Economic Benefits of Conserving Natural Lands:

Case Study: Central Platte Biologically Unique Landscape, Nebraska

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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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Defenders of Wildlife is a national nonprofit membership organization dedicated to the protection of all native wild animals and plants in their natural communities.

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List of Abbreviations

BUL	Biologically Unique Landscape
C	Carbon
CO_2e	Carbon dioxide equivalent
GAP	Gap Analysis Program
IUCN	International Union for the Conservation of Nature (World Conservation Union)
NAWQA	National Water-Quality Assessment
NRCS	Natural Resources Conservation Service
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
yr	Year

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 the Central Platte river Biologically Unique Landscape (BUL), a 658 square-mile area in south-central Nebraska that is under pressure from agriculture and residential development and has been identified as a priority for conservation in Nebraska's Natural Legacy Project.

Our analysis includes the value associated with the open space premiums that accrue to residential properties located in the vicinity of undeveloped open spaces; the value associated with wildlife viewing and recreational fishing in the area by local residents and visitors; and the value of the carbon sequestration service provided by the ecosystems found in the Central Platte BUL.

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 $24 million to $41 million, depending on the prices used to value carbon sequestration, the net greenhouse gas balance of wetlands, and the estimates of the number of recreationists visiting the study area (Table ES-1).

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

	Low estimate	*High estimate*
	million 2004$ per year	
Open space property value premiums	0.5	0.5
Recreation	23.0	36.6
Ecosystem services:		
Carbon sequestration	0.6	3.6
TOTAL	24.2	40.7

These figures do not include the value of hunting and of recreational activities not associated with wildlife, nor do they include the value of the estimated roughly 17-39 tons of nitrogen as well as significant reductions in pesticides from agricultural runoff that are removed annually by riparian vegetation and prevented from entering surface and groundwaters. They also exclude the value of the ecosystem services other than carbon sequestration that the undeveloped lands in the study area provide, such as erosion control or provision of habitat for species that carry existence value for people. Consequentially, 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 activities supported by the lands in the study area also generate large sales, income and employment impacts in the Central Platte area and in the state as a whole. Angling and wildlife viewing alone are estimated to generate between $9.7 and $13.3 million annually in total final output in the Central Platte area. At the state level, Central Platte birding and angling generated total sales estimated at $22.7 to $31.1 million, supported 276 to 387 jobs and resulted in $6.5 to $8.9 million in earnings (salaries, wages, and business earnings). These impacts in turn generate substantial local, state and federal tax revenues.

Land use planning and conservation policy making should consider the economic value generated by the conservation of undeveloped lands and the increasing relative scarcity and rising value of the goods and services provided by those lands in order to achieve economically sensible results. With a large share of both ecologically and economically valuable undeveloped lands in private ownership, not just in the Central Platte study area but also at state and national levels, existing financial incentive systems that encourage land conservation on private lands 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 new cover types, 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-

[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 (e.g., carbon sequestration payments), 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 several human uses supported by the undeveloped lands in a specific area in south-central Nebraska that is under pressure from agricultural and residential development, 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 case studies that examine the economic benefits provided by diverse natural lands identified as priority conservation areas 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

Our Nebraska study area is the Central Platte River area, identified as a *biologically unique landscape* in Nebraska's Mixedgrass Prairie Ecoregion (Schneider et al., 2005). 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. Nebraska was chosen to represent the Midwest and Central Plain states in our sample. Within Nebraska, our study area selection was mostly driven by availability of data on human uses of lands that constitute high-quality wildlife habitat and are under threat.

The Central Platte River biologically unique landscape includes the river channel and floodplain from central Dawson county eastward to central Hamilton county (Figure 1). This area is home to five federal and/or state listed species - the whooping crane, the interior least tern, the piping plover, the bald eagle and the river otter - as well as several Tier 1 at-risk species (Table 1). It contains priority aquatic and terrestrial communities that occur along the Central Platte. This portion of the Platte River is designated as critical habitat for whooping cranes and piping plovers (Schneider et al., 2005) and represents a world-class wildlife observation site during the spring migration of the sandhill cranes (Schneider et al., 2005). The Platte River area represents a crucial stopover in the annual migration of sandhill cranes that allows the birds to accumulate energy reserves needed for successful breeding. The importance of the area is such that the elimination or significant alteration of spring staging areas on the Platte River are considered the most significant potential threat to the mid-continental population of sandhill cranes at the present time (Schneider et al., 2005). The IUCN considers the protection of the Platte River as migratory habitat for sandhill cranes as a priority for conservation (ibid.).

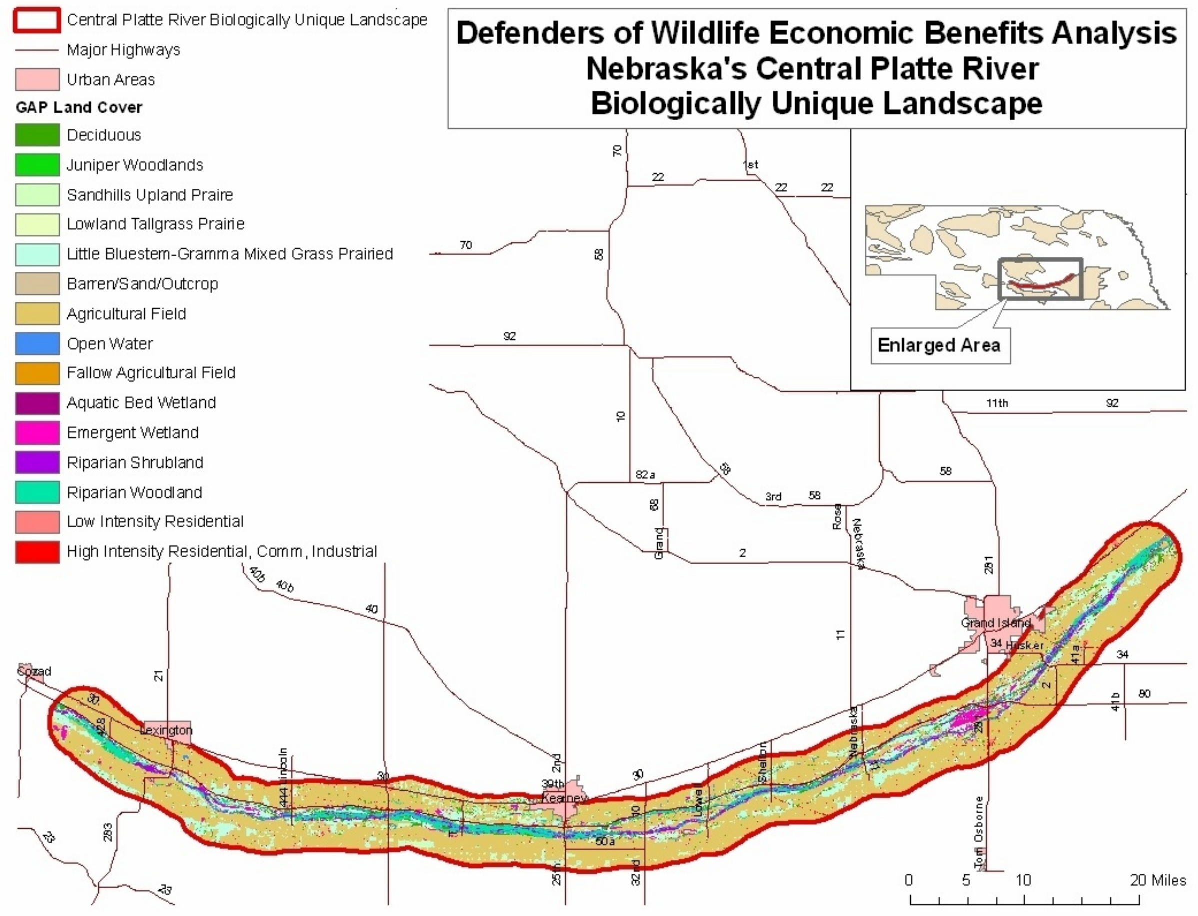

Figure 1: Central Platte river study area (GAP GIS layers)

Table 1: Tier 1 At-risk Species in the Central Platte River Biologically Unique Landscape

Plants
Western prairie fringed orchid (*Platanthera praeclara*)
Animals
Platte river caddisfly
Regal fritillary (*Speyeria idalia*)
Plains topminnow (*Fundulus Sciadicus*)
Bald eagle (*Haliaeetus leucocephalus*)
Interior least tern (*Sterna antillarum athalassos*)
Piping plover (*Charadrius melodus*)
Sandhill crane (*Grus canadensis*)
Whooping crane (*Grus americana*)
River otter (*Lutra canadensis*)

Source: Schneider et al. (2005).

The Central Platte is under stress from a variety of activities, including water depletions, drainage of wetlands and conversion of wet meadows to cropland, continued residential development and development of sandpits, which eliminates native meadows, woodlands, and river channel (Schneider et al., 2005). Residential development will continue to put pressure on the remaining natural habitats in the Platte River. Unprotected wetland and prairie habitats are also facing increasing pressure for conversion of these areas to biofuel crop lands, as a direct or indirect result of the expansion of government incentives for the production of corn-based ethanol. [4]

The total size of the study area is approximately 421,000 acres or 658 square miles. The main land covers are agricultural fields (67 percent), followed by prairie (16 percent), riparian wood- and shrublands (6 percent) and forests (3 percent) (Table 2).

Table 2: Land cover in the study area (GAP analysis data) [5]

Land cover	*Acreage*
Deciduous Forests and Woodlands	12,838
Juniper Woodlands	2,422
Sandhills Upland Prairie	6,538
Lowland Tallgrass Prairie	6,944
Little Bluestem-Gramma Mixedgrass Prairie	54,549
Barren/Sand/Outcrop	132
Agricultural Field	281,398
Open Water	11,679
Fallow Agricultural Field	456
Aquatic Bed Wetland	297
Emergent Wetland	8,927
Riparian Shrubland	8,439
Riparian Woodland	16,636
Low Intensity Residential	2,915
High Intensity Residential, Comm, Industrial, Transportation	7,025

Source: Nebraska GAP land cover data.

Only five percent of the lands in the study area are protected (Table 3), defined as having a GAP status of 1,2 or 3, and most of these (77 percent) are in private ownership. Ninety-nine percent of the lands in the study area are privately owned (see also Figure 2). [6]

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[4] Conversion of these ecosystems to biofuel crop lands takes place even though such conversion is harmful from a greenhouse gas (GHG) emission reduction perspective. The conversion of natural vegetation communities to biofuel crops is counterproductive because the releases of GHGs caused by the conversion of the lands will take at least several decades to recoup through the GHG savings associated with the biofuels produced on the converted lands (Searchinger et al., 2008; Fargione et al., 2008).

[5] In addition to the GAP data, U.S. Geological Survey (USGS) 2001 Land cover data are available for the study area (see Appendix Figure A1). Both data sets have a 30 m resolution. However, the GAP data offer a more detailed breakdown of vegetation types.

[6] GAP biodiversity management status classifications are as follows (Scott et al. 1993; Edwards et al. 1994; Crist et al. 1996): Status 1: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management; Status 2: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance; Status 3: An area having permanent protection from conversion of natural land cover for

Table 3: Land ownership in the study area

Protected	
Platte River Crane Trust	11,465
The Nature Conservancy	3,581
National Audubon Society	1,233
U.S. Fish & Wildlife Service	869
Merrick Co	133
NE Game & Parks Commission	3903
Total protected	21,184
Unprotected	
Unknown/Private Lands	398,642
NE Public Power District	82
Kearney - City/County Park	99
Army Corps of Engineers	871
Total unprotected	399,693

Source: Gap Land Stewardship project data.

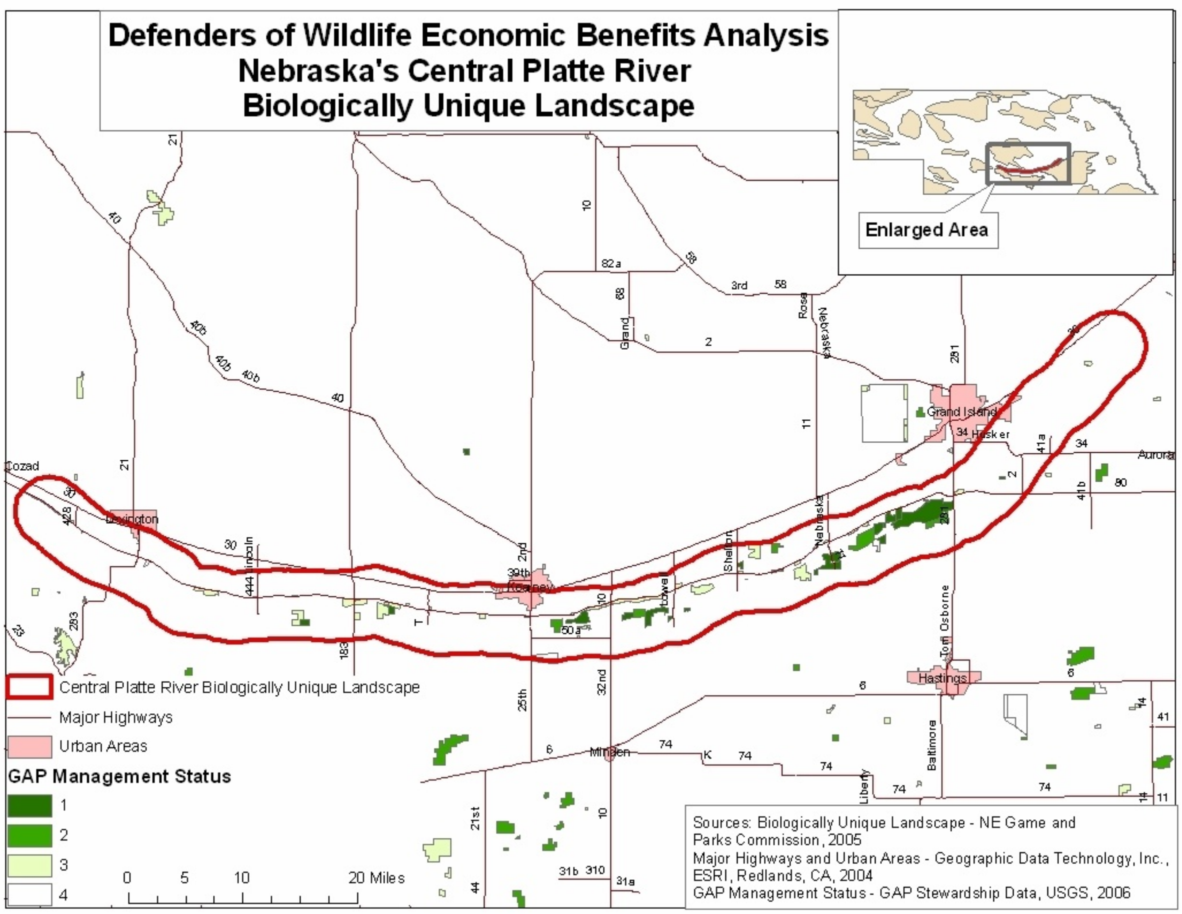

Figure 2: Protected lands in the Central Platter Biologically Unique Landscape

the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense type (e.g., mining). It also confers protection to federally listed endangered and threatened species throughout the area.

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 generated 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., recreation, clean water, carbon sequestration, scenic views). The base year for our analysis is 2004, the most recent year for which most of the needed data are available. 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 uses a welfare analysis-based perspective and attempts to quantify the total economic value of the benefits examined for all individuals in 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.[7]

Uses included in analysis and associated economic values

The native ecosystems in 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 recreation or scenic views from adjacent or proximate properties. 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 the natural lands supply through their filtration of nutrients from agricultural runoff, the maintenance of a diverse fauna and flora, or the sequestration of atmospheric carbon by perennial plants. Finally, some aspects or components of the study area may hold passive use values, to the extent that some people 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 like the river otter (*Lutra canadensis*) or bald eagle (*Haliaeetus leucocephalus*), or they may value the thought of preserving particular areas intact and largely unaffected by human development (see 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

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

uses for which we were able to obtain quantitative information and that are compatible with and contingent upon the continued conservation of the area. These are shown in Table 4 . The fact that a particular use is not indicated in Table 4 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, the ecosystem types present in the study area are habitats for a number of federally listed species, some of which, like the river otter or the sandhill or whooping crane, are charismatic and as such may hold existence value for people.

Table 4: List of documented uses of the study area's ecosystems

Direct uses	Recreation - Camping - Picnicking and general relaxation - Fishing - Hunting - Hiking - Wildlife watching
	Research and education
	Property value premiums
Indirect uses	Ecosystem services - Reduction of nutrient loading of stream (water quality) - Water temperature modulation (water quality) - Biodiversity maintenance - Species habitat provision * - Carbon sequestration

Notes: * Part of the associated value is captured in fishing, hunting, and wildlife viewing uses.

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 with the conservation of above ground natural ecosystems. Examples of such uses are unsustainable timber extraction and agriculture.

Some conservation-compatible 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 5). 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 5: Uses of the study area and types of associated economic values

Use	*Market value*	*Non-market value*
Recreation	ü	ü
Research and education	ü	ü
Property value premiums	ü	
Ecosystem services	ü	ü

Due to limits in the scope of our analysis, we do not develop estimates of the value of research and education, and of most ecosystem services provided by the study area. In addition, information is missing on the value of some of the uses we do include in our analysis. For example, while we do have quantitative estimates of the water quality (runoff uptake) impacts of riparian buffer strips, the economic valuation of these benefits is very difficult. 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 4. 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

The Central Platte river is recognized as one of Nebraska's most attractive areas for wildlife-associated recreation and tourism (ECONorthwest, 2006). The area attracts locals and visitors who engage in a variety of activities, including wildlife viewing, particularly birding, fishing, hunting, canoeing, boating, camping and nature photography (Eubanks, 1999). Of particular significance is the annual spring migration of continental sandhill crane subpopulations, who all use the Platte river as a stopover on their transcontinental journey from their wintering grounds in the southern and southeastern U.S. or Mexico, to their summer habitats in Minnesota, Alaska, Canada and Siberia.

A 1996 survey of birdwatchers along the central Platte river between Columbus and North Platte (Eubanks et al., 1998; see also Stoll et al., 2006) revealed that an estimated 14,500 to 22,700 people per year engage in nonresidential (away-from-home) birdwatching along the central Platte. About half (52 percent) of participants are from out-of-state, with the remainder residing in the Central Platte area (27 percent) or elsewhere in Nebraska (21 percent), respectively (Table 6). The survey sites sampled in that study - Fort Kearney, Rowe Sanctuary and Crane Meadows Sanctuary – all are located in our study area and form the main basis for Eubanks et al.'s visitation estimate.[8] Thus, we expect the overall visitation estimates derived in that study should be applicable to our study area.

Table 6: Estimated annual numbers of participants in away-from-home wildlife-associated recreation activities along the central Platte river

Activity	*Est. number of participants*	*Est. total days of participation*
Birdwatching - TOTAL	14,500-22,700	105,000-164,000
Central Platte residents	3,900-6,100	57,400-89,900
Other Nebraska residents	3,000-4,800	18,800-29,500
Out-of-state visitors	7,500-11,800	28,400-44,500
Fishing * - TOTAL	19,200	217,800
Nebraska residents	17,400	209,200
Out-of-state visitors	1,700	8,600
Hunting	n.a.	n.a.

Notes: See text for explanation of estimates. n.a. - no estimates available. Numbers may not add up due to rounding. * Some of this activity likely occurred outside of the Central Platte BUL.
Sources: Eubanks (1999), Eubanks et al. (1998), U.S. Fish and Wildlife Service and U.S. Census Bureau (2002)

[8] The remaining 23 percent of respondents in Eubanks et al.'s survey came from Nebraska Audubon and Nebraska's Ornithologists' Union, which were sampled in addition to the three on-site survey locations.

The central Platte also provides ample fishing opportunities. Unfortunately, no site-specific information on angler visitation numbers is available for the area. However, based on data from Nebraska's State Comprehensive Outdoor Recreation Survey, an estimated 21 percent of recreational fishing in streams and rivers in Nebraska by state residents took place in the South-central and Southwest regions that contain the Central Platte river as one of their principal stream (Eubanks, 1999). No such breakdown by region is available for out-of-state anglers fishing in Nebraska, which accounted for nine percent of total away-from-home (non-residential) fishing in Nebraska in 2001 (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2002). Assuming recreational fishing activity in Nebraska rivers and streams by out-of-state visitors is distributed across the state's regions in the same way as that by state residents, in 2001 an estimated 19,200 people engaged in non-residential stream and river fishing in the larger Central Platte river area.[9] Based on the breakdown of total anglers in Nebraska into state residents (91 percent) and visitors from out-of-state (9 percent) and the average number of days they fished in Nebraska (twelve and five days, respectively; U.S. Fish and Wildlife Service and U.S. Census Bureau, 2002), this participation in 2001 resulted in an estimated 209,200 fishing days in the area by Nebraskans, and 8,600 days by visitors from out-of-state (Table 6).

The economic value associated with recreation activities in the study area 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 (2008; and earlier issues). 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.[10] For our study area, we have site-specific expenditure estimates for bird watching and fishing (Eubanks et al., 1998) as well as CS estimates for bird watching (Stoll et al., 2006). In addition, CS estimates for fishing are available from other studies. Based on these data, 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.

[9] This estimate is based on total participants in away-from-home fishing in Nebraska in 2001 (93,000; U.S. Fish and Wildlife Service and U.S. Census Bureau; 2002) and the assumption that 20.6 percent of all fishing in the state is taking place in the South-central and Southwest regions that compose the Nebraska Game and Parks Commission's Recreational Planning Regions IV and V (Eubanks, 1999). Note that the boundaries of Regions IV and V overall have expanded considerably since the mid-1990s and now include Hall county in its entirety as well as a total of five more counties (nine counties were added while four were excluded).

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

The total trip expenditures associated with recreational bird watching away from home in the Central Platte area are estimated at between $7.8 and $12.3 million per year, respectively, for the low and high visitation estimates by Stoll et al. (2006) (Table 7). Most (87%) of this spending is accounted for by area residents and visitors from out-of-state.

Table 7: Central Platte birding participation and trip expenditures

Origin of birder	*Total annual birding days in central Platte area* [1]		*Avg. trip length (Days)* [1]	*Total trips by origin of participant*		*Avg. spending/trip (2004$)* [2]	*TOTAL spending (2004$)*	
	Low est.	*High est.*		*Low est.*	*High est.*		*Low est.*	*High est.*
MPRSA residents	57,394	89,911	2.34	24,527	38,423	144	3,536,941	5,540,801
Other NE residents	18,849	29,527	2.54	7,421	11,625	136	1,010,841	1,583,535
Out-of-state visitors	28,426	44,530	3.44	8,263	12,945	398	3,290,433	5,154,634
							7,838,215	12,278,970

Sources: [1] Data are for 1996 and are from Stoll et al. (2006) and Eubanks et al. (1998); [2] excludes equipment purchases.

We estimate that recreational fishing in the study area generates a total of up to $4.2 million in trip-related spending per year. This may be an estimate because it is based on the total number of recreational fishing days in the Nebraska Game and Parks Commission's Regions IV and V. The Central Platte, though important for fishing, though is not the only site in these regions that is visited by anglers. It should be noted however that our spending estimate does not include any equipment purchases, which in 2001 in Nebraska accounted for 45 percent of total spending by participants in recreational fishing (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2002). Thus, unless Central Platte fishing accounts for substantially less than half of total recreational fishing in Regions IV and V, our expenditure estimate does not overestimate total spending by anglers.

Table 8: Central Platte recreational fishing days and associated trip spending

Origin of angler	*Total angling days/yr* [1]	*Avg. trip expenditures/yr per sportsperson 2001$*	*Avg. fishing days/yr in NE*	*Avg. trip expend./day 2001$*	*Total trip exp. /yr 2004$*
State residents	209,205	206	12	17.2	3,828,388
Out-of-state visitors	8,621	192	5	38.4	352,900
					4,181,288

Notes: [1] Based on that fact that 20.6 percent of all river and stream angling in Nebraska takes place in Regions V and IV of the state (Eubanks, 1999), that there are an estimated 657,000 total river and stream fishing days in the state (2001), and that the average number of days of fishing in the state is twelve per year for state residents and per year five for out-of-state visitors.
Sources: U.S. Fish and Wildlife Service and the U.S. Census Bureau (2002); Eubanks (1999).

Based on their survey of recreationists, Stoll et al. (2006) estimate that the average birder in the Central Platte area places a value of $491 (2004$) per year on maintaining the status quo in terms of species diversity and size of the crane population. This amount represents the consumer surplus received by birders because respondents stated their willingness to pay for maintaining the status quo, therefore, the $491 represent willingness to pay above and beyond actual (current) expenditures. Multiplying this value by the total number of participants in non-residential bird watching in the Central Platte area yields an estimated total annual consumer surplus of $7.1 to $11.2 million for the area for the low and high participation estimates, respectively (see Tables 6 and 7).

Unlike in the case of birding, no study is available that provides estimates of the consumer surplus associated with recreational fishing in our study area. However, we used an updated version of the comprehensive sportfishing value database developed by Boyle et al. (1998) to identify studies that estimated the average value of recreational fishing in Nebraska and neighboring Great Plains states, shown in Table 9.[11] Table 9 excludes observations from several studies that reported average fishing values for larger groups of states including Nebraska or for groups of states that included mountain states, which generally offer higher-value fishing experiences.

Table 9: Average net value (CS) of a fishing day in Nebraska and neighboring states

Species	*Study year*	*Sample population*	*Value (WTP) 2004$/day*	*Study area*	*Source*
Bass	1996	Residents and visitors	20.89	IO, KS, MO, NE	Boyle et al. (1998)
Trout	1980	Residents and visitors	30.43	NE	Brown and Hay (1987)
Small- and large-mouth bass	1991	Residents and visitors	41.07	NE	Waddington et al. (1994)
Bass	2001	Residents	40.30	NE	Aiken and La Rouche (2003)
Bass	1985	Residents and visitors	17.92	NE	Hay (1988)
Small- and large-mouth bass	1991	Residents and visitors	19.83	KS	Waddington et al. (1994)
Bass	2001	Residents	21.78	KS	Aiken and La Rouche (2003)
Bass	1985	Residents and visitors	17.92	KS	Hay (1988)

[11] This database contains over 900 observations and will be made available in late 2008 as part of the Wildlife Habitat Benefits Estimation Toolkit developed by Kroeger et al. (2008). The Toolkit can be found at *http://www.defenders.org/programs_and_policy/science_and_economics/conservation_economics/index.php*

The average CS values anglers reported in those studies range from around $18 to $41 per day per individual. Using these values, the total consumer surplus associated with recreational fishing in our study area is an estimated $3.9 to $8.9 million per year.

Thus, the total CS associated with birding and angling in the study area is an estimated $11 to $20 million per year. This value represents primarily use value to birders and anglers and thus largely omits passive use values such as existence, stewardship and bequest values (Stoll et al., 2006). Consequently, it is an underestimate the actual economic net value of the Central Platte river lands.

The total value of birding and angling in the study area is equal to the sum of recreationists' expenditures and their consumer surplus. Based on our estimates, this value is between $23 and $37 million per year (Table 10). Since the consumer surplus estimates for birding and angling are largely unable to capture passive use (existence, stewardship and bequest) values, these estimates likely are underestimates of the actual total economic value associated with birding and angling in the Central Platte BUL.

Table 10: Total annual economic value of fishing and bird watching in the Central Platte BUL

	Total CS		*Total expenditures million 2004$*		*Total economic value*	
	LOW	*HIGH*	*LOW*	*HIGH*	*LOW*	*HIGH*
Bird watching	7.1	11.2	7.8	12.3	15.0	23.4
Angling	3.9	8.9	4.2	4.2	8.1	13.1
Total	11.0	20.1	12.0	16.5	23.0	36.6

Note: Totals may not sum correctly due to rounding.

The Platte river lands also constitute an important statewide habitat for migratory waterfowl and support a variety of hunting opportunities. Unfortunately, the only available information on migratory bird hunting in general and migratory waterfowl hunting in particular is statewide and thus is insufficient to estimate the number of hunting days in the Platte river area, as waterfowl are hunted across much of the state. Most migratory bird hunting was attributable to migratory waterfowl (geese and ducks) as opposed to other migratory birds like mourning doves. In 2001, 63 percent (30,000) and 69 percent (33,000), respectively of all migratory bird hunters surveyed reported hunting geese and ducks, compared to 27 percent (13,000) for doves (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2002). Total migratory bird hunting in Nebraska in 2001 was estimated at 398,000 days for the state as a whole.

In addition to wildlife-associated activities, the habitats along the Central Platter river also support a variety of other recreational activities that generate economic value and output, such as hiking, picnicking, camping, and through their aesthetics add to the benefits people derive from water sport activities along those habitats, such as canoeing or boating. However, we were unable to generate estimates of the number of recreation days for these activities in the study area.

Property value premiums

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).

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 often are comparatively large and enjoy a high level of protection from development, including state parks, forest preserves, and wilderness areas.

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 11 summarizes the findings reported in the literature on how particular study area characteristics influence open space premiums.

Table 11: 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 study area 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 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.[12] They included only those studies that examined open spaces with predominantly

[12] The remainder of the reviewed studies did not provide the required information for their inclusion in the analysis.

natural vegetation, excluding crop lands and heavily-developed urban recreational areas. Their estimated meta-analysis-based regression function has the following form [13]:

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

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. 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 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. [14] For forested, private, or protected open space or for natural area parks, this value is higher, while for agricultural open space it is lower. 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.

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 12.

This model likely overestimates the attenuation of the size of marginal open space premiums that results from large open spaces, for reasons explained in detail in Kroeger et al. (2008). As a result, the model is likely to underestimate premiums in areas with large amounts of open space. However, this is not a concern for the range of open space prevalence found in our Nebraska study area (5-40 percent), which falls within the range observed in the studies we used to estimate our open space premium value model (1-46 percent).

We applied Kroeger et al.'s property value premium function (eq. 1) to estimate the property premiums for properties located in the vicinity of the open space in our study area. We conducted separate analyses for protected private, unprotected private, and protected public lands in the study area, by setting the values of all variables in the function such that they

[13] 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.

[14] $0.4221*10 - 0.0068*(10^2) = 3.5$.

reflect the particular local contexts along the Platte river. We defined open space as undeveloped, relatively undisturbed natural lands that are likely to constitute suitable wildlife habitat, including for sensitive species. As a result, we did not include cropped lands in our analysis. We also generally did not include open spaces in low density residential areas. The only exception to this were some locations where the density of residential structures was very low. In these cases, we used our qualitative judgment to decide whether or not an undeveloped area constituted primarily natural open space.

Table 12: 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 used U.S. Census Bureau (2002) data and maps to partition our study area into subsections and to identify the number of those properties in the Census block groups contained in these subsections that were located within one mile of open spaces in our study area (Table 13). In all cases, the properties in these subsections that we included in our analyses are located within a one-mile radius of the Platte river natural open spaces.

Utilizing Google Earth satellite imagery, we estimated for each property within one mile of Platte river natural lands the percentage of lands within one mile of the property that is in Platte river natural lands. We then scaled our observations up to the block group level, deriving an estimate of the percentage of land within a one-mile radius of the average residential property in each block group that is made up of Platte river natural lands (Table 13). Our decision to truncate the properties included in the analysis at a one-mile distance from Platte river open space is based on two factors. First, the empirical evidence suggests that open space benefits decrease with increasing distance. Second, most studies underlying our property value estimation function analyzed open space impacts within a one-mile radius of a property. 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 13: Location and number of housing units in study area within one mile of natural open space

Location of residences by county and Census subdivision		*Number of housing units*	*Open space as % of area within one mile of average property*
Buffalo Co.	CT 9690, BG 3	23	35
	CT 9690, BG 4	52	35
	CT 9691, BG 2	211	40
Dawson Co.	CT 9680, BG 2	9	5
	CT 9680, BG 3	26	30
	CT 9681, BG 2	18	20
	CT 9684, BG 3	24	15
	CT 9686, BG 1	76	15
	CT 9686, BG 2	5	10
Gosper Co.	CT 9676, BG 1	8	5
Hall Co.	CT 11, BG 3	8	20
	CT 13, BG 1	189	15
	CT 13, BG 2	71	30
	CT 14, BG 2	132	35
Hamilton Co.	CT 9892, BG 1	16	35
	CT 9892, BG 2	50	40
Kearney Co.	CT 9666, BG 1	89	30
	CT 9666, BG 2	46	30
Merrick Co.	CT 9867, BG 3	284	30
	CT 9867, BG 4	10	20
Phelps Co.	CT 9672, BG 1	24	30
	CT 9672, BG 2	26	20

Notes: The number of housing units shown refers only to those units that lie within 1 mile of an open space within our study area. CT – Census tract; BG – block group.
Source: U.S. Census Bureau (2002). Percentage of open space within a one-mile radius of the average property estimated based on satellite imagery.

With the open space percentage (*%OSChange* in eq.1) identified for each subsection of our study area, we set the indicator variables in the property premium function at their appropriate values. Depending on whether a particular open space was a wetland or forested, the *FOR* variable was set to zero or one (1), respectively. The *PRIV* variable was set to one (1) if the space in question was predominantly privately owned, and to zero if it was predominantly publicly owned. For open spaces that were privately-owned and protected, both the *PROT* and *PRIV* variables were set to one. All other variables were set to zero. For block groups in which there were open spaces of different types (for example, protected and unprotected private lands, or riparian woodlands and wetlands), we estimated the property value premiums for each of the various open space types and then averaged the values.

Our analysis indicates that at the block group-level, the average open space premium received by residential properties located within a mile of the Platte river is estimated to range from about two to nine percent (Table 14). The differences in the average premiums are due to differences among the locales in the type of open space (land cover, ownership and protection status) and the proximity of the average property to the Platte river natural lands (which determines the prevalence of open space in the surroundings of the average property in that locale). Combining these premium estimates with information on the number of houses and the median home value in each block group allows us to generate an estimate of the total open space premium received by home owners in the individual block groups and for the Platte river biologically unique landscape as a whole (Table 14).

Table 14: Estimated open space premiums for residential homes located in or adjacent to study area within one mile of natural lands

Census location		*Number of housing units*	*Median home value in 2000 (2004$)*	*Avg. property premium*	
				% of property value	*Total value (million 2004$)*
Buffalo Co.	CT 9690, BG 3	23	$71,785	7.9	$130,000
	CT 9690, BG 4	52	$134,212	7.9	$551,000
	CT 9691, BG 2	211	$106,687	9.3	$2,082,000
Dawson Co.	CT 9680, BG 2	9	$94,136	2.1	$18,000
	CT 9680, BG 3	26	$64,959	6.7	$112,000
	CT 9681, BG 2	18	$110,100	5.9	$116,000
	CT 9684, BG 3	24	$54,940	4.9	$65,000
	CT 9686, BG 1	76	$102,613	3.5	$273,000
	CT 9686, BG 2	5	$90,612	3.7	$17,000
Gosper Co.	CT 9676, BG 1	8	$77,841	2.1	$13,000
Hall Co.	CT 11, BG 3	8	$38,095	5.9	$19,000
	CT 13, BG 1	189	$109,439	7.1	$1,469,000
	CT 13, BG 2	71	$84,557	6.7	$399,000
	CT 14, BG 2	132	$91,934	6.6	$795,000
Hamilton Co.	CT 9892, BG 1	16	$81,804	7.9	$103,000
	CT 9892, BG 2	50	$72,886	7.5	$273,000
Kearney Co.	CT 9666, BG 1	89	$94,246	8.4	$705,000
	CT 9666, BG 2	46	$86,208	8.0	$317,000
Merrick Co.	CT 9867, BG 3	284	$97,659	8.0	$2,219,000
	CT 9867, BG 4	10	$74,758	7.2	$54,000
Phelps Co.	CT 9672, BG 1	24	$120,119	8.0	$231,000
	CT 9672, BG 2	26	$111,641	7.2	$209,000
					$10,169,000

Notes: Column one summarizes properties by census tract only, not by the finer-scale block group level used in the analysis. Number of housing units indicates only units located within one mile of natural area in study area. Median home values shown are weighted values of the respective block groups, not of the specific open space-proximate properties included in our analysis. Total property premiums per block group rounded to the nearest thousand.
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 located within one mile of Platte river natural open spaces in our study area was an estimated $10.2 million dollars (2004$). This value likely is an underestimate of the actual total premium received by homeowners in the study area, for two reasons. First, both the number and the average value of housing units in the area have increased since 2000. Second, many of the natural lands along the Platte river likely also generate premiums for nearby residential properties because of their proximity to water. These premiums are not captured in, and thus are additional to, the open space premiums estimated in our analysis, because our premium estimates are based on an analysis of predominantly terrestrial open space studies. For example, a study of open space premiums in Washington county, Minnesota found that properties commanding a view of water bodies received an extra premium in addition to the "pure" open space premium (Moscovitch, 2007). Thus, to the extent that the natural land cover on properties providing a view of water bodies increases the aesthetic benefits derived from that view, open spaces bordering water bodies generally produce higher value premiums for proximate residential properties than comparable open spaces not bordering water bodies.

The estimated open space premium of over $10 million dollars in 2000 does not represent an annual benefit flow. Rather, it is the total value of the open space premiums captured by the then 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 convert this stock value into its equivalent annual flow. The common approach to doing this is to regard the stock value ($10.2 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 annual interest rate, which is slightly less than the average annual return on certificates of deposit during the last 20 years (1987-2006), the value of the annual payout would be $508,000 (2004$).[15]

These results show that the open space-based property value benefits the natural lands produce for area residents rank among the most important economic benefits generated by the Platte river 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 natural 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 quality, temperature modulation, scenic views) or firms (primarily recreation-related sectors). Other services generate benefits also on a regional or even larger scales (water quality, water generation, 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

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[15] 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 $10.2 million) of the perpetual annuity A, and i is the annual interest rate.

study area. For example, the use value of species enjoyed by humans for recreational purposes is already partially accounted for in our analysis of the recreational value of the study area, in the form of wildlife viewing and fishing 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. In this section, due to the limited scope of the study, we only develop an estimate of the value of the carbon sequestration service provided by the ecosystems in the area. We also assess the water quality benefits of the riparian vegetation in the study area, and develop a rough estimate of the quantity of nitrogen this vegetation removes from agricultural runoff.

Carbon sequestration by natural lands 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).

Of the approximately 421,000 acres of lands in the study area (Table 2), 28 percent or approximately 118,000 acres are in non-agricultural lands (Table 15). These include lands with woody vegetation that are characterized by long-term above- (woody biomass) and belowground (in roots and soil organic matter) carbon storage pools as well as prairies where long-term carbon storage occurs in the soil.

Table 15: Land cover in non-agricultural lands in the study area [16]

Land cover	*ha*
Deciduous Forests and Woodlands	5,195
Juniper Woodlands	980
Sandhills Upland Prairie	2,646
Lowland Tallgrass Prairie	2,810
Little Bluestem-Gramma Mixedgrass Prairie	22,076
Aquatic Bed Wetland	120
Emergent Wetland	3,613
Riparian Shrubland	3,415
Riparian Woodland	6,733

Source: Nebraska GAP land cover data.

These lands absorb atmospheric carbon dioxide during the process of photosynthesis, part of which becomes stored in an increase of perennial plant or soil biomass. An extensive literature search yielded estimates of the annual net carbon fluxes for all types of non-agricultural ecosystems or vegetation communities found in the study area (Table 16). Since none of the studies were carried out in our study area, we selected from these estimates

[16] In addition to the GAP data, U.S. Geological Survey (USGS) 2001 Land cover data are available for the study area (see Appendix Figure A1). Both data sets have a 30 m resolution. However, the GAP data offer a more detailed breakdown of vegetation types.

those that seemed most suitable for our area. For deciduous forests and woodlands, we use the average of the net carbon sequestration estimates for temperate deciduous forests from the studies in the states (Indiana and Wisconsin) closest to and on a similar latitude as Nebraska.

Table 16: Carbon sequestration estimates for ecosystem/vegetation types found in the study area

Ecosystem/vegetation type /species and location	*Measured net C uptake*	*tC/ha/yr*	*Source*
<u>Juniper woodlands</u>			
Western juniper in Southwestern - ID	Aboveground woody biomass	0.07 *	Strand et al. (2008)
Junipers in U.S. Central Plains - KS	Ecosystem	1.60	McKinley (2007)
<u>Deciduous Forests and Woodlands</u>			
Temperate deciduous forest - central MA	Ecosystem	2.24	Goulden et al. (1996)
Temperate deciduous (mixed wood) forest stand - southern Canada	Ecosystem	1.50	Barr et al. (2002)
Temperate mixed hardwood forest (mid-western US - IN)	Ecosystem	2.40	Schmid et al. (2000)
Mixed-deciduous forest (northern lower MI - mixed hardwood-boreal transitional zone)	Ecosystem	2.12	Gough et al. (2008)
North American deciduous forests - TN	Ecosystem	2.64	Curtis et al. (2002)
North American deciduous forests - WI	Ecosystem	1.86	Curtis et al. (2002)
North American deciduous forests - IN	Ecosystem	3.20	Curtis et al. (2002)
North American deciduous forests - MI	Ecosystem	2.12	Curtis et al. (2002)
North American deciduous forests - MA	Ecosystem	1.75	Curtis et al. (2002)
<u>Riparian forest buffers/woodland/shrubland</u>			
Riparian forest buffers - NE; low estimate	Tree biomass	2.17	NE DNR (2001)
Riparian forest buffers - NE; high estimate	Tree biomass	4.34	NE DNR (2001)
Riparian poplar and switchgrass buffer - IA	Aboveground biomass and roots	2.96	Tufekcioglu et al. (2003)
Semi-arid riparian woodland - southwest. US	Ecosystem	2.33	Scott et al. (2006)
Semi-arid riparian shrubland - southwest. US	Ecosystem	2.12	Scott et al. (2006)
<u>Wetlands</u>			
Undisturbed North American prairie wetlands (ND, SD, MN, IA)	Soil	0.83	Euliss et al. (2006)
Freshwater estuarine (river) wetland, OH	Sediment	2.56	Bernal & Mitsch (2008)
Freshwater mineral soil wetlands - North America	Sediment (at landscape scale)	0.17	Bridgham et al. (2006)
<u>Prairie</u>			
Restored grassland - Great Plains	Top 5 cm of soil	0.57	Follet et al. (2001)
8+ yr-old CRP grasslands - WI	Top 5 cm of soil	0.25	Kucharik et al. (2003)
4&5 yr old CRP grassland - WI	Top 5 cm of soil	0.88	Roth (2002)
Previously cultivated grassland 6-60 yrs after cultivation - TX	Top 5 cm of soil	0.45	Potter et al. (1999)
Previously cultivated 4yr old prairie - WI	Top 5 cm of soil	0.72	Kucharik (2007)
Previously cultivated 16yr old prairie - WI	Top 5 cm of soil	0.13	Kucharik (2007)

Notes: * At one (1) ha scale

From the two sequestration estimates available for juniper woodlands, one (Strand et al., 2008) is for a semi-arid region and only measures aboveground carbon sequestration. Therefore, we decided to use McKinley's (2007) estimate for Kansas which is likely to be more appropriate for our study area and measures total ecosystem net carbon storage. For the prairies in our study area, we develop both low and high case estimates. We use Potter et al.'s (1999) estimate of annual net carbon sequestration of Texas prairies as a low case and Follett et al.'s (2001) estimate for restored Great Plains grasslands as an upper bound case.

For riparian shrubland, we use the only carbon net sequestration estimate we could locate in the literature (Scott et al., 2006) which is for a semi-arid southwestern riparian shrubland. For riparian woodland, we use Scott et al. (2006) estimate for a semi-arid southwestern riparian woodland as a low case and the average of low and high estimates of net carbon uptake for riparian forest buffers in Nebraska (Nebraska DNR, 2001) as a high case estimate.

The net contribution of wetlands to atmospheric concentrations of greenhouse gases is still unclear. With the exception of estuarine wetlands, methane emission from wetlands may largely offset benefits from carbon sequestration in soils and plants in terms of climate forcing (Bridgham et al., 2006). We therefore construct a low and high case for wetlands. In the low case we assume that there is no net climate benefit from wetlands as net carbon uptake is fully offset by methane emissions. Of course, wetlands may still qualify for carbon credits in most markets, given that these markets so far do not take into account other greenhouse gases like methane. However, since what we are interested in this analysis are the real economic benefits produced by natural lands, what matters is the net contribution of wetlands to climate change, not the financial income they may generate in the form of carbon credits. In our high case, we assume that the net carbon sequestration rate by wetlands in our study area is that observed by Bernal and Mitsch (2008) for a riverine/estuarine wetland in Ohio.

Table 17: Net sequestration estimates for natural lands in the study area

Land cover	*Net sequestration per ha*		*Total net sequestration*	
	Low	*High*	*Low*	*High*
	tC/ha/yr		*tC/yr*	
Deciduous Forests and Woodlands	2.49	2.49	12,919	12,919
Juniper Woodlands	1.60	1.60	1,568	1,568
Sandhills Upland Prairie	0.45	0.57	1,183	1,508
Lowland Tallgrass Prairie	0.45	0.57	1,256	1,602
Little Bluestem-Gramma Mixedgrass Prairie	0.45	0.57	9,868	12,583
Aquatic Bed Wetland	0	2.56	0	308
Emergent Wetland	0	2.56	0	9,248
Riparian Shrubland	2.12	2.12	7,240	7,240
Riparian Woodland	2.33	3.26	15,687	21,926
TOTAL			49,720	68,902

Note: Estimates of total sequestration are based on areas shown in Table 15.

Based on the available data, we estimate that the natural lands in the study area absorb between 50 thousand and 69 thousand tons net of C per year (Table 17), or between 0.4 and

0.6 tons per acre. This estimate does not include any sequestration by soils or vegetation on agricultural lands.

The value ofcarbon 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, such as coastal inundation or storm surges. Although the potential future impacts of climate change on the U.S. in general or on the Great Plains in particular have been documented (Field et al., 2007; Ojima et al., 2002), 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, and probably is not feasible at this point in time.

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, and the prices of the credits traded on them vary widely. Some of these markets are regulation-driven, and as such they restrict access on both the buyer and seller side.[17] 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. These include the recently created Western Regional Climate Action Initiative, the northeast Regional Greenhouse Gas Initiative (RGGI) and the California Climate Action Registry (CCAR). However, until the reduction targets are set for these markets and the accompanying carbon credit trading begins, it is impossible to predict 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 mandatory and voluntary markets. Depending on the market in question, admissible carbon credits must fulfill a number of conditions with respect to

[17] 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.

verifiability, additionality, permanence and leakage that vary in stringency among the markets. 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 or of avoided loss of vegetation that would result under a business-as-usual scenario. The continued conversion of natural lands in the study area to housing developments and cropland (Schneider et al., 2005) likely would result in the creditability of any carbon sequestration associated with land conservation projects. In any case, the protocols of several existing markets and especially of many of the planned markets are in flux. Here we do not conduct a detailed analysis in order to identify with certainty those markets that currently would accept the credits generated by our study area. Rather, we use prices on those markets that already operate and 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).[18, 19] The average price charged for 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.[20]

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 habitats 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 estimated annual quantity of CO_2 sequestered in our study area, 182 to 253 thousand tons of CO_2e, is equivalent to approximately one percent of the total volume of voluntary transactions in 2006.[21] A sale of the hypothetical credits produced by the ecosystems in our study area therefore would be unlikely to result in a supply shock that would drive down prices. Furthermore, 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.[22]

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[18] 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.

[19] 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.

[20] 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.

[21] 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.

[22] 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).

Applying the low and high prices to the carbon sequestration estimates for our study area (Table 17) yields a total value of the sequestration services estimated at $600 thousand to $3.6 million per year (Table 18).

Table 18: Estimated annual value of carbon sequestration services provided by study area ecosystems

	LOW scenario	*HIGH scenario*
Quantity of C sequestered (metric tons)	49,700	68,900
Corresponding quantity of CO_2 (metric tons)	182,000	253,000
Price per ton of CO_2e (2004$)	3.41	14.21
Value of carbon sequestration (2004$)	622,000	3,590,000

Note: Quantities of carbon dioxide are derived by multiplying the volume of sequestered carbon by 3.667, the ratio of the weight of CO_2 to that of C.

Water quality services provided by undeveloped and restored riparian lands

More than two-thirds of the Central Platte Biologically Unique Landscape (BUL) is used for crop production. Much of the area surrounding the BUL is dominated by crop production as well (see Figures 1 and A1 and Table 2). Of the 42 U.S. river basins and aquifer systems the U.S. Geological Survey's (USGS) National Water-Quality Assessment (NAWQA) Program studied in its second decade of assessments, the Central Nebraska Basin (which includes the Central Platte BUL) is one of the most intensively agricultural areas as determined by the extent of agricultural land and the intensity of estimated pesticide and fertilizer use (Zelt and Frankforter, 2003). The heavy agricultural use of the area has important implications for water quality.

Agricultural practices and their associated surface runoff impact water quality in a number of ways. Runoff of nitrates and phosphorus, the principal components of crop fertilizers, leads to eutrophication[23] in water bodies, destabilizing aquatic ecosystems and potentially affecting water recreation opportunities. In addition, nitrate is a contaminant of concern in drinking water (Mayer et al., 2005). Likewise, runoff of pesticides, sediments and animal waste can also lead to the degradation of public water supplies and aquatic habitats (Dosskey et al., 1997).

Between 1992 and 1995, NAWQA assessed the water quality of the Central Platte Basins and identified a number of concerns for both surface water and ground water. Many of these water quality problems appeared to be caused by agricultural practices in the region. The study found that areas of intense agricultural activity showed high nitrate levels in certain wells and, to a lesser degree, in certain streams, thus impacting the quality of public drinking water supplies (Frenzel et al., 1998). In fact, nitrate concentrations in ground water often were found to exceed the U.S. Environmental Protection Agency's (U.S. EPA) drinking-water Maximum Contaminant Levels (MCLs) in the Platte Valley. Pesticide (alachlor,

[23] Eutrophication is the process that occurs when the presence of artificial nutrients, such as phosphorus and nitrogen, leads to excessive growth of certain plants (such as algal blooms) in water bodies. When these plants decompose, the oxygen level in the water body gets depleted, killing off other aquatic organisms and changing the dynamic of the entire ecosystem (USGS, 2008)

atrazine, cyanazine, and metolachlor) levels in heavily agricultural areas were also significantly higher and for some pesticides were found to potentially exceed MCLs in storm runoff (ibid.).

The Platte River alluvial aquifer is a primary source of Nebraska's drinking water, including water for large cities such as Omaha, Lincoln, Grand Island, and Kearney. Because the aquifer is shallow and the soil in the area is permeable, ground water is vulnerable to infiltration of agricultural runoff (Parnell, 2000). Ground water is also vulnerable because of the hydraulic connections between the surface water of the Platte River and the underlying aquifers. According to Frenzel et al. (1998), the aquifer is affected noticeably by the quantity and quality of water in the Platte river. As a result, agricultural runoff into the river does not only affect water quality in the river but also water quality in the aquifers. The researchers also found that increased ground water withdrawals could lead to increased surface water infiltration, thereby making ground water quality more vulnerable to pollution from surface water (Frenzel et al., 1998).

In addition to public water quality concerns, the NAWQA also found that the high levels of agricultural chemicals found in the water in areas of intense row crop production resulted in degraded aquatic habitats and changes in the composition of fish communities (Frenzel et al., 1998).

Although water quality thus clearly is a concern in the study area, the situation likely would be worse were it not for the positive impacts of vegetation on undeveloped lands along the Platte river. This riparian vegetation functions as a buffer that takes up part of the agricultural runoff and the nutrients dissolved in this runoff, thus preventing them from entering adjacent water bodies.

The Central Platte BUL contains approximately 25,000 acres of riparian shrublands and woodlands, 15,000 acres of other forests and woodlands, 68,000 acres of prairie, and 9,000 acres of wetlands (Table 15). A large share of these lands is located between cropped areas and the Platte River and thus serves as a natural riparian buffer.

McCullough et al. (2002) assessed the benefits of riparian buffers in the Blue River Basin of Nebraska and Kansas, located southeast of the Central Platte BUL. Riparian buffers in the basin, which like the Central Platte area is heavily agricultural, were found to reduce pesticide and nutrient levels in water and to reduce soil erosion, which clogs ditches and transportation waterways and necessitates costly and destructive dredging (ibid.).

Another study (Franti et al., 2004) examined the effects of grassland buffers on the levels of total suspended solids (TSS), phosphorus and the herbicide atrazine in Nebraska's Clear Creek Watershed, a tributary of the Platte River located northeast of the Central Platte BUL. Grassland buffers were found to reduce levels of TSS, phosphorus and atrazine by 14 percent, 17 percent and 27 percent, respectively.[24] Given that atrazine has been identified as

[24] These reductions represent the marginal impacts of grassland buffers. Combined with the other conservation practices applied in the study area, such as riparian forest buffers, conservation tillage, crop rotation, and terraces, grassland buffers led to estimated total reductions of 97 percent for TSS, 96 percent for phosphorus, and 57 percent for atrazine (Franti et al., 2004).

the pesticide most likely to exceed EPA Maximum Contaminant Levels (MCLs) after rainfall at the Platte River test site downstream of the Central Platte BUL and at the Clear Creek Watershed, and given that conventional water treatment is ineffective in removing it from the public water supply (Frenzel et al., 1998), grassland buffers perform an important public and ecological health function by reducing the quantities of atrazine that enter water bodies in the first place.

A comprehensive review of the literature examining the filtration by riparian buffers of nitrogen from agricultural runoff showed that such buffers reduce the nitrogen loading of surface and groundwaters (Mayer et al., 2005). Specifically, a study of riparian buffers in a heavily agricultural area in central Iowa found that riparian buffers immobilized nitrogen in biomass at a rate of 16-37 kg/ha/yr , thus preventing the loss of these quantities of nitrogen to the atmosphere and to ground and surface waters (Tufekcioglu et al., 2003).

High nitrogen concentrations are an environmental concern because they cause eutrophication. They also are a public health concern.[25] Both of these concerns are present in the Central Nebraska Basin, as indicated by the fact that in two areas of intensive crop production, 25 and 45 percent of wells sampled in the mid-1990s had nitrate levels that exceeded the EPA's Maximum Contaminant Levels for drinking water (Frenzel et al., 1998). Using Tufekcioglu et al.'s (2003) nitrogen uptake rates, a 100-foot wide strip of riparian vegetation along both sides of the 108 mile-long stretch of the Platte river in our study area would be estimated to absorb a total of between 17 and 39 tons of nitrogen per year from agricultural runoff, much of which would otherwise enter the river.

In addition to filtering out herbicides, pesticides and nitrogen, riparian buffers also trap sediment contained in agricultural runoff. A study of riparian buffers in Nebraska's Clear Creek Watershed (located northeast of the Central Platte BUL) found that the analyzed buffers trapped an average of 80 percent of the runoff sediment (Helmers et al., 2005). Agricultural runoff is a prime source of suspended solids in surface waters. These suspended particles damage aquatic ecosystems by increasing water temperature which in turn reduces the amount of oxygen available for aquatic life (North Dakota Department of Health, 2005).

This rough assessment nevertheless indicates that the riparian vegetation in the Central Platte area performs important water quality functions. However, the economic valuation of the nutrient and toxin absorption and aquatic particulate reduction services provided by these lands is beyond the scope of this analysis. Such a valuation would need to incorporate dose-response relationships between particular toxins and other pollutants and specific affected health endpoints, the willingness to pay of affected individuals for a reduced likelihood or severity of those health effects, as well as the costs of avoiding these damages through alternative means of pollution reduction, such as constructed (treatment) wetlands or additional/enlarged public water supply filtration plants or additional treatment stages.

An alternative approach that would use information on payments to landowners from government programs aimed at reducing negative water quality impacts from farming is not likely to yield reliable estimates of the economic value of the water quality service provided

[25] Nitrate is particularly harmful to infants as it can prevent oxygen uptake, potentially leading to brain damage or death (Mayer et al., 2005).

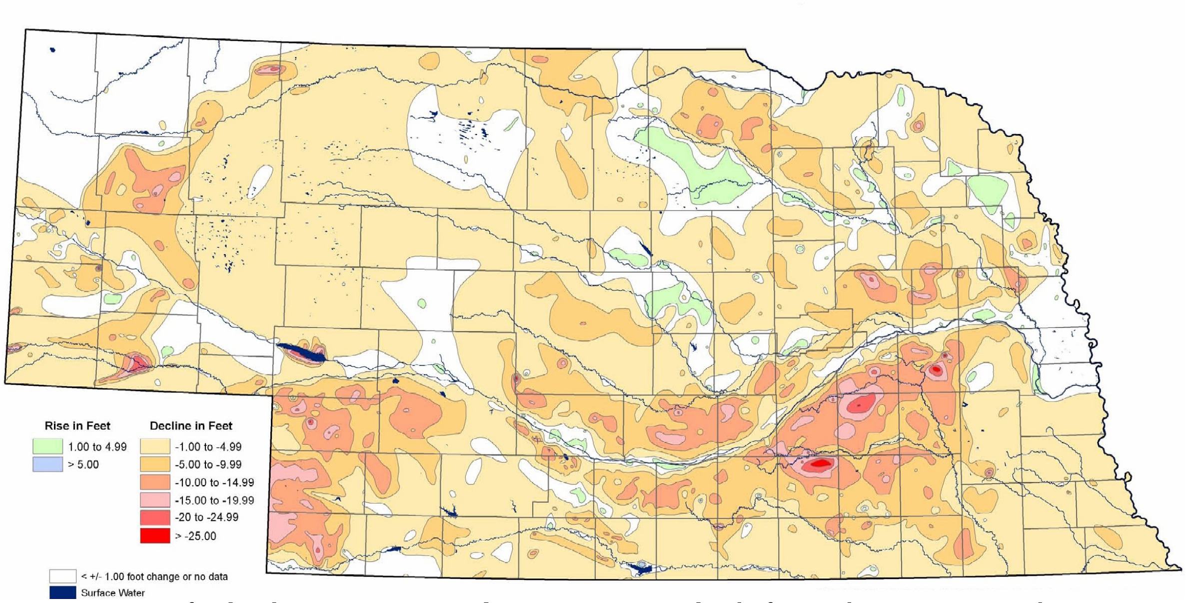
by natural lands. The primary reason for this is that payments from these programs generally are input-based instead of output-based and thus are not tied to specific effluent reductions (Kroeger and Casey, 2007).

While in this section we have limited our focus on the benefits riparian buffers provide for water quality, these buffers can provide additional services besides the filtration of agricultural runoff. For example, they can help control the erosion of river banks, reduce flood damage to agricultural land, roadways and residential areas, and provide habitat for predators of crop pests (University of Nebraska, 2002). Thus, the natural lands along the Central Platte clearly provide valuable ecosystem services that reduce health and material damages and thereby enhance the well-being of local residents.

Water provision by ecosystems along the Middle Platte river

In addition to providing habitat for wildlife and supporting associated human recreational uses, the Middle Platte river also is an important source of irrigation water for agriculture. Withdrawals from the Middle Platte provide surface irrigation for 225,000 acres in south central Nebraska (Jenkins, 1999). However, most of this water does not originate within our study area; rather, it simply flows through the area. Thus we do not consider the stream flow as a benefit generated by the study area. The situation is somewhat different when it comes to the area's groundwater supply.

Groundwater supplies about 80 percent of the state's public drinking water and nearly 100 percent of its private water (Ground Water Protection Council, 1999). Natural lands in the Middle Platte River area provide groundwater recharge services by allowing the infiltration of rainwater into aquifers. This is shown in Figure 3, which indicates changes in Nebraska's groundwater levels between 2000 and the spring of 2007. While groundwater levels have been falling during that period in most areas of the state, as shown by the beige, orange and red-shaded areas, levels have risen or remained unchanged along the Middle Platte river channel. Although currently no shortages of groundwater are foreseen at the state-level for the near term (Institute of Agriculture and Natural Resources, 2007), the recharge services provided by the undeveloped lands do have economic value. This value is equivalent to the cost savings for municipalities and individuals along the Middle Platte from being able to postpone the construction and related costs associated with digging deeper irrigation and drinking water wells. However, it is beyond the scope of this analysis to attempt to quantify these savings.



Source: University of Nebraska, Conservation and Survey Division, School of Natural Resources. Lincoln, Nebraska. September 2007. http://snr5.unl.edu/csd-esic/GWMapArchives/2007GWMaps/Spring2000-2007.pdf

Figure 3: Groundwater-level changes in Nebraska – Spring 2000 to Spring 2007

Local and Statewide Economic Impacts of Undeveloped Lands

In this section we develop estimates of the economic impacts associated with human uses of the natural lands in the study area.

Economic impacts of trip expenditures by recreation visitors

The estimates of recreation visitors' trip expenditures only represent the first round of economic effects 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 ratio of initial, first-round sales impacts and final, total impacts is represented by multipliers. These multipliers are derived from regional economic impact models based on empirical data on the interrelations between all sectors in the economy.[26]

To estimate the total output impacts that recreation trip expenditures in the study area generate in the Central Platte area and the state as a whole, we use a total output multiplier for the Central Platte area of 1.9 and for Nebraska of 2.7 (Jenkins, 1999; Jenkins and Konecny, 1999). To assess the job and earnings impacts at the state level that results from the recreation spending in the study area, we use earnings and job multipliers reported for wildlife watching (U.S. FWS, 2003) and freshwater fishing (Southwick Associates, 2008).

In 2001, trip expenditures by anglers and wildlife viewers in the Central Platte area totaled an estimated $12 to 16.5 million (Tables 7 and 8). An estimated 71 percent of these recreationists' expenditures occurred in the local (Central Platte) area (Stoll et al., 2006). Assuming capture rates of 60 percent for the study area and 70 percent for the state as a whole and applying published impact multipliers (Table 19), angling and birding in the Central Platte area generated an estimated $9.7 to $13.3 million in total final output in the study area (Table 20).[27] At the state level, Central Platte birding and angling generated total

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

[27] The capture rate is the share of total direct spending that stays within the economy for which impacts are estimated. For example, of each dollar spent on gasoline in the Central Platte area, only a small share, namely, the retail margin, stays in, or is "captured" by. the local economy. The rest leaves, or "leaks out" of, the study area because it is transferred to the refineries from which the local retailers buy their supplies. The capture rate varies based on the size and diversity of the economy of an area, and based on the degree to which the local economy is interconnected with the larger state and national economies. The capture rate is high (approaching one [1]) for locally produced goods and services such as local produce, lodging or restaurants and low for goods that require many imported inputs (i.e., goods or services that need to be obtained from outside of the economy in question). The capture rate is equivalent to one (1) minus the leakage rate.

sales estimated at $22.7 to $31.1 million, supported 276 to 387 jobs and resulted in $6.5 to $8.9 million in earnings (salaries, wages, and business earnings).

Table 19: Economic multipliers used in study area impact estimates

Multiplier Type	*Impact region*	
	Central Platte	*Nebraska*
Total output - wildlife-associated recreation *(final output/direct effect)*	1.9	2.7
Employment *(jobs/1,000 $ final output)*		
- wildlife viewing	n.e.	0.013
- fishing	n.e.	0.010
Earnings *(earnings/final output)*		
- wildlife viewing	n.e.	0.28
- fishing	n.e.	0.30

Note: n.e. – not estimated.
Sources: Total effects multipliers: Jenkins (1999), Jenkins and Konecny (1999); Wildlife viewing: U.S. FWS, 2003; Fishing: Southwick Associates (2008).

It is difficult to estimate the portion of these economic impacts that would leave the study area or the state were it not for the Central Platte natural lands found in our study area. To the extent that the money spent in the Central Platte by anglers and birders, both by area residents and visitors from other areas of the state and from out-of-state, would still be spent in the area or the state, the economic impacts of this spending cannot be attributed to the Central Platte natural lands. For example, if the study area natural lands did not exist, area residents as well as visitors might frequent substitute recreation sites in the area, or they might spend the money currently spent on wildlife-associated recreation on other activities within the area. The quality of the recreation experience in the Central Platte is unique in the Central Platte area and perhaps even at the state and regional levels, due in part to the Sandhill crane spring migration; in the absence of such a unique site, many recreationists might very well decide to visit other areas in the state or the region. Thus, one could plausibly argue that the economic impacts presented above are attributable largely or perhaps entirely to the Central Platte natural lands.

Table 20: Estimated economic impacts of angling and birding on Central Platte natural lands in 2004

	Impacts			
	Central Platte		*Nebraska*	
	Low est.	*High est.*	*Low est.*	*High est.*
Total output *(million 2004$)*	9.7	13.3	22.7	31.1
Employment *(jobs)*	n.e.	n.e.	276	387
Earnings *(million 2004$)*	n.e.	n.e.	6.5	8.9

Note: n.e. – not estimated.

Nevertheless, in the interest of generating conservative impact estimates, let us assume that if the Central Platte natural lands did not exist, at least Central Platte residents would still engage in wildlife-associated recreation activities in the area or would divert their current recreation-related expenditures to other activities in the area. In this case, only spending by residents from other areas of the state and from out-of-state visitors could be said to be attributable to the natural lands in the study area.[28] In this case, the total output impact in the Central Platte area attributable to the study area natural lands would be reduced to $6.8 to $8.8 million per year. Similarly, one might assume that Nebraskans as a whole would still engage in recreation activities in the state or would spend their money otherwise in the state if the Central Platte recreation activities did not exist. In this case, from the perspective of the state as a whole, only impacts associated with spending by out-of-state visitors would be lost were it not for the Central Platte natural lands. If this were the case, the state-level impacts attributable to the Central Platte natural lands would shrink to $6.9 to $10.4 million in total output and $1.9 to $2.9 million in total earnings per year, and 89 to 135 jobs (Table 21).

Table 21: Estimated economic impacts from spending by out-of-area anglers and birders in Central Platte natural lands in 2004

	Impacts			
	Central Platte [1]		*Nebraska* [2]	
	Low est.	*High est.*	*Low est.*	*High est.*
Total output *(million 2004$)*	6.8	8.8	6.9	10.4
Employment *(jobs)*	n.e.	n.e.	89	135
Earnings *(million 2004$)*	n.e.	n.e.	1.9	2.9

Notes: n.e. – not estimated. [1] Impacts in Central Platte area from spending by visitors from other areas of the state and by visitors from out-of-state. [2] Impacts on Nebraska from spending by out-of-state visitors only.

The impacts shown in Tables 19 and 20 are upper and lower-bound cases. The actual impacts attributable to birding and angling in the study area likely fall in between the estimates presented in these tables. However, the full economic impacts generated by natural lands in the Central Platte area are larger than those suggested in the tables because the impact estimates presented here do not include any spending and resulting economic impacts that are associated with hunting or with recreational activities in the study area that are not associated with wildlife, such as hiking, camping, picnicking or boating, which we were unable to include in our analysis due to a lack of data on the levels of these activities that occur in the study area.

[28] Stoll et al.'s (2006) survey revealed that an estimated 27 percent of Central Platte birders resided in the Middle Platte Rural Statistical Area (RSA), while 21 percent visited from other areas of the state. The remaining visitors were from out-of-state.

Conclusion

Undeveloped lands support a variety of human activities. These activities carry associated economic values because they contribute to individuals' well-being. Some of these values are at least partially reflected in markets, either because the nature-based activity (e.g., wildlife viewing or 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 they are available, published estimates of non-market values to develop comprehensive value estimates for several activities supported by undeveloped lands in a 658 square-mile area in south-central Nebraska. This area is largely composed of land identified as being of high or very high ecological value. 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 angling and bird watching practiced in the area by local residents and visitors; and the value of carbon sequestration services provided by the undeveloped lands in the area. We also generate an estimate of the water quality services provided by riparian vegetation along the Platte river, which removes substantial amounts of nitrogen from agricultural runoff and thus prevents them from entering surface and groundwaters. The lands in question provide a number of additional uses, such as support for educational and research activities, habitat provision for threatened, endangered, rare or "charismatic" species like the river otter, bald eagle and Whooping and Sandhill cranes, among others. We did not include these uses in our analysis for lack of the required data. In addition, our value estimates for the activities or ecosystem services we do include generally are rather conservative as available data are almost certain to be underestimates. For example, our estimates of the value of outdoor recreation activities in the study area are limited to recreational fishing and birdwatching, and thus exclude the value of hunting and not wildlife-associated recreation activities.

Despite the resulting unavoidable downward biases in our value estimates, 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 $24 million to $41 million, depending on the prices used to value carbon sequestration, the net greenhouse gas balance of wetlands, and the estimates of the number of recreationists visiting the study area (Table 22). It should be noted that the higher estimate is very far from being an upper bound on the values generated by the lands, because even this higher estimate is based on carbon credit prices that do not represent the high end of the price range. In addition, these figures do not include the value of the estimated roughly 17-39 tons of nitrogen as well as significant reductions in pesticides from agricultural runoff that are removed annually by riparian vegetation and prevented from entering surface and groundwaters, nor do they include the value of hunting and of recreational activities not associated with wildlife. Also, due to frequent changes in carbon prices, our estimates should be seen as approximations to the actual values, not as accurate measurements of those values.[29]

Table 22: Annual value of selected uses of undeveloped lands in study area

	Low estimate	*High estimate*
	million 2004$ per year	
Open space property value premiums	0.5	0.5
Recreation	23.0	36.6
Ecosystem services:		
Carbon sequestration	0.6	3.6
TOTAL	24.2	40.7

Note: The value of open space property price premiums shown in the table is the annual benefit flow (see p. 23)

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 or provision of habitat for species that carry existence value for people, and due to the downward bias in our recreation value estimates, the actual economic value of the undeveloped lands is likely to be considerably higher than indicated by our estimates.

The activities supported by the lands in the study area also generate large sales, income and employment impacts in the Central Platte area and in the state as a whole. Angling and wildlife viewing alone are estimated to generate between $9.7 and $13.3 million annually in total final output in the Central Platte area. At the state level, Central Platte birding and angling generated total sales estimated at $22.7 to $31.1 million, supported 276 to 387 jobs and resulted in $6.5 to $8.9 million in earnings (salaries, wages, and business earnings). These impacts in turn generate substantial local, state and federal tax revenues.

[29] 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 tCO_2e, as the upper bound.

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.[30] Land use 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. Since a large share of both ecologically and economically valuable undeveloped lands is in private ownership, not just in our Nebraska study area but also at state and national levels, 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.

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

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Appendix

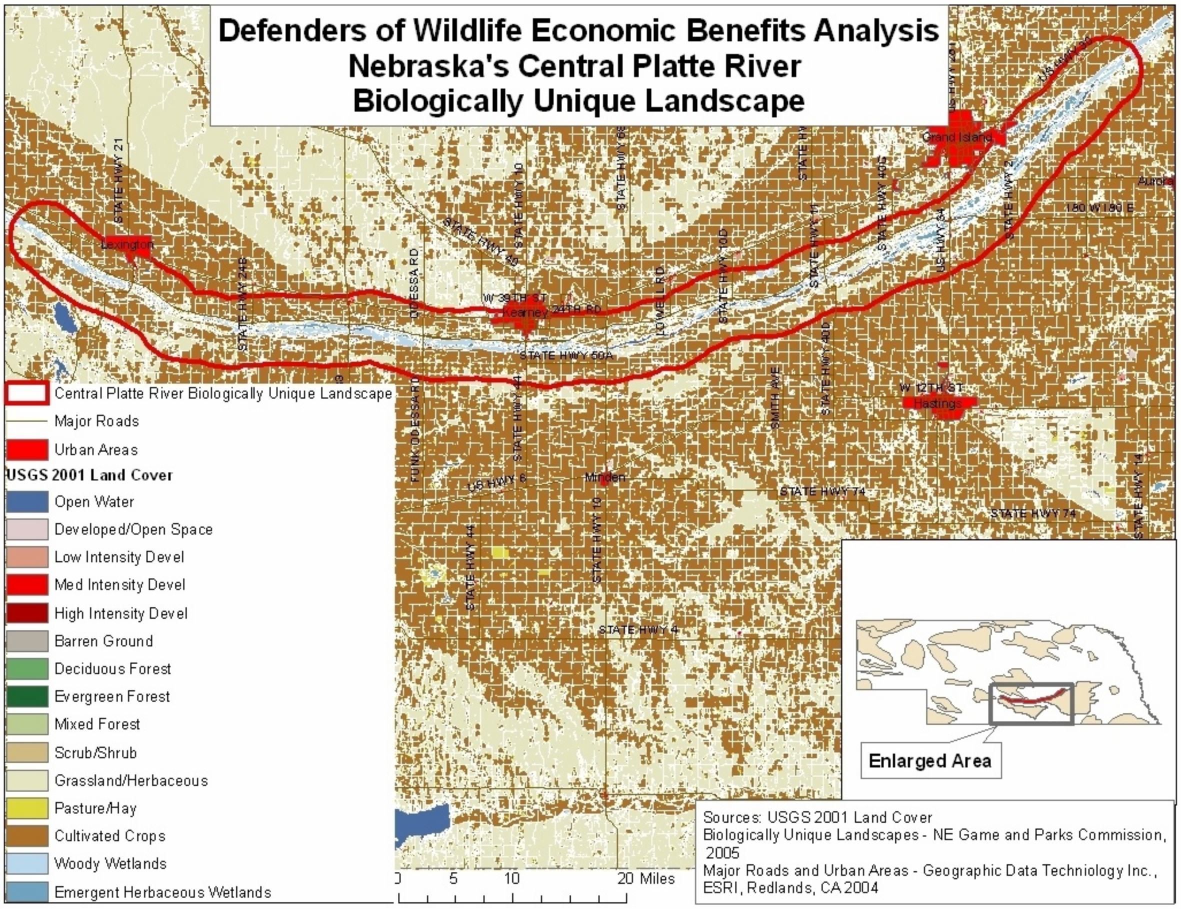

Figure A1: Land cover in the study area (USGS 2001)