in Napa County.

There is a national tendency to focus on treatment costs and the total number of acres treated. These metrics tend to favor fire mitigation programs in other Western States where the costs of labor and materials are lower. Over the past 36 years, the average annual price increase in California has been 8.9 percent. In 2004, the median home price was \$523,150 compared with the national average of \$219,000. These housing trends are undoubtedly contributing to the differences in costs of treatment between the three counties (table 7). Humboldt County, with its dynamically lower housing costs and the presence of the timber industry, benefits in the presence of a cost competitive labor force for implementing fuel treatment projects.

Table 7—BLM planned acres, treatment costs, and costs/acre.

County	Treatment	Planned acres	Cost	\$/acres
Humboldt	Fire	331	101,246	306
	Mechanical	1369	515,946	377
Napa	Fire	50	5,625	113
	Mechanical	158	94,730	600
	Other	255	50,500	198
San Bernardino	Mechanical	576	243,122	422
	Other	20	10,000	500

Source: Table generated from the NFPORS database. Data from 2004-2005

Our geographic disaggregation of ESVs by watershed (fig. 5) and zip code (fig. 3 and 4) allows us to depict ESV hotspots and assist the BLM in prioritizing funding to protect those areas with the highest values. From this analysis, we can compare the overall funds expended within the three counties and a per acre “avoided costs” using the total market and nonmarket values and the acres in the zip code study areas. This then allows for the computation of “net benefits per acre” for each study area acre. Although these costs and benefits are averaged over an entire zip code or watershed unit, in the case studies presented below, we have a spatial treatment footprint and will demonstrate the application at the finest scale possible—that is, of evaluating individual projects. From both of these examples, we can see that as the BLM partners become familiar with GIS, or as the BLM adjusts its grant tracking system to include spatial footprints, it should be possible to track costs and benefits of fuel treatments on different slopes and across different land cover types.

Case Studies

The two specific case studies, Petrolia in Humboldt County and Morongo Valley in San Bernardino County, are both within the wildland/urban interface (WUI). The Healthy Forest Restoration Act (HFRA; HR 1904) requires that 50 percent of the funds expended upon HFRA projects are within the WUI and municipal watersheds surrounding private homes and communities. In this Act, the WUI is defined as a 1.5 mile radius around communities; however, communities can define their own WUI by completing a “community fire

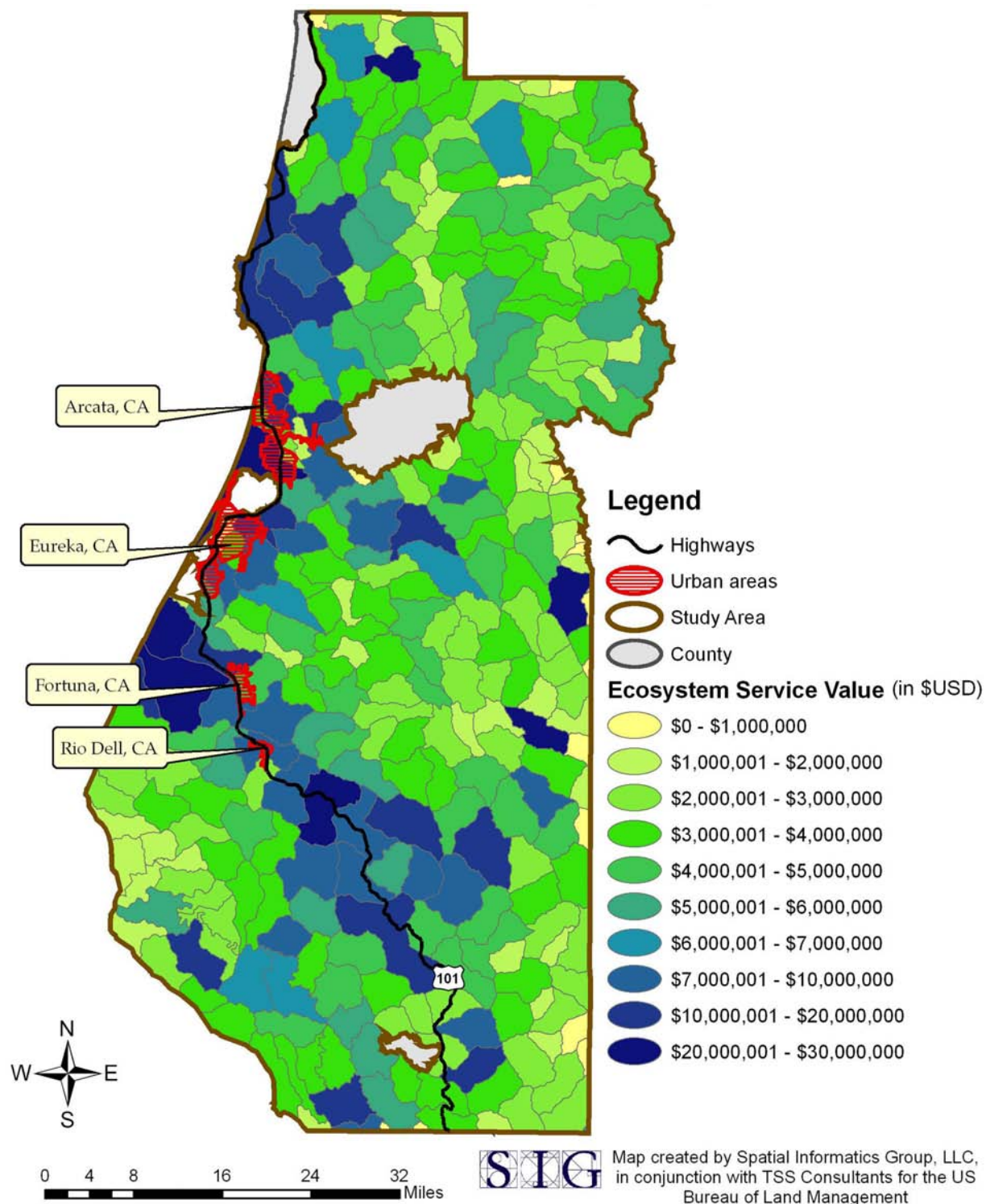


Figure 5—Total estimated ecosystem service value by watershed for Humboldt County study area.

plan.” These case study sites were selected because the BLM has created a spatial foot print for the actual treatment and sphere of influence. An additional 1.5 mile “buffer” was added to each treatment site because of the Healthy Forest Restoration Act’s call for vegetative buffers to protect communities. (The 1.5 mile buffer is relevant because when National Environmental Protection Act analysis is required, the study needs to include only the proposed action and no action alternative for projects within 1.5 miles of an at-risk community or in the WUI as defined in the Community Wildfire Protection Plan [CWWP].) The Total Economic Value (TEV) framework discussed in this study is used to identify and measure both the nonmarket, ecosystem service values *and* the market-based value of protected structures (such as homes) associated with hazardous fuels treatment. When compared with the actual costs of treatment for mechanical thinning and chipped/biomass utilization in Petrolia and Morongo Valley, respectively, these data can be used to evaluate the net social economic benefit associated with treatments on the ground (see table 8).

The Petrolia mechanical thinning project, implemented by the Mattole Restoration Council was selected as a case study for Humboldt County. The project is designed to protect Petrolia, a Community at Risk. It covered 85 acres, and as table 8 shows, the direct cost (excluding administrative) was \$332 per acre for a total one-time cost of \$28,188.

The Morongo Valley chipping and biomass removal project, implemented by the Morongo Valley Fire Safe Council, was selected as a case study for San Bernardino County. The Morongo Valley chipping and biomass removal portions of the project covered 40 acres and 35 acres, respectively, and were designed to protect Morongo Valley, a Community of Interest that is spread over a larger geographic area. The direct cost (excluding administrative) of this project was \$914 per acre for a total of \$69,432.

Table 8 data demonstrate, purely from the total economic value perspective, that both fire treatments considered in this case study appear to be cost effective. When both the nonmarket and market-based values of protected structures, goods, and services within the 1.5 mile buffer zone are taken into consideration, there appears to be a net economic benefit for each community. For instance, in the case of Petrolia, the data show that treatment project costs

Table 8—Cost effectiveness of treatment in two communities.*

Project community	Petrolia	Morongo Valley
Project type	Mechanical thinning	Chipped/biomass utilization
Acres treated	85	76
Total acres within buffer	10,479	17,993
Project cost	\$28,188	\$69,432
Project costs per acre	\$332	\$937
Market value of protected structures	\$2,073,213	\$107,494,431
Nonmarket ecosystem service values	\$4,570,692	\$379,680
Total economic value	\$6,643,905	\$107,874,111
Total economic value per acre	\$634	\$5,995
Net benefit per acre	\$302	\$5,058

* All dollar values are standardized to 2004 equivalents

were \$332 per acre, yet the total economic value of market and nonmarket goods and services within the protected buffer zone yields approximately \$634 per acre, resulting in a net benefit of \$302 per acre. In the case of Morongo Valley, while the costs of treatment were somewhat higher at \$937 per acre, the total economic value of the protected area is also considerably higher resulting in a net benefit of \$5,058 per acre (fig. 6).

What the case study data also show is that the source of economic value differs considerably for each community. In the case of Petrolia, it appears that nonmarket ecosystem service values contribute approximately twice as much to the total economic value of the protected buffer as market-based values. As a result, if one were to leave out the nonmarket component of total value in the cost-effectiveness estimate, the end result would have been quite different: the total economic value would have been only \$197 per acre, resulting in a net cost of \$135 per acre for treatment. On the other hand, in Morongo Valley, the market-based value of homes and structures appears to far outweigh the nonmarket goods and services associated with the protected buffer zone, so that the net cost effectiveness of treatment would remain the same regardless of the nonmarket benefits.

With available time and resources, the approach used in this case study comparison could effectively be expanded to include all communities in the Hazardous Fuels Program throughout California. Given the nature of value transferability, the baseline nonmarket valuation information provided by NAIS could be linked to other land cover types affected by treatment

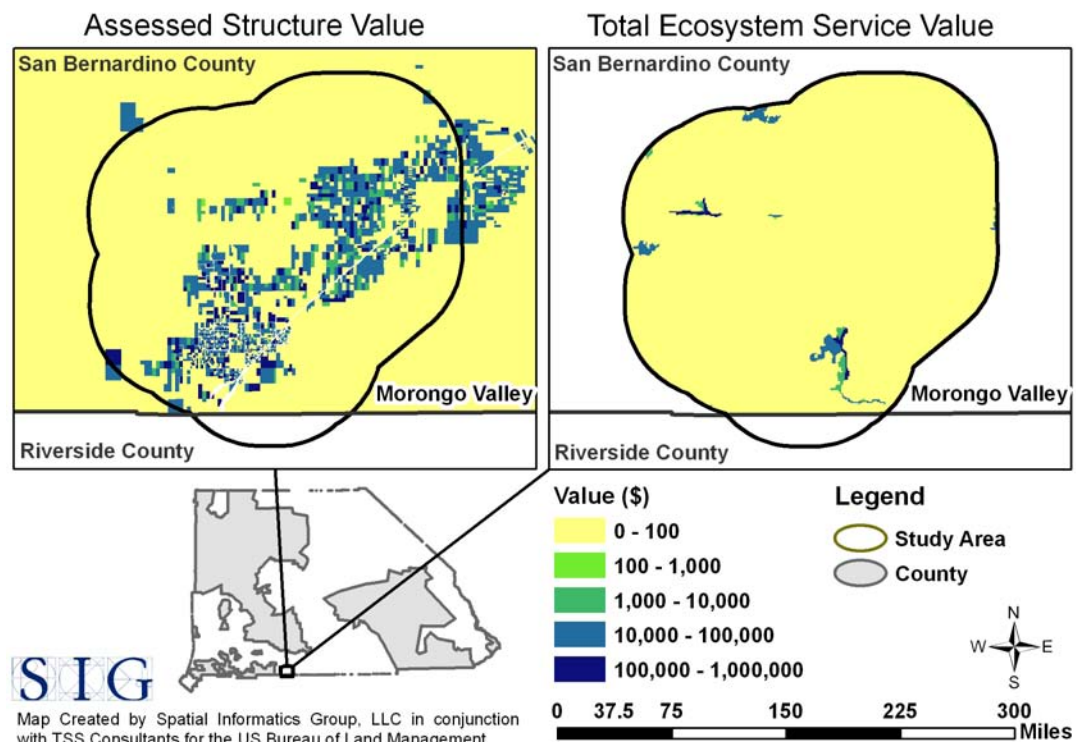


Figure 6—Morongo Valley case study area in San Bernardino County; assessed value of structures by parcel versus total ecosystem service values.

programs throughout California, and once this information is coupled with market-based value estimates, the total economic value can be estimated and compared to treatment costs. The end result would provide the possibility for a rigorous assessment of total social benefits associated with every BLM fire treatment project implemented in California. In sum, the information in this study effectively answers recent calls by policymakers to better account for the full social costs and benefits associated with environmental programs (National Research Council 2004). Armed with such information, it appears that more informed decisions can be made in the future about protecting the natural and built assets that matter most to the people in the wildland/urban interface.

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