Economic Benefits of Conserving Natural Lands:

Case Study: Lincoln National Forest and Surrounding Lands, New Mexico

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Defenders of Wildlife

This study, the remaining case studies, and a companion report (Kroeger and Manalo, 2006) outlining the basic theory underlying economic valuation of natural resources and approaches used in valuation can be found online at
http://www.defenders.org/programs_and_policy/science_and_economics/conservation_economics/economic_valuation_of_natural_resources_and_ecosystem_services/conservation_economics_valuation_publications.php

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List of Abbreviations

AUM	Animal unit month
BLM	Bureau of Land Management
BoR	Bureau of Reclamation
CCX	Chicago Climate Exchange
FS	Forest Service (USDA)
GMU	Game Management Unit
MBF	Thousand board feet
NASS	National Agricultural Statistics Service (USDA)
NF	National Forest
NMCWCS	New Mexico Comprehensive Wildlife Conservation Strategy
NMDGF	New Mexico Department of Game and Fish
NVUM	National Visitor Use Monitoring
OHV	Off-highway vehicle
tCO_2e	Ton of carbon dioxide equivalent
USDA	United States Department of Agriculture

Executive Summary

The ongoing loss of ecologically important natural lands in many parts of the U.S. is well-documented. This loss carries an associated economic cost, because natural lands and the ecosystems they contain support a large variety of human uses that carry economic value.

Documenting the economic value of human activities supported by natural lands in itself is not sufficient to ensure the conservation of those lands and the protection of the values they provide. Nevertheless, assessing the economic value of natural lands can yield information that can inform better land use decisions and conservation policy making.

In this study, which forms part of a set of five case studies that cover natural lands in Florida, Maine, Nebraska, New Mexico and Oregon, we develop estimates of the economic value of several human uses supported by a 4,900 square-mile area in southeastern New Mexico. This area is largely composed of lands identified as high-priority habitat and "key areas to consider for conservation planning efforts" (New Mexico Department of Fish and Game, 2006:90).

Our analysis includes the value associated with open space premiums that accrue to residential properties located in the vicinity of undeveloped open spaces; the value associated with outdoor recreation activities practiced in the area by local residents and visitors; the value of timber, non-timber products and grazing provided by the area; and the value of the ecosystem service of carbon sequestration provided by the lands in the area.

Our results show that the undeveloped lands in the study area generate substantial economic value. The total estimated annual value of the land uses included in our analysis ranges from $106 million to $205 million, depending on the price used to value the carbon sequestration services provided by the lands (Table ES-1).

Table ES-1: Annual value of selected uses of undeveloped lands in the study area

	Low estimate	*High estimate*
	million 2004$ per year	
Open space property value premiums	5.3	5.3
Timber and non-timber harvests	6.9	6.9
Grazing	2.2	2.2
Recreation	70.3	70.3
Ecosystem services: Carbon sequestration	21.5	120.3
TOTAL	106.1	204.9

Our analysis shows that the value of the single ecosystem service included in our study – carbon sequestration – accounts for one fifth to over one half of the total economic value generated by the lands, with a mean estimate of $70 million per year. This is comparable in magnitude to the value of recreation activities, which represent the highest-value of the other uses included in the analysis. The uncertainties surrounding an accurate pricing of net carbon uptake are not expected to affect this result, as the prices used to value this service are likely to be conservative.

The lands analyzed in this study provide a number of additional uses, such as support for educational and research activities, water supply for off-stream uses, or provision of habitat for threatened, endangered, rare or "charismatic" species like the Peregrine falcon, the golden eagle or the Mexican spotted owl. We did not include these latter uses and their associated values in our analysis for lack of the required data.

Due to these limitations on available data and the use of generally conservative value estimates throughout our analysis, both our "Low" and "High" value estimates should be considered conservative. Thus, the actual economic value of the undeveloped lands is likely to be considerably higher than indicated by our estimates. Furthermore, given the increasing scarcity of undeveloped lands and of many of the goods and services they provide, and given the expected continuation of that trend for many services, the value of these outputs is only expected to increase over time.

The lands in the study area also generate large sales, income and employment impacts in the area, conservatively estimated at $126 million annually in total final output, $51 million per year in earnings, and over 1,600 jobs, respectively. These impacts in turn generate substantial local, state and federal tax revenues.

Land use, land management and conservation planning, in order to achieve economically sensible results, should take into account the economic value generated by the conservation of undeveloped lands and the fact that the increasing relative scarcity of these lands will only increase conservation values. In areas where large tracts of land are publicly owned, as is the case in many areas in the western U.S., a shift toward land management that better takes into account ecosystem service values could be achieved through the incorporation of economic benefit considerations into land use planning and land management. However, in many regions of the country, a large share of both ecologically and economically valuable undeveloped lands is in private ownership. Where this is the case, existing financial incentive systems that encourage land conservation will need to be improved and in many cases additional ones will need to be created in order to better align privately and socially desirable outcomes. This is a challenging task whose urgency is increasing in lockstep with the continuing loss and degradation of natural lands.

Introduction

Ecosystems and the habitats and species they contain provide a wide range of economic benefits to society (Hassan et al., 2005; Daily et al., 1997). The type, quantity and quality of services provided vary among different ecosystems. Therefore, the type, quantity and quality of the ecosystem services a particular piece of land provides for onsite and offsite uses generally is affected by changes in the ecosystem. For example, conversion of the land cover from forest to pasture, through its impacts on both ecosystem structure and function, is expected to result in changes in the type, quantity or quality of the services provided by the land. The degree to which service flows change as a consequence of land cover changes depends on a variety of factors, including the original and the new cover type, the extent of the loss of the original cover and the spatial arrangement of any remaining original cover, both on the site itself and in relation to off-site land covers.

At the landscape scale, land cover changes on any given plot occur periodically as a result of natural disturbance regimes. Thus, the flow of ecosystem services from a particular piece of land is never static. For example, soil production and erosion control services may be reduced after a disturbance from storms, fires or pest infestations. However, as the ecosystem recovers from the disturbance, the service flows generally gradually return to pre-disturbance levels. In the case of human-induced disturbances, the return of the ecosystem to pre-disturbance conditions often is impeded because of the placement of long-lived or permanent (at least as measured on societal time scales) structures such as paved surfaces or buildings, or because of measures directed at preventing the return of vegetation to pre-disturbance conditions, as in the case of agriculture or lawns.

The modified ecosystems do not necessarily provide an inferior suite of services. [1] In fact, the economic value of the particular suite of services desired by a landowner may be higher for the converted land, judging from her decision to carry out the conversion.

Nevertheless, the particular services that increasingly are of primary public concern, such as biodiversity conservation, water provision or erosion control are usually reduced or lost altogether on the converted lands.[2] Most of these services represent what economists refer to as *public good* ecosystem services. Public good services are characterized among other attributes by the fact that they benefit not just the landowner on whose property they are produced, but also others, whom the landowner is not able to prevent from enjoying these benefits and who therefore receive them for free. Prime examples of public good ecosystem services are biodiversity preservation (except perhaps in the rare cases where the species of concern occurs only on one or a few privately-held properties) or climate regulation. Because the landowner cannot exclude others from the off-site benefits they receive off her lands and charge them for these services, she has no financial incentive to take the value of those third-

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[1] Of course, all ecosystems by now are impacted by human activities (Vitousek et al., 1997a, 1997b, 1997c) and thus may be considered modified. However, here we refer to systems purposefully changed by humans through land conversion.

[2] We follow general usage and apply the term "conversion" here to describe a change from "natural" vegetation or land cover to a "developed" use such as residential/commercial or agriculture. Thus, conversion does not describe changes in the opposite direction, which also occur, for example in the case of wetland reclamation or afforestation or natural succession on abandoned farmlands.

party benefits into account in her land use decisions. This divergence between individual and society-wide benefits from public good ecosystem services provided by a property may lead to land use decisions that are suboptimal or inefficient for society as a whole (Kroeger and Casey, 2007). The total value of the services the land provides to society as a whole may be lower following the conversion, but the *private* benefits to the landowner from the conversion exceed the *private* cost for the landowner in the form of the services reduced or foregone by *her*. It is the realization of this conflict between privately and socially desirable land use choices that underlies much of public natural resource conservation policy making.

The recognition of and the generation of quantitative information about the value of natural lands is an important, though neither a necessary nor a sufficient condition for making intelligent conservation policy decisions. Even if the value of the goods and services provided to society by a particular land or ecosystem, or some approximation thereof, is known, the protection of those values is contingent on two further factors. First, institutional mechanisms must be in place that allow the owner of the land to capture the value of the off-site services her land provides. Such mechanisms can take several possible forms, including government payment programs, ecosystem service markets based on regulation or voluntary action, or fiscal incentives (e.g., tax deductions) (Kroeger and Casey, 2007). In addition to the need for a value capture mechanism, the sum of the landowner's private (on-site) benefits and the compensation she receives for the off-site benefits her land provides must exceed the benefits she expects to obtain from land development. [3]

Thus, information on the value of the benefits associated with land conservation by itself cannot guarantee the conservation of undeveloped lands, but it is a first step towards making that outcome more likely.

In this study we identify a variety of human uses supported by the undeveloped lands in a specific area in Southwestern Florida that is under high development pressure, and develop quantitative estimates of the economic value of those uses for which we have sufficient data.

This study forms part of a set of five diverse case studies that examine the economic benefits provided by natural lands that as priority conservation areas identified in the respective states' Comprehensive Wildlife Conservation Strategies or Wildlife Action Plans.

[3] This assumes landowners act as profit-maximizers. In the case of a landowner who has a preference for keeping the land in an undeveloped state for non-financial motives, the payment would not necessarily need to be financially competitive with development. Rather, payment would merely need to be sufficient to make it financially possible for the landowner to avoid selling off the property to developers.

Methodology

Study area selection and characteristics

The main objective in selecting our sample of five case study areas was to achieve a representation of diverse geographic regions, ecosystem types, and land ownerships within the sample.

The two principal criteria underlying the selection and delineation of the New Mexico study area were its composition of predominantly high priority areas as identified in the New Mexico Comprehensive Wildlife Conservation Strategy (hereafter NMCWCS; New Mexico Department of Game and Fish, 2006) and its spatial discreteness.

New Mexico's Comprehensive Wildlife Conservation Strategy identifies "key areas to consider for conservation planning efforts" (NMCWCS, fig. 4-8, p. 90). The Strategy shows a discrete area of high conservation concern east of Alamogordo, as well as a larger area of intermixed high and highest conservation concern between Alamogordo and Carlsbad.

Our study area boundary encloses the contiguous, discrete high priority area east of Alamogordo identified (Figure 1, yellow and orange-colored areas in sections *A* and B of our study area), as well as some surrounding areas of priority Madrean pine-oak and oak-conifer habitat (Figure 2, red areas in section *A*). The study area comprises the entirety of the Madrean pine oak and conifer oak forest and woodland habitat type, identified as a key terrestrial habitat in the Arizona-New Mexico Mountain Ecoregion (NMCWCS, fig. 5-2, p. 114).

Much of this area is located on and between the central and northern segments of the Lincoln National Forest (gray shaded areas in Figures 1 and 2). In addition, section *B* of our study area encompasses a largely contiguous high priority area (turquoise and light blue areas in Figure 1), the western part of which is overlapping with the eastern end of the southern portion of Lincoln National Forest. This section also includes substantial amounts of Chihuahuan semi-desert grassland habitat, identified as a key terrestrial habitat in the Chihuahuan Desert Ecoregion (NMCWCS, fig. 5-3, p. 150), and Madrean pine-oak and oak-conifer habitat (see purple and red-colored areas in section *B* in Figure 2).

The boundaries are drawn such that they include major sections of the identified high priority areas and habitat types in the area. Since substantial portions of these high-priority areas and habitats are located on the Lincoln National Forest, we decided to include the forest as a whole in the study area, primarily for reasons of convenience with respect to data collection. Specifically, information on the levels of some human activities in the area is expected to be available for the National Forest that may not be available for the state, private or Indian lands. In these cases, the National Forest data may be useful as a minimum estimate for overall levels of particular activities in the study area. The northern and eastern portions of section *B* of our study area are delimited by roads as convenience boundaries, which also has the desired effect of increasing the proportion of private lands included in the study area (Figure 3).

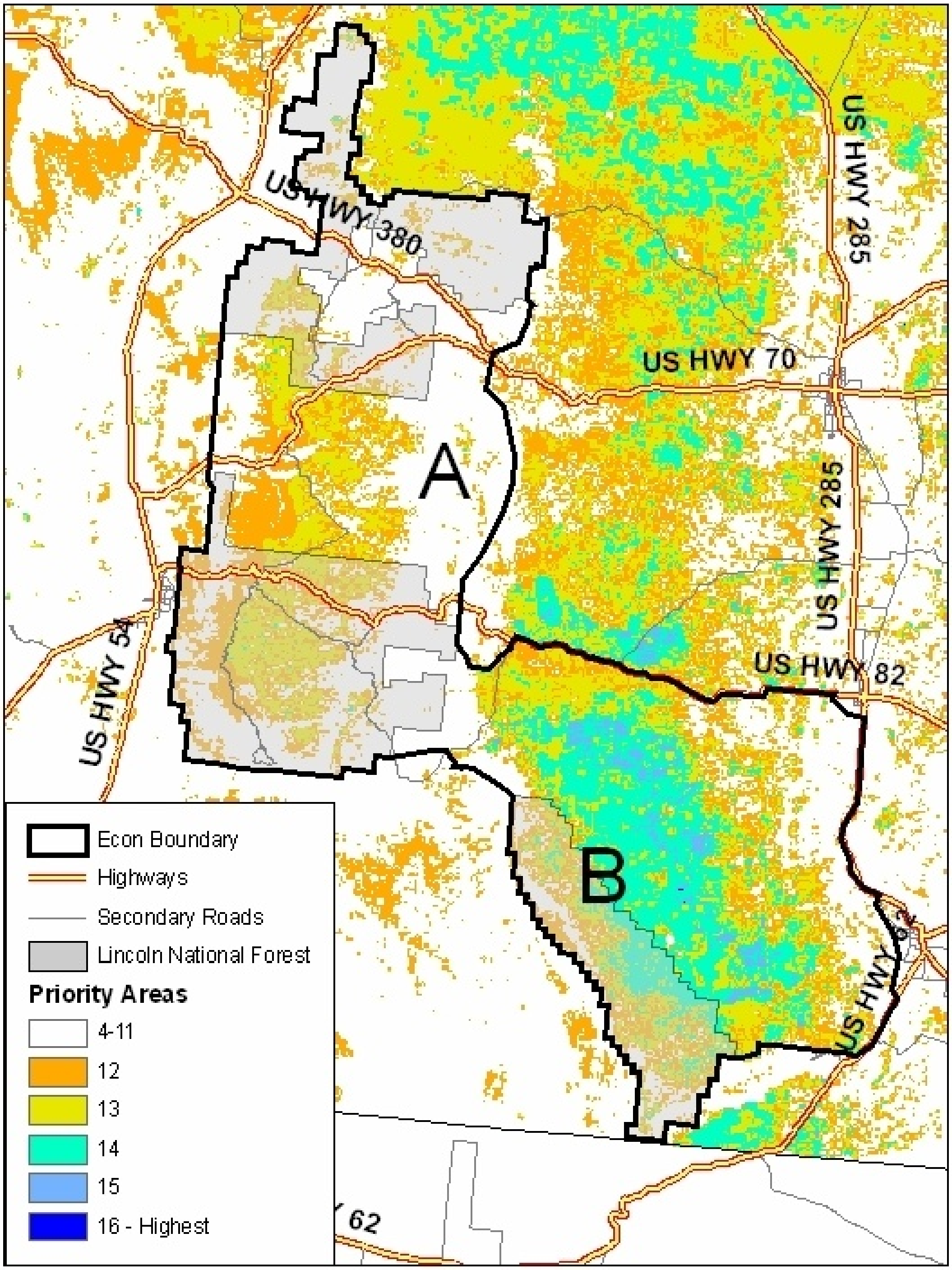

Figure 1: Study area boundary and high priority areas as identified in New Mexico's Comprehensive Wildlife Conservation Strategy (New Mexico Department of Game and Fish, 2006)

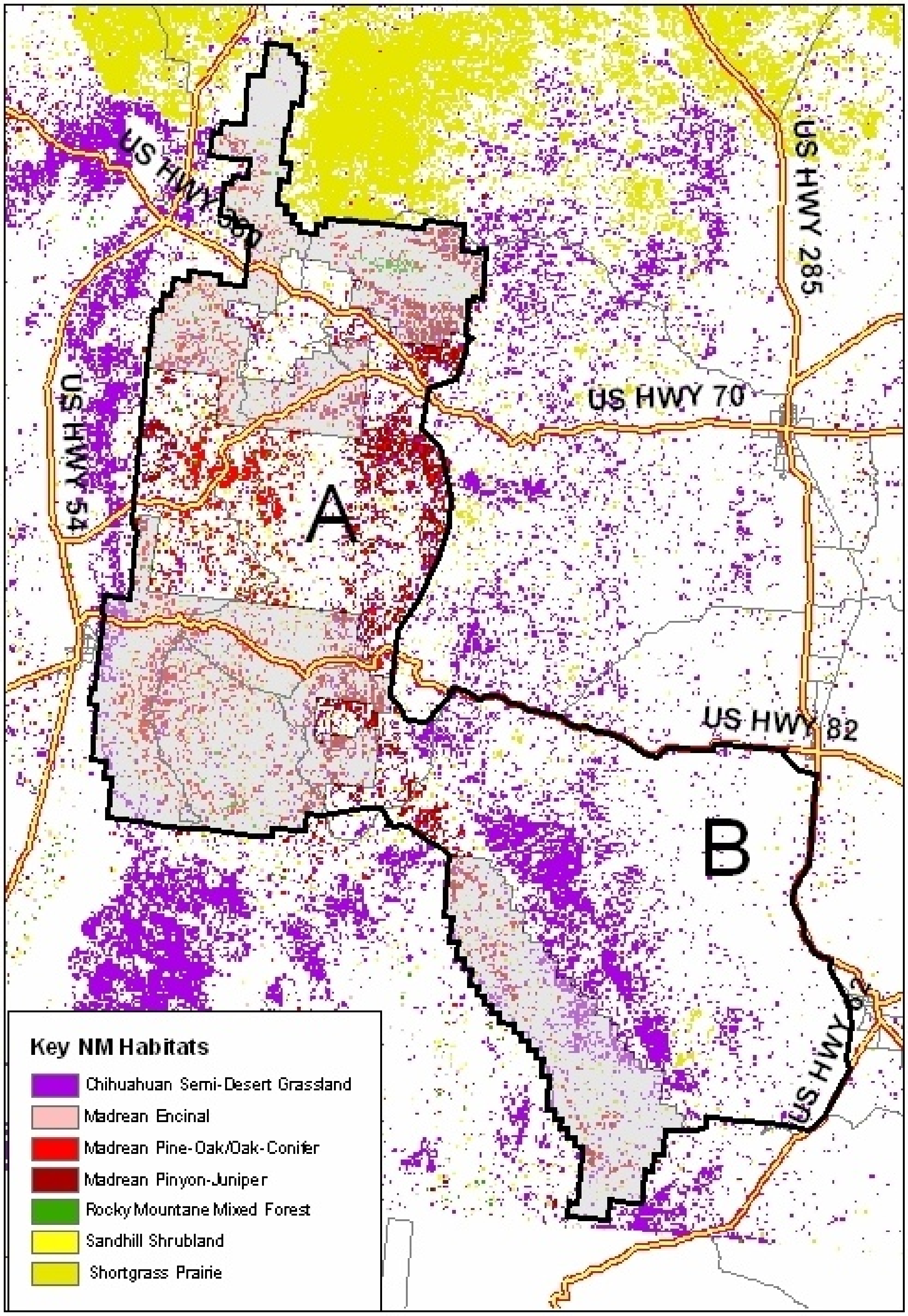

Figure 2: Study area boundary and priority habitat types as identified in New Mexico's Comprehensive Wildlife Conservation Strategy (New Mexico Department of Game and Fish, 2006)

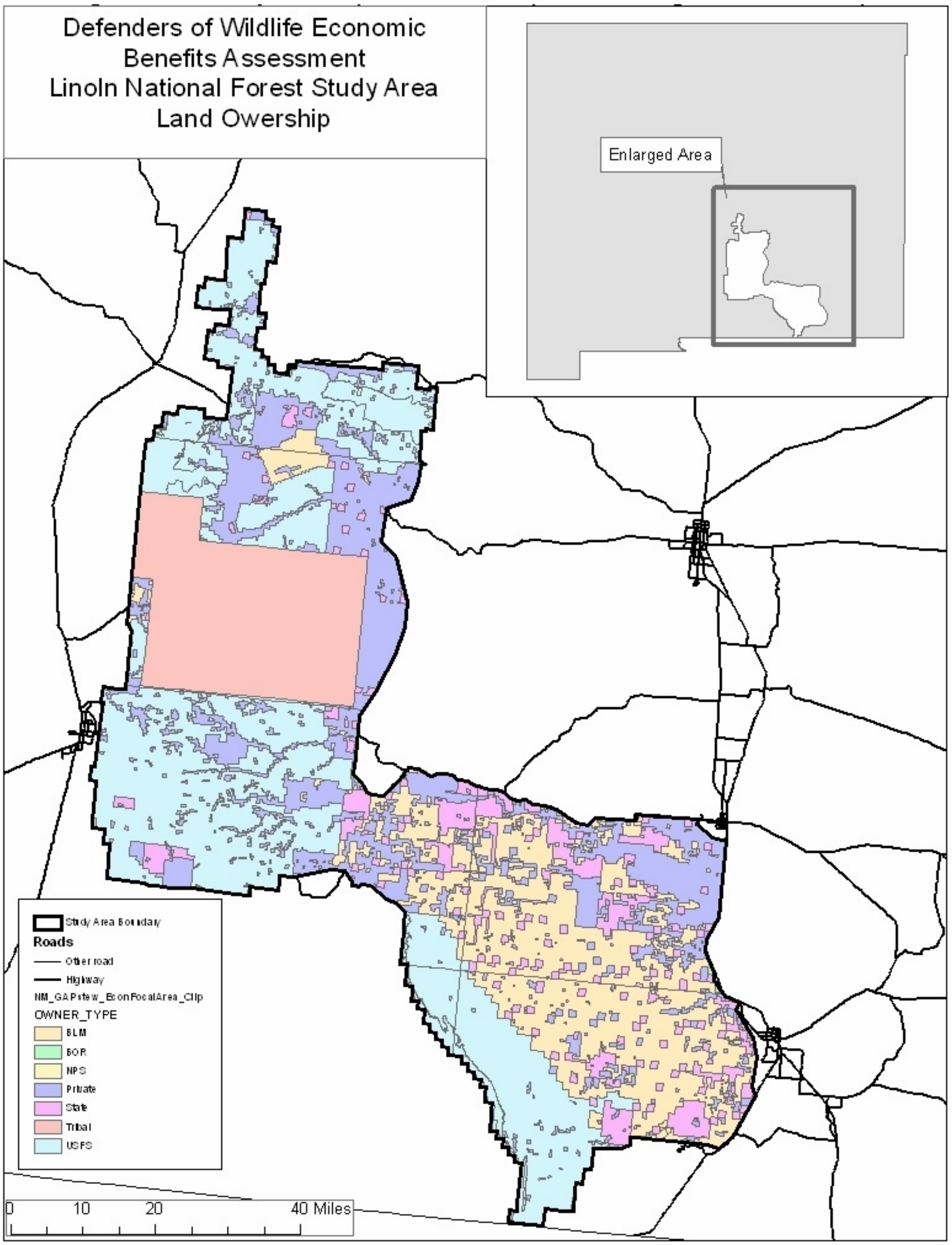

Figure 3: Land ownership in the study area

The study area covers a total of over 3.1 million acres (Table 1). The Forest Service is the main land owner, with over one-third of the area located on the Lincoln National Forest. The next largest shares of the area are in private, Bureau of Land Management, tribal, and state ownership, respectively.

Table 1: Land ownership in the study area

Landowner Type	*Percent*	*Acres*
Forest Service	35	1,078,289
Private	22	690,841
BLM	21	642,261
Tribal	14	438,149
State Land	8	255,857
BoR	0	1,402
NPS	0	976
Total	100	3,107,774

Notes: BLM – Bureau of Land Management, BOR - Bureau of Reclamation; NPS – National Park Service.
Source: GIS data

Economic analysis framework

The economic theory underlying the valuation of natural resources and the general approaches used in valuation applications are discussed in a companion report (Kroeger and Manalo, 2006). In this study, we develop quantitative estimates of the economic value of the annual flows of benefits produced by the study area. Our estimates therefore represent the values of benefit flows in a given year, not the total present values of the natural resource stocks. In other words, we do not estimate the total economic net present value of the natural assets in the area (e.g., the forest and woodlands, animal and plant species, etc.), but rather the value of the benefits flowing from these stocks that accrue to humans in a given year (e.g., timber harvests, recreation, carbon sequestration, scenic views). The base year for our analysis is 2004, the most recent year for the majority of available data. In those cases where the only available data are for a different year, we indicate this in the text. All values are expressed in 2004 dollars ($2004).

Following common practice, our analysis of the economic values provided by the area is separated into two parts. The first employs a welfare analysis-based perspective and attempts to quantify the total economic value of the benefits examined for all individuals who directly or indirectly use the area. The second is based on an economic impact analysis perspective and attempts to quantify the total contribution the natural lands in the study area make to the local economy, by quantifying the total final output (sales), labor income, and employment in the area derived from activities supported by the natural systems in the study area. The welfare analysis-based assessment includes the market as well as the non-market values and the use as well as the passive-use and ecosystem service values of the benefits provided by the ecosystems in the study area, while the impact analysis-based assessment only includes observed market impacts attributable to expenditures associated with those ecosystems.[4]

[4] For a more detailed discussion of the different types of values, see Kroeger and Manalo (2006).

Uses included in analysis and associated economic values

The ecosystems that constitute the study area provide a wide variety of benefits to local and regional human populations. Part of these benefits result from the direct use humans make of the ecosystems or their components, as for example in the case of timber extraction, livestock grazing, or recreation. In addition to these direct uses, the ecosystems in the area provide a number of services that benefit local or regional residents. Examples of such services are clean water (through the retention, creation [as a result of the orographic effect] and filtering of water), a diverse fauna and flora, or the sequestration of atmospheric carbon by perennial plants.[5] Finally, some aspects or components of the study area may hold passive use values, to the extent that individuals appreciate their existence independently of any direct use of these features. For example, studies have shown that people value the existence of unique landscapes, of particular, "charismatic" species, or they may value the thought of preserving particular areas intact and largely unaffected by human development (see the studies cited in Kroeger and Manalo, 2006).

Out of the full range of benefits potentially provided by the natural systems in an area (see table 1 in Kroeger and Manalo, 2006), in this study we focus only on the benefits from those uses for which we were able to obtain information, and that are compatible with and contingent upon the continued conservation of the area. These are shown in Table 2. The fact that a particular use is not indicated in Table 2 does not imply that this use does not occur in the study area. It merely indicates that in our research we have not found evidence of its occurrence. Specifically, the fact that no passive uses are included in the table should not be taken to mean that the area does not hold value to people independent of their active uses of the area. For example, a number of the species of greatest conservation concern listed in the Madrean pine-oak conifer-oak forest and woodland habitat, which is located almost in its entirety in our study area, are charismatic species for which several studies have shown people holding substantial passive use values. These species include the Peregrine falcon, the golden eagle, the Mexican spotted owl (Loomis and Ekstrand, 1997; Loomis and Gonzáles-Cabán, 1998), and the jaguar (NMCWCS, table 5.4).[6]

Due to our focus on uses that depend on the conservation of the area, we do not quantify the economic value associated with uses that are not dependent on or compatible the conservation of above ground ecosystems. Examples of such uses are caving, which represents an important recreational activity in the area but is not dependent on the conservation of above-ground ecosystems, and mining, which is either not dependent on (below ground mining) or incompatible with land conservation (surface mining, mine tailings, access roads, etc.).[7]

[5] The Forest Service's economic impact assessment of Lincoln National Forest mentions, but does not attempt to quantify, the important services the forest provides water in terms of retention and generation, temperature modulation, air quality, and scenic views for the region (Aldrich and Mitchell, 2006).

[6] The Mexican wolf is also listed as occurring in this habitat type (NMCWCS, table 5-4), but it presently occupies only lands in western New Mexico, which contain the few areas of Madrean pine-oak conifer-oak forest and woodland habitat located outside of our study area.

[7] We do include the OHV use and downhill skiing in our analysis, however, since these potentially incompatible uses are in fact compatible with ecosystem conservation as long as they do not encroach on currently intact lands. These uses furthermore are dependent to some extent on the scenic attractiveness provided by the surrounding natural lands, which attract skiers and OHV users.

Table 2: List of documented uses of the study area's ecosystems

Direct uses	Timber extraction Non-timber products Grazing Recreation - Camping - Backpacking - Picnicking and general relaxation - Scenic viewing and pleasure driving * - Fishing - Hunting - Hiking - Horseback riding - Skiing - Swimming - Wildlife watching - Caving - Bicycling - OHV and snowmobile use *** - Visits to archaeological sites Cultural preservation (archeological sites) Research and education Property value premiums
Indirect uses	Ecosystem services - Water retention and generation (water quantity) - Water quality - Species habitat provision ** - Biodiversity maintenance - Temperature modulation - Carbon sequestration - Air quality

Notes: * Part of the associated value of scenic viewing is captured in property value premiums. ** Part of the associated value is captured in fishing, hunting, and wildlife viewing uses. *** These activities may be compatible with land and species conservation if they are restricted to designated trails or areas and follow appropriate rules.
Sources: Aldrich and Mitchell (2006), Kocis et al. (2004), BLM Carlsbad Field Office.

Some uses of the study area have important non-market values, that is, their full economic value cannot be assessed on the basis of observed market transactions alone (Table 3). Whenever possible, we attempt to capture this non-market value component by using appropriate valuation approaches. For example, in the case of many recreation activities, studies have shown that the average participant in these activities derives a value from engaging in them that surpasses his or her trip recreation-associated expenditures. We use published consumer surplus estimates for particular recreation activities practiced in the area in order to quantify this non-market portion of the value of recreation.

Table 3: Uses of the study area and types of associated economic values

Use	*Market value*	*Non-market value*
Timber extraction	ü	
Non-timber forest products	ü	
Grazing	ü	
Recreation	ü	ü
Cultural/historical preservation	ü	ü
Research and education	ü	ü
Property value premiums	ü	
Federal agency activities on FS and BLM lands	ü	
Ecosystem services	ü	ü

Due to limits in the scope of our analysis, we do not develop estimates of the value of cultural or historical preservation, research and education, and most ecosystem services provided by the study area. In addition, information is incomplete on the levels of some of the uses we do include in our analysis. For example, while we do have quantitative information on the numbers of recreation visitors for the National Forest lands in the study area, we were unable to obtain such information (for all uses except hunting) for all other lands in the area. As a result, our value estimates exclude some uses and incompletely capture the value of others, and thus necessarily represent underestimates of the total value of the annual flow of benefits provided by the ecosystems in the area.

Estimates of the Economic Value of Land Uses

In this section, we develop estimates of the value of some of the uses supported by the natural lands in the study area shown in Table 2. We limit our analysis to the value of those uses that are compatible with or contingent upon natural lands in the study area and for which we were able to obtain data.

Recreation

Although a variety of outdoor recreation activities are practiced throughout the study area, data on the number of recreation visitors participating in activities relevant for this study are available generally only for the National Forest lands in the area, with the exception of hunting on private lands.

Lincoln National Forest

The most recent visitation estimate for the Lincoln NF is based on the National Visitor Use Monitoring (NVUM) survey conducted in 2002-2003 (Kocis et al., 2004). Based on the recently revised estimate (FS, 2006), a total of an estimated 829,000 persons visited the Lincoln NF during that year.

The economic value of recreation activities on the forest is measured as the total willingness-to-pay (WTP) of participants for the activities they engage in. The total value individuals assign to a particular recreation activity can be distinguished into two components, on the basis of the different approaches needed for quantification. The first is the actual expenditures individuals incur in the process of engaging in a particular activity such as wildlife watching. The second is the consumer surplus (CS), or net benefit, they receive from the activity, which measures how much the individuals would have been willing to spend on the activity above and beyond what they actually spent. Information on trip and equipment expenditures is reflected in market transactions, and is collected in comprehensive statewide expenditure surveys conducted every five years by the U.S. Fish and Wildlife Service and the U.S. Census Bureau (2007). Information on consumer surplus is obtained through revealed preference approaches such as contingent valuation surveys, and is commonly reported in terms of consumer surplus per activity day, that is, per day spent fishing, hunting, or engaging in some other activity of interest. [8] We can construct an estimate of the total value visitors attach to nature recreation activities in our study area by combining estimates of total activity days per year with information on average consumer surplus and spending per activity day.

Recreation expenditures

Of the visitors to Lincoln NF during October 2002 to September 2003, 65.6 percent (approximately 543,800) stated that recreation on the forest was their primary purpose for the visit (Kocis et al., 2004). The trip-related expenditures these visitors made in the vicinity of Lincoln NF can be attributed to the recreation opportunities offered by the forest.

[8] For a more detailed description of the different valuation methods, see Kroeger and Manalo (2006).

The average trip expenditures by visitors to Lincoln NF whose primary purpose was recreation were $167 (2004$) per party (Stynes and White, 2005). These expenditures do not include any spending on equipment. They only include spending on trip-related items (lodging, restaurant, groceries, gasoline and oil, other transportation expenses, activities, admissions and fees and souvenirs) made within a 50-mile radius of Lincoln NF. Total (trip and equipment) expenditures made in the state by visitors to Lincoln NF are much higher. For example, total expenditures in New Mexico made by participants in wildlife-associated recreation on Lincoln NF are over one hundred times as high as the actual trip expenditures on Lincoln NF visits. However, it is difficult to identify with reasonable certainty the portion of equipment expenditures that is effectively attributable to a particular location such as Lincoln NF (American Sportfishing Association, 2006). Trip expenditures therefore are best interpreted as a lower bound estimate of recreationists' actual total spending on visits to Lincoln NF, while total (trip and equipment) expenditures are best regarded as an upper bound estimate. Unfortunately, estimates of total expenditures by recreationists in a state are available only for wildlife-associated recreation (FWS and Census Bureau, 2003).

With an average size of visiting parties of 2.5 (Stynes and White, 2005), average trip expenditures by recreation visitors were $67 per person, yielding a total estimated trip spending of $36.4 million in 2004 within a 50-mile radius of the forest.

Consumer surplus of recreation activities

To develop estimates of the total value of the consumer surplus from recreation activities on Lincoln NF, we first identify the numbers of visitors who participated in various recreation activities on the forest, and then multiply these numbers with the corresponding average consumer surplus values for the particular recreation activities.

The 2002-03 NVUM survey of the Lincoln NF identifies for each recreation activity the percentage of visitors stating that that activity was their primary activities during their visit (Table 4). The percentages of participation in the various primary activities does not sum to 100, because some visitors indicated more than one primary activity. In order to be able to estimate the total number of activity days spent on each recreation activity by multiplying total visitor days spent on the forest with the percentage of days associated with specific activities, we adjust the percentages reported for several of the listed activities such that participation rates sum to 100 percent. Specifically, we proportionately reduce the percentages of people stating they engaged in "relaxing", hiking/walking", or "viewing natural features" as their primary activities, since the majority of recreation visitors are likely to engage in these activities and as such these activities likely are the most prone to lead to multiple responses. Both the reported (in parentheses) and adjusted participation rates are shown in Table 4. The 544,000 recreation visitors to Lincoln NF in 2002-03 spent an average of 29.6 hours, or 1.2 days, on the forest, yielding a total of 671,000 activity days.

Loomis (2005) presents the most comprehensive compilation of estimates of the average consumer surplus per person per activity day for a variety of outdoor recreation activities, by major geographic region in the U.S. (Table 5).[9, 10] We use his estimates for specific activities

[9] The regions roughly correspond to the U.S. Census Bureau regions: Alaska, Intermountain, Northeast, Pacific Northwest and Southwest, and Southeast (Loomis, 2005).

Table 4: Primary activities of recreation visitors to Lincoln NF (2002-03)

Primary activity	*Percent of visitors participating*
Developed camping	2.84
Primitive camping	4.38
Backpacking	0.81
Resort use	0.81
Picnicking	2.98
Viewing natural features	5.36 *[6.65]*
Visiting historical sites	0.25
Nature center activities	3.98
Nature study	0.05
Relaxing	11.17 *[13.87]*
Fishing	0.36
Hunting	1.57
OHV use	3.56
Pleasure driving	4.72
Snowmobiling	0.1
Motorized water activities	0
Other motorized activity	2.38
Hiking/walking	23.05 *[28.61]*
Horseback riding	0.47
Bicycling	2.6
Non-motorized water	0
Downhill skiing	22.35
Cross-country skiing	2.52
Other non-motorized	1.75
Gathering forest products	0
Wildlife viewing	1.94

Notes: Values in parentheses are those presented in Kocis et al., (2004). These values were then adjusted to ensure they sum to 100 (see text).
Source: Kocis et al. (2004)

in the Intermountain Region, which includes New Mexico, except in a few cases where no data are available for that region. In these cases, we use consumer surplus values for other regions, preferably those derived from studies covering multiple regions. Some activities listed in the NVUM survey do not match those in Loomis (2005). We estimate the consumer surplus associated with these activities by identifying those activities in Loomis (2005) that most closely matched the NVMU activities. More detail on this can is provided in the Appendix (Table A-1).

Visitors engaging primarily in wildlife-related activities (hunting, fishing, wildlife viewing) accounted for four percent of all recreational visitors. Our analysis indicates that hiking/walking, downhill skiing, relaxing, and pleasure driving are the activities that generate the largest total consumer surplus. Total consumer surplus of recreation activities on the Lincoln NF is estimated at approximately $26 million per year.

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[10] An activity-day represents the typical amount of time a person pursues an activity within a 24-hour period (Loomis, 2005).

Table 5: Average CS per activity day per person, 2004$

Activity	*Average consumer surplus (2004$)*
Developed camping	34.72
Primitive camping	34.72
Backpacking	52.10
Resort use	-
Picnicking	28.27
Viewing natural features	23.58
Visiting historical sites	23.58
Nature center activities	6.01
Nature study	56.35
Relaxing	48.46
Fishing	49.57
Hunting	48.55
OHV use	22.81
Pleasure driving	69.74
Snowmobiling	36.29
Motorized water activities	n/a
Other motorized activity	56.35
Hiking/walking	38.53
Horseback riding	18.12
Bicycling	48.46
Non-motorized water	n/a
Downhill skiing	39.62
Cross-country skiing	29.88
Other non-motorized	56.36
Gathering forest products	n/a
Wildlife viewing	37.24

Notes: n/a – not applicable. For coding of recreation activities, see Table A-1 (Appendix).
Source: Loomis (2005)

The foregoing analysis of trip spending and consumer surplus data indicates that Lincoln NF holds a minimum value for primary purpose recreation visitors of at least $62 million per year. About 60 percent ($36 million) of this amount is reflected in market transactions associated with trip spending, while the remainder represents consumer surplus that is not captured by markets but nevertheless represents real economic value. The actual total economic value of recreation activities on the Lincoln NF likely is larger than $62 million per year, because the market portion of this value only includes trip spending within a 50-mile radius of the forest and does not include any equipment purchases by visitors to the forest. As discussed above, part of these equipment expenditures are attributable to recreation on the forest and thus should be counted as part of the WTP of recreation visitors. Due to the lack of data on equipment spending by NF recreationists other than those engaging primarily in wildlife-associated recreation (which only represent about four percent of all visitors to Lincoln NF) it is impossible to estimate the size of equipment expenditures. Based on the ratio of equipment to trip expenditures in the case of participants in wildlife-associated recreation activities, however, it is likely that equipment expenditures are larger than trip expenditures. The total recreation value of Lincoln NF thus may be much higher than the estimate of $62 million developed above, likely surpassing $100 million per year.[11]

Table 6: Total consumer surplus of various recreation activities on Lincoln NF

Activity	*Total consumer surplus (2004$)*
Developed camping	661,358
Primitive camping	1,019,982
Backpacking	283,049
Resort use	-
Picnicking	565,042
Viewing natural features	847,292
Visiting historical sites	39,539
Nature center activities	160,434
Nature study	18,897
Relaxing	3,631,849
Fishing	119,691
Hunting	511,243
OHV use	544,646
Pleasure driving	2,207,816
Snowmobiling	24,340
Motorized water activities	n/a
Other motorized activity	899,518
Hiking/walking	5,956,412
Horseback riding	57,121
Bicycling	845,076
Non-motorized water	n/a
Downhill skiing	5,939,239
Cross-country skiing	505,033
Other non-motorized	661,527
Gathering forest products	n/a
Wildlife viewing	484,563

BLM lands

Twenty-one percent of our study area is managed by the BLM (Table 1). Most of these lands are managed by the BLM's Roswell and Carlsbad field offices.

The single most significant individual site for outdoor recreation on BLM lands in the study area is the Roswell office's 24,000 acre Fort Stanton recreation area, designated as area of critical environmental concern. The Fort Stanton area contains 60 miles of developed trails for hiking, horseback, and mountain biking through open meadows and canyons with great

[11] Fishing, hunting, and wildlife watching require substantial investments in equipment. This is also true however for a number of other, high-volume recreation activities practiced on Lincoln NF, such as downhill and cross-country skiing, OHV use and camping. Thus, it is not obvious why the ratio of trip expenditures to equipment expenditures for the average non-wildlife recreation visitor to the forest would be fundamentally different from that observed for wildlife-associated recreation visitors.

views of the surrounding Lincoln National Forest, the Sacramento and Capitan mountains. [12] It also offers opportunities for backpacking, caving, and wildlife watching, visits to historic sites (Historic Fort Stanton), picnicking, hunting, fishing, camping, and nature Study.[13]

The Carlsbad field office area also provides opportunities for hiking, horseback riding, camping, biking, off-road vehicle use, fishing, caving, hunting, wildlife viewing. However, estimates on visitation data are available only for caving, which is not an activity that necessarily depends on the conservation of natural habitats above ground and as such is not included in our analysis.[14]

Hunting on state, private, and federal lands

In addition to federal lands, private and state lands in our study area also provide recreation opportunities. However, available data is sparse, and generally is limited to hunting. Animals legally hunted in the study area include elk, deer, bighorn and Barbary sheep, pronghorn antelope, javelina, cougar, bobcat, bear, turkey, as well as several smaller birds such as bandhill and bento pigeons, morning dove, quail.[15] Due to constraints on the scope of the study, we limit our analysis to deer and elk hunting, which account for the vast majority of all big game hunting in New Mexico (Fish and Wildlife Service and Census Bureau, 2003).

The New Mexico Department of Game and Fish maintains data on the number of elk and deer hunting permits issued in game management units (GMU) 30, 34, and 36 that are overlapping with our study area (NMDGF, 2007). Each elk permit is valid during a particular season. For all permits except bow permits, the elk season is five days long. The bow season is 22 days long (NMDGF, 2007). We obtained the estimated number of elk hunting activity days in each GMU by multiplying the number of the various elk permits for the unit by the number of days in each permit season. [16] To account for the fact that about ten percent and 50 percent, respectively, of GMUs 34 and 36 lie outside of our study area, we reduced our unit-wide activity day estimates for these units by the respective percentages to obtain an estimate of the number of elk hunting activity days in each unit that occurred in our study area. Based on the NMDGF data, an estimated 16,000 activity days of elk hunting occur in the study area per year (Table 7), or approximately seven percent of all elk hunting days per year in the state (Fish and Wildlife Service and Census Bureau, 2003).

In the case of deer, we obtained 2006-2007 permit numbers for GMUs 30, 34 and 36 from NMDGF's deer harvest estimates (NMDGF, 2007b) and adjusted these numbers on the basis of the percentage of each unit that is located in our study area. To develop and estimate of deer hunting activity days, we multiply permit numbers by 5.3, which is the number of days the average big game hunter in New Mexico hunts per year (Fish and

[12] Public Lands Information Center, *http://www.publiclands.org/explore/site.php?id=110&PHPSESSID=23cfeb7c9* Accessed August 8, 2007.
[13] BLM Roswell Field Office, *http://www.nm.blm.gov/recreation/roswell/fort_stanton_acec.htm* Accessed August 10, 2007.
[14] Pers. comm., Dario Lunardi, BLM Carlsbad Field Office, July 2, 2007.
[15] Pers. comm., Darrel Weybright, big game coordinator, NM Department of Game and Fish, July 26, 2007. Pers. comm., Tim Mitchusson, small game coordinator, NM Department of Game and Fish, July 31, 2007.
[16] This was the procedure suggested by Darrel Weybright, big game coordinator, NM Department of Game and Fish.

Wildlife Service and Census Bureau, 2003). Based on the NMDGF data, we estimate that a total of approximately 39,000 deer hunting days occur in the study area per year, or about 10 percent of all deer hunting days in New Mexico (Fish and Wildlife Service and Census Bureau, 2003).

Table 7: 2007-2008 elk hunting licenses in the study area

License type	*Hunt dates (number of days)*	*Fee type*	*Number of licenses*	*Bag limit*	*Activity days*	
					Unit-wide	*In study area*
Any legal sporting arm						
GMU 34						
	Oct. 13-17 (5)	HD	150	MB	750	675
	Nov. 24-28 (5)	S	250	A	1,250	1,125
	Dec. 1-5 (5)	S	250	A	1,250	1,125
Youth Only	Sept. 29-Oct. 3 (5)	S	150	ES	750	675
Mobility-Impaired Only	Sept. 29-Oct. 3 (5)	HD	50	MB	250	225
GMU 36						
	Oct. 13-17 (5)	HD	75	MB	375	188
	Oct. 13-17 (5)	S	143	A	715	358
	Oct. 27-31 (5)	HD	250	MB	1,250	625
Bows only						
GMU 34	Sept. 1-22 (22)	HD	148	ES	8,800	7,920
GMU 36	Sept. 1-22 (22)	HD	148	ES	3,256	1,628
Muzzleloaders and bows						
GMU 34	Oct. 6-10 (5)	HD	250	MB	1,250	1,125
GMU 36	Oct. 6-10 (5)	HD	125	MB	625	313
Total GMUs 34 & 36					20,521	15,981

Notes: No elk hunting permits are issued for GMU 30.
Source: NMDGF (2007)

Table 8: Deer hunting licenses and activity days in the study area

	Number of licenses		*Estimated number of deer hunting days in study area*
	Unit-wide	*In study area*	
GMU 30	3,558	3,558	18,929
GMU 34	3,551	3,196	17,002
GMU 36	1,240	620	3,298
Total	8,349	7,374	39,229

Source: NMDGF (2007b)

These estimates of elk and deer hunting activity in our study area include hunting on all lands. Since we already include hunting activity on the Lincoln National Forest in our separate analysis of the value of recreation activities on the Lincoln, we reduce the elk and deer hunting activity day estimates developed above by the approximately 10,500 annual hunting days on the Lincoln. We assume that the breakdown of deer-to-elk hunting days on the Lincoln is the same as for the study area as a whole, which is 2.45 to 1.

To estimate the economic value of elk and deer hunting, we again sum expenditures and consumer surplus estimates. To generate conservative estimates, we only include trip expenditures of hunters and not equipment expenditures. In New Mexico in 2001, trip expenditures for big game hunters averaged $446 per year (Table 9).[17] For elk and deer hunters, who accounted for 89 percent of all big game hunting days in the state, the weighted average number of hunting days was 5.5 (Fish and Wildlife Service and Census Bureau, 2003), resulting in average expenditures of $84 per elk or deer hunting day excluding equipment expenditures.

Table 9: Expenditures of big game hunters in New Mexico, 2001

Expenditure category	*Total expenditures 2004$*	*Expenditures per hunting day (elk and deer hunters)**
Trip		
Food and lodging	191	35.9
Transportation	113	21.2
Other trip costs	142	26.7
Total trip expenditures	446	83.8
Equipment	498	90.6

Notes: * Based on average number of elk and deer hunting days per year of 5.5.
Source: Fish and Wildlife Service and Census Bureau (2003)

The total estimated annual expenditures of $3.7 million on elk and deer hunting trips in the study area are derived by multiplying trip expenditures per hunting elk/deer day with the total number of elk and deer hunting days outside of Lincoln National Forest. If equipment expenditures are included, total spending increases to $7.8 million.

We use consumer surplus (CS) estimates for deer hunting in New Mexico and for elk hunting in western states (Table 10) to estimate the total consumer surplus associated with elk and deer hunting in our study area outside of Lincoln National Forest. For elk hunters, separate estimates are available for in-state residents and out-of-state residents. This distinction is useful as 22 percent of all elk hunters in our study area are from out-of-state (NMDGF, 2007). For deer hunters, CS estimates are available only for state residents. For this reason, we apply the same CS estimate to out-of-state deer hunters.

Total annual consumer surplus for elk and deer hunting in our area outside of Lincoln National Forest is estimated at almost $4.2 million (Table 11).

[17] This estimate is the average for state residents and out-of-state residents. Separate estimates for out-of-state residents hunting elk and deer in New Mexico could not be developed because the information required for this is not available. The *2001 National Survey of Fishing, Hunting and Wildlife-Associated Recreation* does provide estimates for food and lodging and transportation expenditure subcategories for non-resident hunters, but not for “other” trip costs. However, estimated expenditures are very similar for food and lodging and transportation ($365 for state residents vs. $369 for non-residents; 2004$).

Table 10: Consumer surplus estimates for deer and elk hunters per hunting day

	In-state (2004$)	*Out-ofState (2004$)*
Elk *	89.5	127.9
Deer **	91.7	n.a.

Notes: * Average for Colorado, Idaho, Montana, Oregon, and Wyoming. ** New Mexico.
Source: Fish and Wildlife Service (2003)

Table 11: Total estimated annual consumer surplus for deer and elk hunting in the study area

	In-state (2004$)	*Out-ofState (2004$)*
Elk	903,262	363,952
Deer	2,910,428	

Deer and elk hunting outside of Lincoln National Forest increase the total value of the recreation activities analyzed in this study to an estimated over $70 million per year. Trip spending in the local area by recreationists accounts for 57 percent ($40 million) of this total, with the remainder of the value occurring in the form of consumer surplus. As stated in the preceding section, the spending-related estimates are likely to be substantial underestimates because they do not include equipment spending and trip spending that occurs beyond a 50-mile radius of the Lincoln. Thus, the actual economic value of recreation activities in the study area likely surpasses $100 million per year for the Lincoln National Forest alone.

Grazing

Grazing is an economically important land use throughout much of the study area. Though the importance of grazing has declined from its historic heights, it still constitutes the economically second most important use of NF lands in the area (Aldrich and Mitchell, 2006), after recreation. On both FS and BLM lands, the actual volume of grazing, measured in terms of animal unit months (AUMs) covered by active grazing permits, in recent years has declined, with a number of allotments closed or vacant due to climatic, economic and legal factors.[18] The estimated number of active AUMs on the Lincoln National Forest in 2004 was approximately 121,000, while for the BLM lands in our study area it was an estimated 102,000 (Table 12). No estimate is available of the number of cattle grazed on private lands in the study area.

The minimum value of grazing on public lands is best estimated on the basis of private grazing lease rates, which more accurately reflect the market value of the grazing. Public grazing fees are substantially lower than private grazing leases because the formula used to set public fees does not adequately capture the market value of the public lands for grazing (Torrell et al., 2003). In 2004, the grazing fee for Western public lands was $1.43 per AUM.

18 An AUM is defined as the amount of forage needed to sustain a cow and a calf, a horse, or five sheep or goats (NASS, 2005).

By comparison, the average private land grazing fee in New Mexico was $9.70 per AUM (National Agricultural Statistics Service [NASS], 2005). Using the private lease rate, the total market value of grazing on FS and BLM lands in our study area in 2004 was an estimated $2.2 million (Table 12).

Table 12: Quantity and value of grazing on lands in study area

	AUMs	*Public land grazing fee per AUM*	*Av. private grazing rate per AUM*	*Value of grazing permits @public land fee*	*@private rate*
Lincoln NF lands	121,020 [a]	$1.43	-	173,000	1,174,000
BLM lands	101,868 [b]	$1.43	-	146,000	988,000
Private lands	n/a	-	$9.70	n/a	n/a

Notes: n/a – not available. [a] 2002 AUMs. [b] Estimated 2006-07 active AUMs in study area.
Sources: Aldrich and Mitchell (2006); BLM Carlsbad Field Office (pers. comm., Steve Daly, range management officer, Feb. 13, 2007); National Agricultural Statistics Service (2005).

Extraction of timber and non-timber products

Timber is harvested from both Lincoln National Forest and from private lands in the study area. Since the mid-1900s, most timber harvest occurred on private lands in the surrounding area (Spoerl [1983] cited in Aldrich and Mitchell [2006]). However, to satisfy increasing demand for construction lumber, efforts are under way to increase timber harvests from Lincoln NF, which have been declining in recent years (Aldrich and Mitchell, 2006).

About three quarters by volume of all wood harvested from the Lincoln NF takes the form of timber (sawtimber, pulpwood, poles, posts and fuelwood), with the remainder dominated by Christmas trees (Table 13). At 2004 prices, the market value of the various timber products sold from the forest in that year was $3.2 million, while that of the Christmas trees was an estimated $3.7 million (Table 13).

Table 13: Quantities and value of timber and non-timber forest products harvested from the Lincoln National Forest, 2004

	Sales volume (MBF)	*Market price (2004$)*
Timber products	8,599	3,211,300
Non-timber products		
Christmas trees	2,705	$13,525*/$3,690,000**
Miscellaneous	300	$1,542

Notes: MBF – 1000 board feet; *Value of FS Christmas tree permits; **Estimated wholesale price of harvested Christmas trees, assuming average size of trees is seven feet and average retail price is $10 (New Mexico State University, 2002).
Source: Harvest volumes, timber product prices, and Christmas tree permit prices from Aldrich and Mitchell (2006).

We were unable to obtain data on timber harvests in our study area outside of Lincoln National Forest. The majority of harvests in this area occur on Indian lands, while timber harvests on private lands currently seem to be limited.[19] Because of the omission of timber harvests on lands off the Lincoln, our estimate of the value of timber harvest in the study area is likely to underestimate actual harvest value.

Property value premiums

The Lincoln national forest and surrounding BLM lands constitute large open spaces that generally are protected from development. Evidence from a large volume of studies suggests that proximity to such open spaces increases the values of nearby properties. Thus, the open space property value premiums attributable to the forested lands constitute one of the benefits produced by these protected lands. In this study, we focus on Lincoln forest lands only. Many of the BLM lands in the area exhibit physical attributes similar to those on the Lincoln. However, much of the literature on property value premiums of open space focuses on forest lands, we limit our analysis to the Lincoln national forest. This undoubtedly introduces a downward bias in our estimate of the aggregate property value premium generated by the protected lands in our study area.

The increment in value a property receives due to its proximity to open space is variously referred to as the open space property value premium, the property enhancement value, or the amenity premium. This premium is the result of what Crompton (2001) calls the proximate principle, namely, the general observation that the value of an amenity is at least partially captured in the value of properties in proximity to that amenity. The idea underlying the proximate principle is that a property, like any good, may be thought of as a bundle of attributes (Lancaster, 1966). The price of the good therefore reflects the value consumers assign to that bundle of attributes. In the case of a property, these attributes include the physical characteristics of the property itself and of any structures, such as property size, relative scarcity of land, size and quality or age of structures, as well as neighborhood characteristics such as schools, public safety, and environmental amenities provided by surrounding lands, such as scenic views, clean air, or recreation opportunities. If people value open space and the amenities associated with it, then these values to some extent should be reflected in property prices.

The evidence in the published literature for the existence of the property enhancement value of open space is certainly strong. There are over 60 published articles in the economics literature that examine the property enhancement value of open space (McConnell and Walls, 2005). A number of recent literature reviews have been conducted on the topic. Some of these cover various types of open space, including forest lands, parks, coastal and inland wetlands, grasslands, and agricultural lands (e.g. Fausold and Lillieholm, 1999; Banzhaf and Jawahar, 2005; McConnell and Walls, 2005 – by far the most comprehensive review), while others are specific to particular types of open space such as parks (Crompton, 2001), wetlands (Brander et al., 2006; Boyer and Polasky, 2004; Heimlich et al., 1998), or agricultural lands (Heimlich and Anderson, 2001).

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[19] Pers. comm., Eddie Tudor and Bill Rogge, Capitan Forestry District, New Mexico State Forestry Division, July 31, 2007.

These findings suggest that in general, there appears to be an inverse relationship between the scarcity of open space and its property enhancement value, suggesting that open space is relatively more valuable where it is in relatively short supply (McConnell and Walls, 2005).

This of course does not mean that property premiums do not exist in rural areas. As Ready and Abdalla (2005) note in response to a reviewer's comments, it is theoretically plausible that individuals' WTP for open space could also be higher in suburban or rural areas, because at least a part of the residents in those areas locate there specifically because of their high preferences for open space. There are a number of studies in rural areas that do show that open space does indeed increase property values considerably also in those areas (Phillips, 2000; Vrooman, 1978; Brown and Connelly, 1983; Thorsnes, 2002). These studies generally involve public open spaces that generally are comparatively large and enjoy a high level of protection from development, including state parks, forest preserves, and wilderness areas. The Lincoln national forest with its large wilderness areas certainly exhibits these characteristics.

In fact, the attractiveness of living close to national forests is evidenced by the fact that counties with national forests and grasslands have been experiencing some of the highest population growth rates in the U.S. (Garber-Yonts, 2004; Johnson and Stewart, 2007; U.S. Forest Service, 2006), a trend that is expected to continue over the next decades (Stein et al., 2007).

Open space is not a homogenous good, and the particular attributes of a given open space can be expected to influence the size of the associated premiums received by nearby properties. This is confirmed by the large range in open space premiums (measured as a share of the total value of a property) found in the literature. Table 14 summarizes the findings reported in the literature on how particular study area characteristics influence open space premiums.

Table 14: Variables that influence the property enhancement value of open space

Variable	*Direction of influence*
Scarcity of open space	+
Protected status/permanence	+
Size of open space	+
Distance to open space	- *
Type of open space	+/-
Opportunity costs / value of competing land uses	+
Income	+

Notes: * Exception: In cases of heavily used public open spaces such as some urban parks, adjacency to such areas may lead to a loss in privacy for some properties and to an associated negative open space premium on properties adjacent to the park.
Source: Kroeger et al. (2008)

No study on the open space premiums of property values exists for our study area. In situations where no original studies are available on the value of the benefits produced by environmental amenities like open space, benefits transfer is a possible tool for inferring the value people assign to these benefits. Benefits transfer is a technique in which researchers estimate the value of particular benefits for a site of interest by using the results of existing studies of similar sites (Loomis, 2005). The validity of the resulting transfer-based estimate depends on the similarity of the sites and user groups. The context-dependence of open space premiums calls into question the validity of using a particular open space premium reported in the literature as an indicator of the premiums received by properties in a different area. Because no original study exists for the Lincoln national forest or an area that would appear to be similar in terms of its physical characteristics and ownership, application of either point or average value based benefits transfer approaches to estimate the Lincoln property value premiums would possess questionable validity. This leaves meta-analysis-based benefits transfer as a possible approach. Meta-analysis is a statistical technique that uses regression analysis of the findings of several empirical studies to systematically explore study characteristics as possible explanations for the variation of results observed across primary studies (Brouwer, 2000; U.S. Environmental Protection Agency, 2000). The values of key variables from the policy case then are inserted into the estimated benefit function to develop policy-site-specific value estimates. One such meta-analysis of open space property value premiums is available in the literature (Kroeger et al., 2008).

Kroeger et al. (2008) conducted a meta-analysis of 21 original quantitative studies in the U.S. containing a total of 55 observations of open space impacts of conserved lands on property values.[20] They included only those studies that examined open spaces with predominantly natural vegetation, excluding crop lands and heavily-developed urban recreational areas. Their estimated meta-analysis-based regression function has the following form [21]:

$$\begin{aligned} P_{OS} &= -6.5903 + 0.4221 * \%OSChange - 0.0068 * \%OSChangeSquared + 2.7619 * FOR \\ &\quad + 1.677 * PARK - 2.7367 * AG + 3.5067 * PROT + 5.3409 * PRIV, \end{aligned} \qquad \text{(eq.1)}$$

where P_{OS} is the open space property premium in percent, $\%OSChange$ is the percentage of the area within a given radius of a property that is occupied by the open space in question, FOR is an indicator (dummy) variable set at 1 if the open space is forested and at zero otherwise, $PARK$ is an indicator variable set at 1 if the open space is an urban park whose prime purpose is provision of wildlife habitat or dispersed recreation and that is characterized by predominantly native vegetation, and at zero otherwise, and AG, $PROT$ and $PRIV$ are indicator variables set at 1 if the open space is natural agricultural land (pasture, or pasture with some cropland), is protected, or is privately owned, respectively, and at zero otherwise.

Kroeger et al.'s model explains almost 50 percent of the variation observed in the data and as a whole is highly significant (p=0.0000). Their detailed results are shown in Table 15.

Kroeger et al. found that the share of open space in the vicinity of a property ($\%OSChange$) was highly significant. The elasticity of property value premiums with respect to the

[20] The remainder of the reviewed studies did not provide the required information for their inclusion in the analysis.
[21] The full model estimated by Kroeger et al. included a number of additional variables hypothesized to impact open space premiums. However, these were not found to be statistically significant and were excluded from the model.

percentage of open space in the vicinity of a property is 0.42 while the coefficient on the open space percentage squared is -0.0068. Thus, an increase in the percentage of open space in an area from zero to ten percent will increase property values on average by 3.5 percent.[22] Importantly for the case at hand, this value is higher for forests and for protected lands, as is indicated by the positive signs on the coefficients of the *FOR* and *PROT* variables (Table 15). Because of the increasing power of the negative squared term for successively larger increases in open space, the marginal (i.e., additional) open space property premiums become negative once open space accounts for approximately 1/3 (32 percent) of the total area. This closely matches Walsh's results who found that in Wake county, North Carolina, marginal open space premiums turned negative for percentages of open space that exceed roughly 1/3 of the total area.

Table 15: Estimation results for the open space property premium model

Variable	*Unstandardized Coefficients*	*Std. Error*	*Standardized Coefficients*	*t-statistic*	*p-value*
(Constant)	-6.5903	1.6353		-4.0299	0.0002
%OSChange	0.4221	0.1290	1.3370	3.2714	0.0020
%OSChangeSq.	-0.0068	0.0032	-0.8801	-2.1432	0.0373
OS-Forest	2.7619	1.1329	0.3092	2.4379	0.0186
OS-Park	1.6768	1.9629	0.1073	0.8543	0.3973
OS-Agland	-2.7367	1.1696	-0.2938	-2.3399	0.0236
Protected	3.5067	1.1039	0.3926	3.1767	0.0026
Private	5.3409	1.2818	0.6555	4.1667	0.0001
R^2		0.5433	N=55	F-statistic	7.9878
Adjusted R^2		0.4753		Prob.(F)	0.0000
Std. Error of the Estimate		2.9658			

Notes: OLS estimation. Dependent variable: %INCR_PV.
Source: Kroeger et al. (2008)

We applied Kroeger et al.'s property value premium function (eq. 1) to estimate the property premiums for the properties in each of the towns and communities located on or in the vicinity of Lincoln national forest. To do so we set the values of all variables in the function such that they reflect the local context of the Lincoln national forest.

In order to estimate the value of the *%OSChange* variable, we used the National Atlas of the United States and Google Earth satellite images to identify populated places on or in proximity to the forest. These are Alto, Cloudcroft, Glencoe, High Rolls, Hollywood, Mayhill, Mountain Park, Ruidoso, Ruidoso Downs, Sacramento, Sunspot, Timberon and Weed. We used U.S. Census Bureau (2002) data to identify the number of properties located in the Census tracts or block groups containing these places (Table 16). In all cases, the properties located in these tracts or block groups are within three miles of the Lincoln forest.

Using satellite imagery, we estimated for each of the residential areas the percentage that Lincoln open space forest land accounts for within a two-mile radius of the average property (Table 16). Our decision to truncate the open space included in the analysis at a two-mile

[22] $0.4221*10 - 0.0068*(10^2) = 3.5$.

distance from the outer edges of a developed place is based on two factors. First, the empirical evidence suggests that open space benefits decrease with increasing distance. Second, very few of the studies underlying our property value estimation function considered open space impacts across distances larger than two miles. Nevertheless, this truncation will tend to decrease the aggregate open space premium estimate for the areas because the additional benefits of protected open space at larger distances are unlikely to be zero.

Table 16: Location and number of housing units of populated places on or within two miles of Lincoln national forest

Populated place by Census location	*Number of housing units*	*Lincoln NF open space as % of area within two miles of average property*
Census Tract 9806, Lincoln Co.	6,522	75
Census Tract 9808, Lincoln Co.	2,098	75
Census Tract 9804, BG 2, Lincoln Co.	2,332	30
Census Tract 9804, BG 3, Lincoln Co.	1,271	90
Census Tract 6.02, BG 2, Otero Co.	81	95
Census Tract 9, BG 1, Otero Co.	581	90
Census Tract 9, BG 2, Otero Co.	2,478	90
Census Tract 9, BG 3, Otero Co.	1,175	95
Timberon CDP, Otero Co.	458	85

Notes: BG – block group.
Source: U.S. Census Bureau (2002). Percentage of open space within a two-mile radius of average property that is made up of Lincoln national forest open space was estimated based on satellite imagery.

With the open space percentage identified for each populated place in our study area, we set the indicator variables in the function at their appropriate values, with *FOR* and *PROT* set to one and the remaining variables set to zero and estimate for each community individually the average open space property value premium its residences receive as a result of the presence of Lincoln national forest lands.

Unfortunately, the open space found in the Lincoln National Forest is rather different in terms of its dominance in the study area from the open spaces analyzed in the studies we used to estimate our open space property value premium model. This, combined with the fact that, for methodological reasons, our model overestimates the attenuation of the size of marginal open space premiums for large open spaces, complicates the application of our model to the open spaces in the Lincoln National Forest. [23]

[23] This downward bias in estimated open space premiums stems from the fact that when estimating our model, part of the premium estimates in our pooled dataset (those based on the transformation of property value premium estimates from studies that measure premiums as a function of reductions in distance to nearest open space or of adjacency to open space) were "interpreted" by the regression analysis to be associated only with the sizes of the particular open spaces in question, while in fact the premiums also were affected by the other open spaces present in the respective source study contexts. With few exceptions, the source studies do not provide information on the total open space in the respective areas that would have allowed us to incorporate this factor in the analysis. Any analysis of open space premiums based on these transformed observations will attribute observed decreases in the returns to open space fully to the particular open spaces whose impacts are analyzed, as opposed to to the total open spaces in the study areas. Consider for example a case in which the results reported in a study indicate that a 200m reduction in the distance of the mean property to the nearest

Figure 4 shows the open space premiums predicted by our model for the open space type found in our study area: protected forestland. Note that for this type of land, open space premiums are predicted to become zero when the open space reaches 61 percent of all land around a property included in the analysis; for additional increments of open space, premiums become negative.[24]

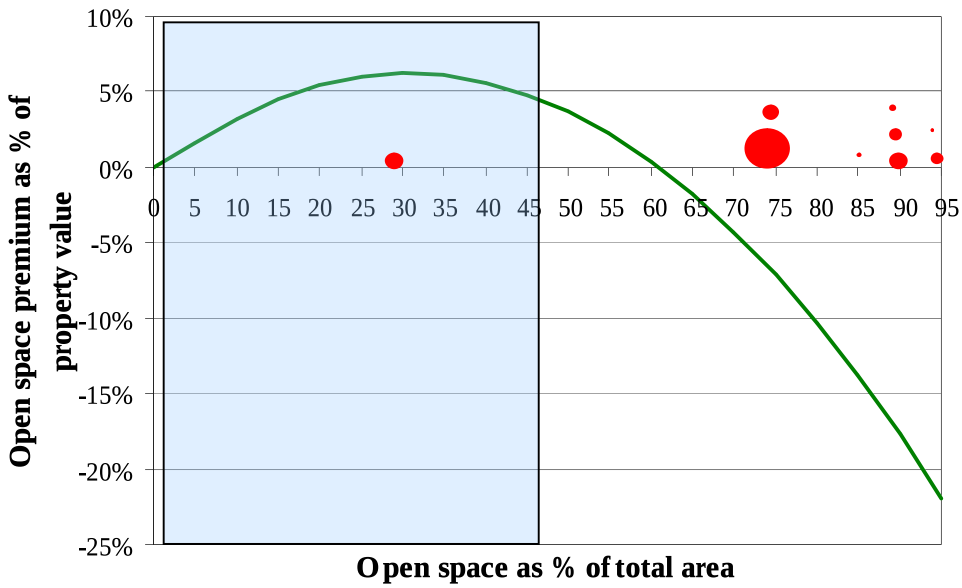

Figure 4: Open space premiums predicted by Kroeger et al.'s (2008) model

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open space increases property values by five percent. Assume that given the shape and size of the open space considered in that study and given the initial distance of the mean property from the open space, the reduction in distance results in a 20 percent increase in the percentage of open space within a ¼ mile radius of the property. The premium reported in the original study was a function, in addition to the reduction in distance to the open space, also of the total open space (and its distribution) in the area. After transforming the observation from "reduction in distance" to "increase in the percentage of open within a ¼ mile radius" in order to be able to include it in our pooled dataset, however, the premium is treated as being the result only of the 20 percent increase in open space. Our regression thus will associate the "20 percent" value of the open space variable with the "five percent" property value variable. This would be correct if the open space in question were the only open space in the original study. However, in most studies, this was not the case. Thus, the "20 percent" increase in open space might in fact represent an increase in total open space in the area of analysis from, say, 30 percent to 50 percent. Consequently, the five percent premium reported in the study reflects the premium of moving from 30 percent to 50 percent open space, not from zero to 20 percent. If, as the literature suggests (Acharya and Bennett [2001]; Bin and Polasky [2005]; and Walsh [2004]), marginal open space premiums decline beyond a certain point, a 20 percent increase in open space from a basis of 30 percent would be expected to result in lower property value premiums than a 20 percent increase from a base of zero. Our model therefore will underestimate the premium that is associated with an increase from zero to 20 percent. Since almost half (47 percent) of the observations included in our analysis are of this "transformed" type, our estimated model likely suffers from this overattenuation of open space premiums. This overattenuation manifests itself in a downward bias in the coefficient on the *%OS* variable and an upward bias in the coefficient on the *%OS squared* term. The combined effect of these two factors is an overall downward shift of our estimated premium curve (shown in Figure 4) and an overly steep decline of premiums to the right of the peak, compared to the actual curve. Thus, our model is likely to overestimate the attenuation of the property value benefits of additional open space increments, and to underestimate open space premiums.

[24] The average radius of the area included in the observations used to estimate our model was 1.04 miles; the median, 0.31 miles.

It is important to note that the open spaces in the studies based on which our model was estimated accounted for between 1 and 46 percent of the total areas around the properties for which those studies analyzed open space premiums, the range indicated in light blue in Figure 4. However, all of the properties found in our study area (the Lincoln National Forest) save for those located in Census Tract 9804 lie considerably outside of the range of observations over which our model was estimated. The open space percentages that characterize the properties in our study area are shown as red dots in Figure 4, with the size of the dots proportional to the number of properties.

To address the limitations of our model with respect to estimating the premiums associated with open spaces that account for high percentages of the total area around a property, we modify our model. Specifically, in order to correct the over-attenuation of premium estimates especially for large open spaces (where large is defined as accounting for a high percentage of the total area around a property), we reduce the square term in the estimation equation such that the estimated open space premium becomes zero when open space accounts for 95 percent of total area, which is the upper end of the range found in our study area.[25] Thus, we assume that there are no properties included in our analysis whose value is negatively affected by being located inside of or along the periphery of Lincoln National Forest. There is strong evidence in the literature that supports this assumption. First, not a single one of the studies that examined the property value impacts of forest or forest-like open spaces reviewed in Kroeger et al. (2008) found a negative impact. Second, the open space premium function (the green line in Figure 4) represents the best fit to the data, that is, to open space premiums reported in the original studies we analyzed. Only six of the 55 observations on the basis of which the model was estimated exceeded 30 percent of open space in the area analyzed. The fact that the function has an "inverted U" shape is the result of several observations of high premiums for open spaces that accounted for ten to 20 percent of total area (see Figure 5).

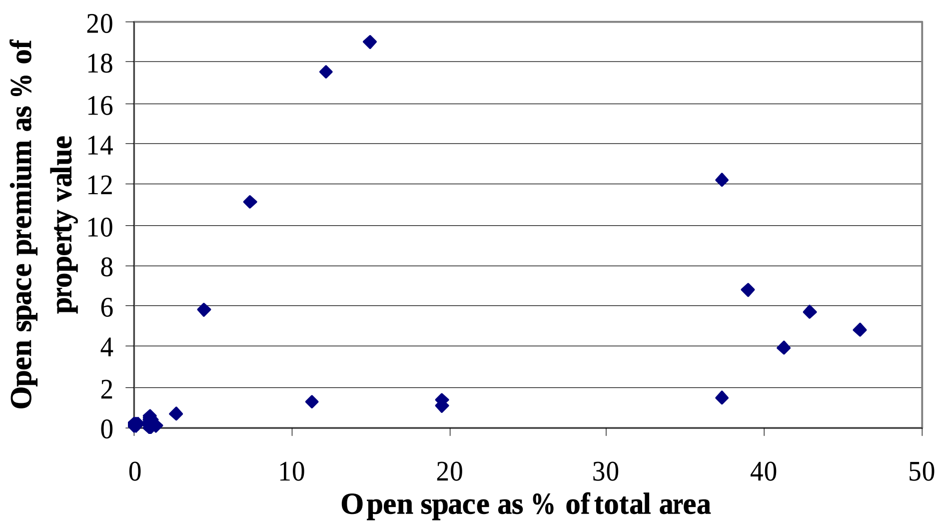

Figure 5: Scatter plot of open space premiums for forestland (based on studies reviewed in Kroeger et al., 2008)

[25] The negative coefficient on the square term is reduced in size from -0.0068 (see eq. 1) to -0.0044.

Thus, the observations over which the function was estimated do not support negative open space premiums for forestland. Rather, the negative predicted premiums in areas dominated by open space are the result of out-of-range applications of the model. The actual observations in the literature do not contain any negative premiums even for any of the large (in terms of percent of total area) open spaces analyzed in those studies (see the six dots on the right hand side of Figure 5). Thus, applying Kroeger et al.'s model unmodified to areas with very large percentages of open space like those found in our study area would constitute an out-of-range application of the model, something against which the authors strongly caution. We expect that the model modification we introduce makes out-of-range applications less of a concern because the results the model yields (open space premiums larger or equal to zero) for the open spaces included in our analysis no longer contradict the literature findings of positive premiums for forested open spaces.

The third justification for our model modification is the fact that there most National Forests have been experiencing strong housing growth along their periphery (Stein et al., 2007). This strong growth provides evidence of the amenity value of National Forests and their large open spaces, which is factored into property values (Kroeger et al., 2008 and studies reviewed therein).

The modified open space property value premium model is indicated by the blue line in Figure 6. As a result of the modifications, the maximum premiums now are generated by open spaces that account for 50 percent of total area as opposed to 30 percent as in the original model, and the maximum premium increases from 6.2 percent to 9.8 percent.

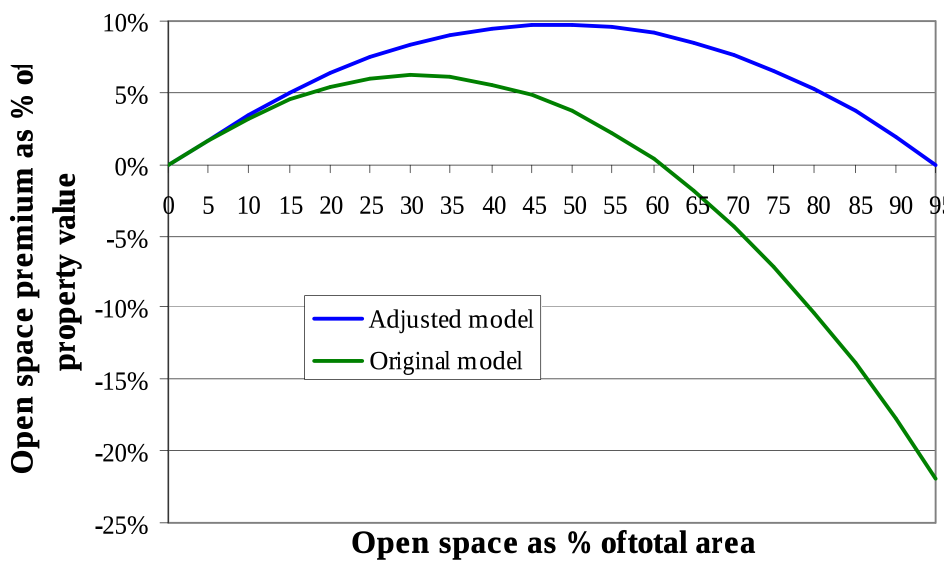

Figure 6: Model estimates of open pace premiums for protected forestland

Based on this modified model, we estimate that the average open space premium received by residential properties ranges from zero to about 8.4 percent for the different communities (Table 17), as a result of the different amounts of Lincoln forest lands found in the vicinity of the average property in those communities. Combining these estimates with information on the number of houses and the median home value in each locale allows us to generate an estimate of the total open space premium received by each community (Table 17).

Table 17: Estimated open space premiums for residential homes located on or adjacent to Lincoln national forest

Populated place by Census location	*Number of housing units*	*Median home value in 2000 (2004$)*	*Avg. property premium*	
			% of property value	*Total value (million 2004$)*
Census Tract 9806, Lincoln Co.	6,522	119,128	6.53	50.7
Census Tract 9808, Lincoln Co.	2,098	98,540	6.53	13.5
Census Tract 9804, BG 2, Lincoln Co.	2,332	161,957	8.37	31.6
Census Tract 9804, BG 3, Lincoln Co.	1,271	69,693	1.95	1.7
Census Tract 6.02, BG 2, Otero Co.	81	148,635	0	0
Census Tract 9, BG 1, Otero Co.	581	107,237	1.95	1.2
Census Tract 9, BG 2, Otero Co.	2,478	125,954	1.95	6.1
Census Tract 9, BG 3, Otero Co.	1,175	99,861	0	0
Timberon CDP, Otero Co.	458	63,418	3.69	1.1

Notes: BG – block group. CDP – Census designated place.
Source: Number of housing units and median home values from U.S. Census Bureau (2002).

Our analysis indicates that in 2000, the latest year for which comprehensive Census data on housing numbers and median home values are available, the total property value premium received by residences in or adjacent to the Lincoln national forest was an estimated $106 million (2004$). Although this value is quite large, it is likely to be an underestimate of the actual total premium in the study area, for four reasons. First, the number of housing units in the area has increased since 2000. Second, the median home value in the area has increased since 2000, given the continued migration of people into rural areas with high amenity national forest lands (Johnson and Stewart, 2007; Stein et al., 2007). Third, in the central section of the Lincoln, we only included data for the place of Timberon in our analysis, because the Census tract in which the place is located extends too far beyond the forest boundary to justify the inclusion in its entirety in an analysis of open space premiums attributable to the Lincoln. We thus omitted any residential units along the periphery of that section of the forest that also receive open space premiums. Finally, our analysis only considers premiums attributable to national forest lands, ignoring any premiums received by residences close to protected scenic BLM lands in the study area.

The estimated open space premium of around $106 million in 2000 does not represent an annual benefit flow. Rather, it is the total value of the open space premiums captured by residential properties that existed in that year, that is, the value incorporated in the existing residential property stock. In order to make this benefit comparable to the other benefits generated by natural lands in the study area that are assessed in this report, we can convert this stock value into its equivalent annual flow. The common approach to doing this is to regard the stock value ($106 million) as a principal that could be invested at market rates. The principal could generate a perpetual stream of annual payouts equivalent to the interest earned. At a five percent interest rate, slightly less than the average annual return on certificates of deposit during the last 20 years (1987-2006), the annual payout would be $5.3 million (2004$).[26]

[26] The annual payout is derived using the following perpetuity formula: $PV = A/i$, where PV is the present value (in our case, the principal of $106 million) of the perpetual annuity A, and i is the annual interest rate.

These results show that the open space-based property value benefits the Lincoln national forest lands produce for area residents rank among the most important economic benefits generated by the natural lands in the study area. The relative importance of the property value premium benefits is even larger than suggested by our analysis because the open space benefit estimates are constructed using house price data. These data, like all observed willingness-to-pay data, are an indicator only of the minimum value home owners assign to the amenity benefits generated by the proximity to national forest lands. The actual value is likely to be higher. Its estimation however requires the construction of an aggregate housing demand curve that incorporates natural amenities, something that to date has not been done.

Ecosystem services

The natural systems in the study area provide a wide variety of ecosystem services. The benefits associated with some of these services accrue primarily to local residents and visitors (water retention and generation, air quality, temperature modulation, scenic views). Other services generate benefits also on a regional or even larger scales (water quality, water generation, species habitat provision, biodiversity maintenance, carbon sequestration). In some cases, the value of some of these services is already captured in our analysis of other human uses of the study area. For example, the use value of species enjoyed by humans for recreational purposes is already accounted for in our analysis of the recreational value of the study area, in the form of fishing, hunting, and wildlife viewing values. Likewise, the value of the scenic views provided by the land is already captured in our estimate of the property enhancement value generated by the open lands in the area, and in our recreation value estimates (e.g., pleasure driving, hiking and walking, viewing of natural features, picnicking). In this section, due to limited scope of the study, we only develop an estimate of the value of carbon sequestration services provided by the ecosystems in the area.

Carbon sequestration by forests in the study area

The quantity of carbon taken up by a given plant varies with the species, the age of the particular specimen, and environmental conditions such as nutrient and water availability, ambient atmospheric carbon dioxide concentration, temperature (and its fluctuation), and the amount of available sunlight. As a result, rates of carbon uptake vary among species and locations. In addition to the species and growing location, forest management practices are an important variable in carbon sequestration (Richards et al., 2006).

Forest and woodlands together account for almost 48 percent of all lands in the study area, with a total of 1.5 million acres. Based on GIS data, the predominant forest or woodland vegetation alliances found in our study area are pinyon-juniper woodland, pine-oak forest and woodland, conifer-oak forest, and ponderosa pine woodland (Table 18). Vegetation associations other than the forests or woodlands shown in Table 18 also sequester carbon dioxide. However, inclusion of these in our analysis was not possible due to limits of scope. Due to the absence of information on management practices on private and on some of the public lands in our study area, the heterogeneity of practices applied on the remaining public lands in the area, and the lack of age class information for the majority of the forest and woodlands in the area, we construct low and high estimates of carbon sequestration rates.

Table 18: Major forest and woodland types in study area and associated acreages

Total Habitat Acreage	*GAP Vegetation Alliance Classification*
454	Colorado Plateau Pinyon-Juniper Woodland
260	Inter-Mountain West Aspen-Mixed Conifer Forest and Woodland Complex
366,138	Madrean Pine-Oak Forest and Woodland
689,968	Madrean Pinyon-Juniper Woodland
163,857	Madrean Upper Montane Conifer-Oak Forest and Woodland
7,297	Rocky Mountain Aspen Forest and Woodland
41	Rocky Mountain Bigtooth Maple Ravine Woodland
4,975	Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland
3,317	Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland
111,034	Rocky Mountain Ponderosa Pine Woodland
924	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
301	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland
24,088	Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
128,127	Southern Rocky Mountain Pinyon-Juniper Woodland
1,500,781	Total

Source: Table A-2.

The only lands in our study area for which detailed timber data are available are those on the Lincoln National Forest. The Lincoln contains approximately 897,000 acres of forest land, of which about 139,400 acres, or 54 percent of the total lands on the forest classified as "tentatively suitable for management as timber lands" (257,103 acres), are actively managed for timber.[27] On these, average rotation ages for even-aged stands range from 60-80 years for Aspen to 100-140 years for mixed conifer/ponderosa pine.[28] We combine information on carbon sequestration rates for ponderosa pines in U.S. mountain states (Table 19) and information on the age structure of the forest on Lincoln timber lands to construct estimates of the carbon uptake on these lands (Table 20).

Table 19: Approximate carbon sequestration rates for ponderosa pines, U.S. Mountain states

Age	*Carbon sequestration rate (Tons/acre/year)*
10 yrs	1.13
30 yrs	1.80
45 yrs	2.33
50 yrs	2.40
60 yrs	2.75
90 yrs	2.55
95 yrs	2.45
125 yrs	1.25
150 yrs	0.75

Source: Stavins and Richards (2005)

27 Lincoln National Forest plan (http://www.fs.fed.us/r3/lincoln/projects/index.shtml).
28 Lincoln National Forest plan, p. 39.

Table 20: Age class distribution and estimated carbon sequestration of timber lands on Lincoln National Forest

Age class	*Percent of total lands suitable for timber harvest*	*Acres*	*Estimated carbon sequestration (Tons/year)*
1-20 yrs	23	32,062	36,070
21-40 yrs	13	18,122	32,620
41-80 yrs	32	44,608	122,672
81-100 yrs	19	26,486	67,539
100+ yrs	13	18,122	13,592
Total	100	139,400	272,492

Notes: We use the mid-point of each age class to estimate sequestration rates, except for the 100+ years age class, for which we assume an average age of 150 years.
Source: Lincoln National Forest plan; Table 19.

We estimate that the total carbon uptake by timber production lands on the Lincoln is approximately 270,000 tons per year, or approximately two tons per acre. For the other 117,700 acres on the Lincoln classified as "tentatively suitable for timber production" but not used for that purpose because they are needed for minimum maintenance roads, managed for multiple use objectives, or lack of their cost-effectiveness for timber harvest, we assume that their average productivity and hence carbon sequestration rate is equal to that of the timber production lands. Thus, we estimate that these lands store an additional total 230,000 tons of carbon per year.

A total of 62 percent (557,240 acres) of all forest lands on the Lincoln are considered not capable of producing crops of industrial wood, and a further 82,880 acres of forest lands are withdrawn from timber production.[29] We assume that average productivity on these lands is only 50 percent of that of tentatively suitable timber lands, that is, they sequester just under one ton of carbon per acre per year.

For the remaining forest and woodlands in the study area, mostly BLM, Indian, state, and private lands, we develop a low and a high carbon sequestration estimate. Average productivity of these lands for timber production may or may not be lower than on Lincoln timber lands, given that in recent decades private lands have been providing the majority of timber harvests in the area (Aldrich and Mitchell, 2006). Our low estimate assumes that average productivity on these lands is 50 percent lower than on Lincoln timber production lands, while our high estimate assumes that average productivity is the same as on timber lands on the Lincoln.

All forest and woodlands in the study area combined sequester an estimated 1.7 million - 2.3 million tons of carbon per year (Table 21). These estimates are best seen as rough, first-order approximations of the quantities of carbon sequestered by the area. For one thing, they do not include the carbon taken up by vegetation communities other than forest or woodlands, which together account for over one-half (51.7 %) of all lands in the study area. Furthermore, the carbon sequestration rates on which these estimates are based may be incorrect. Specifically, the actual sequestration rates may be higher or lower on average than

[29] Lincoln National Forest plan, p. 213.

Table 21: Estimates of total carbon sequestration by forest and woodlands in the study area

Study area land type	*Carbon sequestration Tons of C/yr*	
	High estimate	*Low estimate*
Lincoln timber lands *	502,572 [1]	
Other Lincoln non-timber forest and woodlands	625,635 [2]	
Other study area forest and woodlands **	1,179,809 [1]	589,904 [2]
Total	1,718,112	2,308,016

Notes: * Lands classified as tentatively suitable timberlands; includes lands used for timber production (139,420 acres) and lands suitable but currently not used for timber production (117,700 acres). ** Includes mostly BLM, private, state, and Indian lands. [1] Assumed average carbon sequestration rate of 1.95 t/acre/yr. [2] Assumed average carbon sequestration rate of 0.98 t/acre/yr.

the assumed rates, which represent averages for ponderosa pine in U.S. mountain states. Although timber productivity on the Lincoln National Forest is average to high relative to other areas of the Southwest (Aldrich and Mitchell, 2006), it is difficult to assess whether or not it is similar to average productivity in the mountain states region. Also, the carbon content per pound of wood varies among the tree species in our study area, due to differences in the specific gravity of the different species' wood, although these differences are rather small (Table 22).

Table 22: Carbon density of different tree species in the western U.S.

Species	*Pounds per cubic foot merchantable wood (dry weight)*	*% C of dry weight*	*Pounds C/cu.ft. in merchantable wood*
Douglas fir	28.1	0.512	14.38
White fir	21.8	0.5	10.92
Aspen	24.4	0.5	12.20
Ponderosa pine	23.7	0.512	12.14
Southwestern white pine	27.0	0.5	13.50

Sources: Sampson (2002); Schlaegel (1975); U.S. Forest Service (1984).

The value of carbon sequestration services

Assigning an economic value to the carbon sequestration services provided by the ecosystems in our study area is complicated by several factors. The true value of the carbon uptake consists in the associated incremental reduction in the negative consequences of increased atmospheric carbon concentrations. Although the potential future impacts of climate change on the U.S. in general, on the U.S. southwest, or on New Mexico in particular have been documented (Field et al., 2007; New Mexico Agency Technical Working Group, 2005; Sprigg et al., 2000), estimating the expected value of damages associated with climate change is impossible due to the structural uncertainties in the science of climate change and the inability to place a meaningful upper bound on the potential catastrophic losses associated with disastrous temperature changes (Weitzman, 2008). Thus, estimating the reduction in the severity of these impacts that is achieved through the uptake and storage of atmospheric carbon by the ecosystems in our study area is beyond the scope of our study.

An alternative approach to valuing the carbon uptake produced by the ecosystems is based on the prices of carbon credits in appropriate markets. However, several different markets exist for carbon credits. Some of these are regulation-driven, and as such they restrict access on both the buyer and seller side.[30] All of these regulation-driven markets currently are outside of the U.S., and under their current legal frameworks, carbon credits generated in the United States are not eligible for transaction in these markets (Diamant, 2006).

Several regional U.S. emission trading schemes currently are under development. One of these is the recently created Western Regional Climate Action Initiative, in which the states of Arizona, California, New Mexico, Oregon and Washington will jointly set a regional emission reduction target, and by August 2008 will establish a market-based system – such as a cap-and-trade program covering multiple economic sectors – to aid in meeting the target.[31] However, until the reduction targets are set and the accompanying carbon credit markets begin operation, it is impossible to know what credit prices will be on these markets once they begin operation.

Nevertheless, a number of voluntary carbon credit markets already exist in the U.S. whose carbon prices can serve to construct first rough estimates of the value of carbon sequestration provided by the study area. These include the Chicago Climate Exchange, various carbon-offset schemes operated by private suppliers, and a new offset-scheme created by the U.S. Forest Service and the National Forest Foundation.

An accurate valuation of the carbon sequestration services provided by the ecosystems in the study area based on market prices for carbon requires a careful analysis of the access conditions of the various markets. Depending on the market in question, admissible carbon credits must fulfill a number of conditions of verifiability, additionality, permanence and leakage that vary in stringency. Some of those markets currently would not admit sequestration-based carbon credits from existing, protected forest lands, while others would accept such credits if they were the result of changes in land management practices. In any case, these conditions are in flux for several existing markets and especially for many of the planned markets. Therefore, we do not conduct a detailed analysis in order to identify with certainty those markets that currently would be likely to accept the credits generated by our study area. Rather, we use in our analysis prices on those markets that already operate and that are not off limits to U.S.-based carbon credits.

The average price on the Chicago Climate Exchange (CCX) during January to July of 2007 was $3.55 per ton of carbon dioxide equivalent (tCO_2e).[32, 33] The average price charged for

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[30] Examples are all Kyoto-based or regionally defined carbon credit markets, such as the EU's, the UK's, and Norway's Emissions Trading Schemes, Australia's NSW Greenhouse Gas Abatement Scheme, the Clean Development Mechanism and Joint Implementation programs, or Canadian, Japanese, and Swiss programs.

[31] Five Western Governors announce regional greenhouse gas reduction agreement. Press release, February 26, 2007. http://www.pewclimate.org/docUploads/2007-02-26%20NGA%20greenhouse%20gas%20event%20release.pdf Last accessed August 3, 2007.

[32] All prices given here refer to metric tons. The prices given by Kollmuss and Bowell (2007) have been converted from short tons to metric tons.

air travel CO_2 offsets is \$15 per ton (Kollmuss and Bowell, 2007). A recent survey of voluntary carbon markets (Hamilton et al., 2007) found that the average price paid for carbon credits for U.S.-based projects was \$10 per ton of carbon dioxide equivalent (tCO_2e). Finally, the new "Carbon Capital Project" created by the Forest Service and the National Forest Foundation will charge \$6 per ton of verified CO_2 offset.[34]

Because of the range of prices of voluntary carbon credits, we construct a low and a high estimate of the value of the carbon sequestered by the forests and woodlands in our study area. The low carbon price is that found on the CCX during January-July 2007 - \$3.55 per metric tCO_2e. The high price is the average price of air travel carbon offsets in 2006/07 - \$14.80 per metric tCO_2e. The question as to the appropriateness of these price assumptions is a valid one. After all, the estimated annual quantities of CO_2 sequestered in our study area are equivalent to up to 27 to 36 percent, respectively, of the total volume of voluntary transactions in 2006.[35] A sale of the hypothetical credits produced by the ecosystems in our study area therefore would likely result in a supply shock that would drive down prices. On the other hand, transaction volumes on voluntary carbon markets have been increasing rapidly in recent years, which would make the quantities of carbon sequestered in our study area relatively smaller as a share of the overall market. Importantly also, carbon constraints are likely to tighten in the future with expected increases in both voluntary and mandatory emission reductions, which is likely to raise demand for credits and increase prices.[36]

Applying the low and high prices to the low and high, respectively, carbon sequestration estimates for our study area forests and woodlands (Table 21) yields an estimated total value of the sequestration services of between \$21 million and \$120 million per year (Table 23).

Table 23: Scenario assumptions and estimated annual value of carbon sequestration services provided by study area forests and woodlands

	LOW scenario	*HIGH scenario*
Quantity of C sequestered (metric tons)	1,718,112	2,308,016
Corresponding quantities of CO_2 (metric tons)	6,299,743	8,462,726
Price per ton of CO_2 (2004\$)	3.41	14.21
Value of carbon sequestration (2004\$)	21,482,297	120,257,722

Note: Quantities of carbon dioxide are derived by multiplying the volume of sequestered carbon by 3.67, the ratio of the weight of CO_2 to that of C.

The large difference between the low and high estimates is the unavoidable result of combining two low estimates (for sequestration and carbon value) and two high estimates

33 Average of monthly average closing prices of all vintages. See Chicago Climate Exchange at http://www.chicagoclimatex.com/ On the CCX, CO_2 is traded in the form of Carbon Financial Instruments (CFI), which each represent 100 tons of CO_2. However, prices are reported in terms of \$/metric tCO_2.

34 Friends of the Forest, "Forest Service & NFF Combat Climate Change". July 25, 2007. [online] http://www.carboncapitalfund.org/news/news-59.html Last accessed August 6, 2007.

35 The total transaction volume on voluntary carbon markets in 2006 was at least 23.7 million tons of tCO2e (Hamilton et al., 2007). As Hamilton et al. (2007) point out, this estimate may constitute a considerable underestimate of the actual transaction volume of because it was impossible for their survey to capture all over-the-counter transactions.

36 For example, several bills considered in the U.S. Congress in February of 2008 are expected to result in carbon prices of between \$15 and \$40 per metric ton of CO_2e as soon as 2015 (New Carbon Finance, 2008).

(for carbon sequestration and carbon value), respectively. The average estimate of the value of sequestration services, constructed by using the mean of low and high sequestration estimates and carbon prices, respectively, is $65 million per year.

These results suggest that carbon sequestration is the second highest value generator in the study area, after recreation.

Local Economic Impacts Associated With Uses of Natural Lands

The estimates of recreation visitors' trip expenditures only represent the first-round of economic impacts associated with that spending. These first-round impacts consist of retail sales in sectors that directly cater to recreationists, such as gas stations, restaurants, hotels and grocery stores, to name a few. The sales impact these sectors receive ripples through the economy because no sector operates independently. The sectors that register the first-round, direct sales impact from recreationists' spending in turn increase their demand for inputs, which results in increased sales in the sectors supplying these inputs, and so forth. These impacts are commonly referred to as indirect impacts. At each turn, some additional output is generated. In addition, the direct and indirect increases in sales lead to increases in jobs and earnings, that is, in salaries, wages, and proprietors' incomes in the sectors directly or indirectly affected by recreation-related spending. Part of this increase in earnings is spent, thus generating further sales, which are referred to as induced impacts. The same is true for the forestry and grazing sectors, with sales in sectors that provide inputs to forestry and grazing operations generating additional sales in associated sectors.

Thus, sales in the local area generate multiplier effects in the local, regional and state economies. The ratio of initial, first-round sales impacts and final, total impacts is represented by multipliers. These multipliers are derived from regional economic impact models that combine empirical data on the interrelations between all sectors in the economy.[37] In this study we focus on local impacts, where the "local" area includes the counties that overlap with our study area - Chaves, Eddy, Lincoln, Otero. These local impacts are smaller than total state-wide impacts. This is due to the fact that a portion of the sales in the local area are spent on inputs purchased outside of the local area and thus generate most of the associated multiplier effects there.

Recreation

Our economic impact estimates for recreation activities are based on trip-related spending only and thus exclude any impacts associated with equipment purchases.

Lincoln National Forest

Our economic impact estimates are based on the latest visitation numbers for Lincoln NF from the 2003 NVUM survey (FS, 2006), expenditure information for the forest from Stynes and White (2005), and the IMPLAN-derived local impact multipliers given in Aldrich and Mitchell (2006).

Of the estimated $36.4 million trip expenditures recreationists made within a 50-mile radius of Lincoln NF, an estimated $32.3 million were captured in the four-county area, representing the direct local output impact from Lincoln NF recreation visitor spending.[38] These direct output impacts produce indirect and induced output effects in the local

[37] See for example U.S. Department of Commerce (1997).

[38] Based on Aldrich and Mitchell (2006), we derive the overall capture rate for recreational expenditures as the ratio of direct area output from recreation to recreation visitor trip spending. This yields a capture rate for recreational expenditures in the area of 89 percent.

economy. With an overall recreation spending output multiplier of 1.42 for the area (Aldrich and Mitchell, 2006), the total output effect associated with Lincoln NF recreation in the area is estimated at $45.9 million per year (Table 24).

Recreation spending also generates important employment impacts in the four-county area. Using the direct employment/direct output ratio from Aldrich and Mitchell (2006) of 18 jobs per million dollar local output in recreation related sectors, the direct local output supported by spending by recreation visitors to Lincoln National Forest ($32.3 million) directly generates an estimated 581 full-time jobs in the area. Indirect and induced output impacts associated with the locally captured spending generate an additional 163 jobs.[39]

The direct output supported by Lincoln NF recreationists' spending generates direct labor income impacts estimated at $12.2 million, and additional indirect and induced labor income impacts estimated at $4.1 million (Table 24).[40]

Table 24: Estimates of local economic impacts from recreation in the study area, 2004

	Total output effect (2004$)	*Total employment effect (No. of full-time jobs)*	*Total labor income (2004$)*
FS lands	45.9 million	743	16.3 million
Other lands – elk and deer hunting only *	2.4 million	39	0.9 million

Notes: Includes mostly private, BLM, Indian, and state lands (Table 1).

Other lands in the study area

Our estimate of the local economic impacts associated with elk and deer hunting in our study area outside of Lincoln National Forest is based on the trip expenditures associated with elk and deer hunting in that area ($3.7 million). The trip expenditure estimate however represents state-wide spending on hunting trip-associated items by elk and deer hunters in our area, only part of which occurs in the four-county area. To exclude that portion of trip expenditures that is spent outside of our impact analysis area, we multiply our state-wide total (trip and equipment) expenditure estimate ($7.8 million) by the ratio of total state-wide hunting expenditures to local (50-mile radius) trip expenditures observed among Lincoln National Forest hunting visitors, which is approximately 4.6:1 (American Sportfishing Association, 2006).[41] Our resulting estimate of the trip expenditures associated with deer and elk hunting on lands in the study area outside of Lincoln National Forest is $1.7 million.

We use the same capture rate and recreation multipliers given in Aldrich and Mitchell (2006) to derive impact estimates for the non-Lincoln hunting activity taking place in our study area that we use for the Lincoln portion. Our analysis indicates that elk and deer hunting in the

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39 Aldrich and Mitchell (2006) give a total employment multiplier for recreation of 1.28.

40 These estimates are based on Aldrich and Mitchell's ratio of direct labor income to direct output of 0.378 and their total labor income multiplier for recreation related industries of 1.34.

41 To derive this ratio, we divide statewide travel and equipment expenditures (Approach #2; Appendix D, American Sportfishing Association [2006]) made by hunters on Lincoln National Forest by travel-related expenditures made by hunters within a 50-mile radius of the forest (Approach #1; Appendix C).

area outside of the Lincoln generate total local output estimated at $2.4 million and a total of $850,000 in labor income per year and support 39 full-time jobs (Table 24).

Grazing

Grazing in the study area generates economic impacts that are an order of magnitude larger than the value of the grazing itself. Using the common IMPLAN methodology, Aldrich and Mitchell (2006) estimate that grazing on FS lands in the study area alone produced a direct economic impact (that is, sales) of over $13.7 million in 2004, 92 full-time jobs, and $5.1 million in labor income.[42, 43] Using the same multipliers, the corresponding estimates for grazing on BLM lands are a direct output of $11.5 million, 81 full-time jobs, and labor income of $4.3 million.

These direct impacts in turn generate multiplier effects in the local economy, in the form of indirect and induced impacts. In the case of grazing, indirect impacts result from purchases of inputs associated with grazing activities (e.g., fences, trucks), the corresponding purchases of inputs that in turn are needed to produce those associated inputs (e.g., steel, gasoline), and so forth. Induced impacts represent the value of economic activity generated by the spending of incomes from employees that produce the direct output and inputs associated with grazing. The total output of grazing activities in the local area is the sum of the direct, indirect, and induced impacts of grazing.

Using IMPLAN modeling, Aldrich and Mitchell (2006) estimate the total output, employment, and labor income generated in the local area by grazing on the Lincoln National Forest in 2004. We apply the multipliers used in their analysis to develop corresponding estimates for grazing on BLM lands. These estimates show that grazing on federal lands in the study area supported a total local output of over $44 million, created 339 full-time jobs, and generated total labor income of over $15 million (Table 25).

Table 25: Estimates of local economic impacts from grazing in the study area, 2004

	Total output effect (2004$)	*Total employment effect (No. of full-time jobs)*	*Total labor income (2004$)*
FS lands	23.5 million	181	8.4 million
BLM lands	20.6 million	158	7.3 million
Private lands	n/a	n/a	n/a
Total	44.1 million	339	15.7 million

Notes: n/a – not available. BLM estimates use same grazing multipliers used in Aldrich and Mitchell's (2006) analysis of FS lands in the study area.
Sources: Aldrich and Mitchell (2006)

[42] Labor income comprises employee compensation and proprietor income.
[43] All monetary values are given in 2004 dollars, unless indicated otherwise.

Timber and non-timber products

Estimates of the economic impacts in 2004 of timber harvests from Lincoln National Forest must be based on the value of the actual timber cut in that year (as opposed the sold volume). Using market prices, the value of timber harvested from the Lincoln National Forest was approximately $1.3 million in 2004 (Aldrich and Mitchell, 2006). In addition, the market value of non-timber harvests in 2004 (principally Christmas trees) was an estimated $3.7 million (Table 13). Using the timber harvest IMPLAN multipliers employed by Aldrich and Mitchell (2006), harvests of timber and non-timber wood products from the Lincoln National Forest in 2004 directly supported an estimated 29 full-time jobs in the area and generated direct labor income estimated at $811 thousand.

The total (direct, indirect, and induced) impacts from timber and non-timber harvest activities on Lincoln National Forest in 2004 are shown in Table 26. Harvests supported total economic output in the local area estimated at almost $8 million, generated 54 full-time jobs, and labor income of approximately $1.7 million.

Table 26: Estimated local economic impacts from timber and non-timber harvests from Lincoln National Forest

	Total output effect (2004$)	*Total employment effect (No. of full-time jobs)*	*Total labor income (2004$)*
Timber harvest	$2.08 million	14	$0.44 million
Non-timber products	$5.85 million	40	$1.23 million
Total	$7.93 million	54	$1.67 million

Notes: Non-timber products are primarily Christmas trees.
Sources: Aldrich and Mitchell (2006); Table 13.

Since we have not included timber harvests on any lands in our study area that lie outside of the Lincoln National Forest, our estimates are likely to underestimate the actual impacts on the local economy from timber harvests.

Forest Service activities

Forest Service activities, including both the Service's operations and wildfire suppression activities, generate local economic impacts through equipment expenditures and through payments of wages and salaries to Forest Service employees, both of which result in increased output in the local economy from indirect and induced impacts.[44] Using data on Forest Service expenditures and salary and wage payments, Aldrich and Mitchell (2006) estimate that Forest Service operations, including wildfire suppression activities, directly generate 244 full-time jobs, $16 million in output, and $9.8 million in labor income in the

[44] Because the direct economic value of Forest Service operations is unknown, Aldrich and Mitchell (2006) use Forest Service expenditures to measure first-round indirect impacts (that is, sales increases for local firms providing inputs to Forest Service operations) of these operations, and salary and wages paid by the Forest Service to measure first-round induced impacts. Total output, employment, and labor income are then conventionally estimated through IMPLAN modeling.

area, and indirect and induced impacts in the form of an additional full-time 199 jobs, $9.3 million in output, and $7.1 million in labor income in the area.

Table 27: Estimated local economic impacts from Forest Service activities on Lincoln National Forest

Total output effect (2004$)	*Total employment effect (No. offull-time jobs)*	*Total labor income (2004$)*
$25.4 million	443	$16.8 million

Economic impacts from operations on BLM lands are likely smaller in scale given the smaller acreage i our study area that is managed by the BLM.

Conclusion

Undeveloped lands support a variety of human activities. These activities have economic value because they contribute to people's well-being. A portion of this value is at least partially reflected in markets, either because the nature-based activity (e.g., hunting) requires inputs (e.g., transportation, food and lodging, permits, equipment) that are bought and sold in markets, or because the goods or services provided by undeveloped lands (e.g., water provision or carbon sequestration services) are themselves traded in markets. Thus, to some extent market expenditures associated with human uses of natural lands can serve as a lower-bound indicator of the value individual place on those uses. However, the value of many goods and services provided by natural lands is not fully reflected in market transactions, either because a good or service is not amenable to being bought and sold in markets (e.g., populations of individual threatened or endangered species or biodiversity more generally); because individuals value these goods or services not for their use alone but also, and in some cases primarily, for their existence per se (e.g., particular "charismatic" species; unique scenic landscapes such as Yellowstone National Park, or untouched, wild places such as wilderness areas); or because market prices do not reflect the consumer or producer surplus or net benefit to individuals or firms that is associated with their consumption of the good or service or with its use as an input to production. Thus, capturing the full value of human activities supported by natural lands requires the use of valuation approaches capable of capturing the portion of the value of natural lands that is not reflected in the market transactions.

This study uses market prices and, to the extent that they are available, published estimates of non-market values to develop comprehensive value estimates for several activities supported by undeveloped lands in an almost 4,900 square-mile area in southeastern New Mexico. This area is largely composed of lands identified as high-priority habitat and "key areas to consider for conservation planning efforts" (New Mexico Department of Fish and Game, 2006:90). Our analysis includes the value associated with open space premiums that accrue to residential properties located in the vicinity of undeveloped open spaces; the value associated with outdoor recreation activities practiced in the area by local residents and visitors; the value of timber, non-timber products and grazing provided by the area; and the value of the ecosystem service of carbon sequestration provided by the undeveloped lands in the area. The lands in question provide a number of additional uses, such as support for educational and research activities, water for off-stream uses, habitat provision for threatened, endangered, rare or "charismatic" species like the Peregrine falcon, the golden eagle or the Mexican spotted owl. We did not include these latter uses in our analysis for lack of the required data.

As a result of the omission of these additional values from our analysis, our estimate of the economic value generated by the study area is likely to be conservative. This conservative bias is increased substantially by the fact that our recreation analysis only considers trip spending within a 50-mile radius of the forest and thus does not include any equipment purchases by visitors to the forest. In addition, we were unable to obtain visitation estimates for recreation on BLM lands, and there is no information on recreation activities on private and state lands except for hunting. Finally, our results do not include any timber harvests on state or private lands. The combined effect of these factors is that our value estimates are almost certain to be substantial underestimates of the true economic value generated by the natural lands in the study area.

Despite the unavoidable downward biases in our value estimate, our analysis shows that the undeveloped lands in the study area generate substantial economic value. The total estimated annual value of the land uses included in our analysis ranges from $106 million to $205 million, depending on the price used to value carbon sequestration services provided by the lands (Table 28). It should be noted that the higher estimate is very far from being an upper bound on the value generated by the lands, because even this higher estimate is based on carbon credit prices that do not represent the high end of the range. Also, due to frequent changes in some of the prices we used to value these ecosystem services, our estimates should be seen as approximations to the actual values, not as accurate measurements of those values.[45] Nevertheless, our analysis shows that the value of the one ecosystem service included in our study – carbon sequestration – with a mean estimate of $70 million per year is comparable to that of recreation activities, which represent the highest-value of the other uses included in the analysis. The uncertainties surrounding an accurate pricing of net carbon uptake are not expected to affect this result, as the prices used to value this service are likely to be conservative.

Table 28: Annual value of selected uses of undeveloped lands in the study area

	Low estimate	*High estimate*
	million 2004$ per year	
Open space property value premiums	5.3	5.3
Timber and non-timber harvests	6.9	6.9
Grazing	2.2	2.2
Recreation	70.3	70.3
Ecosystem services: Carbon sequestration	21.5	120.3
TOTAL	106.1	204.9

Note: The value of open space property price premiums shown in the table is the annual benefit flow (see p. 31)

Considering the omission from our analysis of several other economically important services provided by the undeveloped lands in the study area, such as erosion control, water supply, air quality, temperature modulation, scenic views or habitat for species that carry existence value for people, the actual economic value of the undeveloped lands is likely to be considerably higher than indicated by our estimates. For example, the water provision

[45] For example, the price of a carbon credit (called "Carbon Finance Instrument" or CFI) on the Chicago Climate Exchange between February and May 2007 fluctuated between $2.60 and $7.40 per metric ton of CO_2e while the price of CFI futures (maturity date December 2010) fluctuated between $3.25 and $9.75 during the same period. A recent analysis (New Carbon Finance, 2008) suggested that a potential future cap-and-trade system in the U.S. along the lines proposed in several bills considered in the U.S. Congress in February of 2008 might result in carbon prices of between $15 and $40 per metric ton of CO_2e as soon as 2015, depending on whether only domestic or also international trading would be allowed. For comparison, in our calculations we used the average January-July 2007 price of $3.55 per metric ton of CO_2e as a lower bound, and the average price of air travel carbon offsets in 2006/07, $14.80 per metric t$CO_2$e, as the upper bound.

services of National Forest lands alone are valued conservatively at over $4 billion per year, over $200 million of which is contributed by National Forests in Arizona and New Mexico (2004 dollars; Sedell et al., 2000).

The lands in the study area also generate large sales, income and employment impacts in the area, estimated at $126 million in total final output, $51 million in earnings, and over 1,600 jobs, respectively (Table 29). These impacts in turn generate substantial local, state and federal tax revenues.

Table 29: Estimated total annual local economic impacts associated with analyzed uses of the study area

	Total output	*Total income*	*Total employment*
	million 2004$ per year		*Jobs*
Grazing	44.1	15.7	339
Timber & non-timber harvest	7.9	1.7	54
Recreation *	48.2	17.2	782
FS activities **	25.4	16.8	443
TOTAL	125.7	51.4	1,618

Notes: Totals may not sum due to rounding. * Impacts shown here are those associated with trip spending only, and exclude those associated with equipment spending. ** Includes wildfire suppression and Forest Service operations.

Given the increasing scarcity of undeveloped lands and of many of the goods and services they provide and given the expected continuation of that trend, the value of these outputs is only expected to increase over time.[46] Land use, land management and conservation planning, in order to achieve economically sensible results, should take into account the economic value generated by the conservation of undeveloped lands and the fact that the increasing relative scarcity of these lands will only increase conservation values. In areas where large tracts of land are publicly owned, as is the case in many areas in the western U.S., a shift to ecosystem service value-based practices could be achieved through the incorporation of economic benefit considerations into land use planning and land management. However, in many regions of the country, a large share of both ecologically and economically valuable undeveloped lands is in private ownership. Where this is the case, existing financial incentive systems that encourage land conservation will need to be improved and in many cases additional ones will need to be created in order to better align privately and socially desirable outcomes. This is a challenging task whose urgency is increasing in lockstep with the continuing loss and degradation of natural lands.

[46] This already is evident for water provision and carbon sequestration.

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Appendix

Not all of the recreation activities listed in the Forest Service's NVUM surveys and reports match those for which Loomis (2005) provides average consumer surplus (CS) estimates. To assign CS values to the activities practiced on Lincoln NF for which Loomis (2005) does not provide CS estimates, we identified those activities listed by Loomis (2005) that are most similar to the respective NVUM activities. In general, we used Loomis' CS values for particular recreation activities in the Intermountain Region, which includes New Mexico. In cases where Loomis (2005) does not provide a CS estimate for a NVUM activity in the Intermountain Region, we used his average CS values from (an)other region(s). Table A-1 shows the recreation activities practiced on Lincoln NF (Kocis et al., 2004) and the activity and region of the corresponding CS values from Loomis we used to assign CS values to the Lincoln NF activities.

Table A-1: Crosswalk of NVUM recreation activities and those listed in Loomis (2005)

Activity listed in NVUM reports	*Activity listed in Loomis (2005)*
Developed camping	Camping – Intermountain Region
Primitive camping	Camping – Intermountain Region
Backpacking	Backpacking – Pacific Northwest Region
Resort use	-
Picnicking	Picnicking – Intermountain Region
Viewing natural features	Sightseeing – Intermountain Region
Visiting historical sites	Sightseeing – Intermountain Region
Nature center activities	Visiting environmental education centers – Northeast Region
Nature study	Other recreation – Intermountain Region
Relaxing	General recreation – Intermountain Region
Fishing	Fishing – Intermountain Region
Hunting	Hunting – Intermountain Region
OHV use	OHV use – Intermountain Region
Pleasure driving	Pleasure driving – Intermountain Region
Snowmobiling	Snowmobiling – Intermountain Region
Motorized water activities	n/a
Other motorized activity	Other recreation – Intermountain Region
Hiking/walking	Hiking – Intermountain Region
Horseback riding	Horseback riding – Multiple area studies
Bicycling	General recreation – Intermountain Region *
Non-motorized water	n/a
Downhill skiing	Downhill skiing – Intermountain Region
Cross-country skiing	Cross-country skiing Wildlife viewing
Other non-motorized	Other recreation – Intermountain Region
Gathering forest products	n/a
Wildlife viewing	Wildlife viewing – Intermountain Region

Notes: * Loomis (2005) provides a value for mountain biking ($184.48), but that is a very specialized activity the high value of which may not be indicative of the value of biking in general.
Sources: Loomis (2005) table 2.

Table A-2: GAP vegetation alliance classification of lands in the study area and associated total acreages

Total Habitat Acreage	GAP Vegetation Alliance	Total Habitat Acreage	GAP Vegetation Alliance
1857	Agriculture	9692	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
76672	Apacherian-Chihuahuan Mesquite Upland Scrub	3132	North American Warm Desert Playa
705678	Apacherian-Chihuahuan Piedmont Semi-Desert Grassland and Steppe	11	North American Warm Desert Riparian Mesquite Bosque
311421	Chihuahuan Creosotebush, Mixed Desert and Thorn Scrub	3279	North American Warm Desert Riparian Woodland and Shrubland
319	Chihuahuan Gypsophilous Grassland and Steppe	2	North American Warm Desert Volcanic Rockland
11958	Chihuahuan Mixed Salt Desert Scrub	2549	North American Warm Desert Wash
3091	Chihuahuan Sandy Plains Semi-Desert Grassland	276	Open Water
2095	Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub	6028	Recently Burned
756	Chihuahuan Succulent Desert Scrub	28	Rocky Mountain Alpine-Montane Wet Meadow
13984	Coahuilan Chaparral	7297	Rocky Mountain Aspen Forest and Woodland
195	Colorado Plateau Mixed Bedrock Canyon and Tableland	41	Rocky Mountain Bigtooth Maple Ravine Woodland
38	Colorado Plateau Mixed Low Sagebrush Shrubland	3458	Rocky Mountain Cliff and Canyon
454	Colorado Plateau Pinyon-Juniper Woodland	58595	Rocky Mountain Gambel Oak-Mixed Montane Shrubland
1178	Developed, Medium - High Intensity	14854	Rocky Mountain Lower Montane Riparian Woodland and Shrubland
4284	Developed, Open Space - Low Intensity	709	Rocky Mountain Lower Montane-Foothill Shrubland
38	Inter-Mountain Basins Active and Stabilized Dune	4975	Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland
4	Inter-Mountain Basins Big Sagebrush Shrubland	3317	Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland
29	Inter-Mountain Basins Greasewood Flat	111034	Rocky Mountain Ponderosa Pine Woodland
39	Inter-Mountain Basins Mixed Salt Desert Scrub	924	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
827	Inter-Mountain Basins Montane Sagebrush Steppe	453	Rocky Mountain Subalpine Mesic Meadow
887	Inter-Mountain Basins Semi-Desert Grassland	301	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland
5450	Inter-Mountain Basins Semi-Desert Shrub Steppe	24088	Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
10	Inter-Mountain Basins Shale Badland	172	Rocky Mountain Subalpine-Montane Riparian Shrubland
260	Inter-Mountain West Aspen-Mixed	22250	Southern Rocky Mountain Juniper

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	Conifer Forest and Woodland Complex		Woodland and Savanna
13608	Madrean Encinal	84242	Southern Rocky Mountain Montane-Subalpine Grassland
34336	Madrean Juniper Savanna	128127	Southern Rocky Mountain Pinyon-Juniper Woodland
366138	Madrean Pine-Oak Forest and Woodland	599	Western Great Plains Cliff and Outcrop
689968	Madrean Pinyon-Juniper Woodland	2835	Western Great Plains Foothill and Piedmont Grassland
163857	Madrean Upper Montane Conifer-Oak Forest and Woodland	995	Western Great Plains Riparian Woodland and Shrubland
28411	Mogollon Chaparral	8	Western Great Plains Saline Depression Wetland
186	North American Arid West Emergent Marsh	7586	Western Great Plains Sandhill Shrubland
211	North American Warm Desert Active and Stabilized Dune	165342	Western Great Plains Shortgrass Prairie
2333	North American Warm Desert Bedrock Cliff and Outcrop		

Source: Kendall Young and Ken Boykin, Center for Applied Spatial Ecology, New Mexico State University.