OPEN SPACE BENEFITS IN THE CITY OF EL PASO

August 2016

EARTH ECONOMICS

Earth Economics

www.eartheconomics.org

info@eartheconomics.org

Report Version 1.1

Primary Authors:
Matt Chadsey, Program Director, Earth Economics
Peter Casey, Research Lead, Earth Economics

Year: 2016

Suggested Citation:
Chadsey, M., Casey, P., 2016. Open Space Benefits in the City of El Paso.
Earth Economics, Tacoma, WA.

Acknowledgements: Thanks to all who supported this project:

100 Resilient Cities Initiative for connecting Earth Economics with the City of El Paso via its Platform Partner Program

Funding from the Kresge Foundation

City of El Paso: Nicole Ferrini - Chief Resilience Officer, Lauren Baldwin – Sustainability Program Specialist, Javier Jaime - GIS Analyst

Earth Economics: Zachary Christin (research), Rowan Schmidt (research), Jessica Hanson (editor)

We would also like to thank Earth Economics' Board of Directors for their continued guidance and support: Alex Bernhardt, David Cosman, Elizabeth Hendrix, Greg Forge, Ingrid Rasch, Joshua Farley, Molly Seaverns, and Sherry Richardson.

The authors are responsible for the content of this report.

Cover Photo: Flickr Commons – Hector E. Balcazar

Executive Summary

El Paso's abundant natural capital is a critical part of the regional ecosystem and the economy. The shrublands surrounding the Franklin Mountains support rich biodiversity, capture water for the Hueco Bolson aquifer, and provide many other ecosystem benefits, from erosion control to moderation of flood events. El Paso's natural capital also provides direct benefits to local residents, including increased property values and improved health via recreation. All of these benefits are called **ecosystem services**, and they represent significant, long-term contributions to the local economy. This is the first study to estimate the dollar value associated with these critical ecosystem services within El Paso.

Across the country, planners and policy makers are starting to include the value of natural capital assets (watersheds, forests, shrublands) and ecosystem services in their analyses. Though the techniques to identify, quantify, and monetize these economic contributions are still evolving, the values available today can immediately be used to gain a better understanding of the **symbiotic relationship between a healthy environment, a resilient economy, and a thriving community**. Including these values in planning and policy-making yields a more complete and accurate understanding of restoration and stewardship projects or policies and ultimately fosters more practical, cost-effective outcomes.

Natural capital within the study area contributes $3.4 million to $6.7 million in ecosystem service benefits each year.

This analysis finds that the natural capital within the study area contributes **$3.4 million to $6.7 million in ecosystem service benefits *each year***. El Paso's shrubland can also be viewed as a natural capital asset that provides a flow of benefits over time, similar to a building or a bridge. When measured like an asset with a lifespan of 100 years and a three percent discount rate, **El Paso's natural capital has an asset value between $107 million and $211 million**. With sufficient stewardship to maintain the health and function of El Paso's natural capital, this economic contribution will continue in perpetuity. These are highly conservative estimates that will grow as more detailed data becomes available and economic methods are developed.

EARTH ECONOMICS

Introduction

For many years, our natural capital (watersheds, forests, shrublands) has been treated very differently than our built assets. While constructing roads, bridges, and water conveyance systems is nearly always discussed as a vital investment with significant benefits to the economy, dollars allocated to ecosystem restoration and stewardship are often considered as costs or lost opportunities to be minimized. One reason for this disconnect is that, until relatively recently, it has not been cost-effective to identify and monetize the benefits that people receive from nature (ecosystem services). Advances in ecological economics and a rapidly growing cache of primary academic research on the value of natural systems and functions has facilitated more reliable estimates of nature’s value. These values can now be combined with traditional economic data to conduct important financial analyses such as benefit-cost or return on investment calculations.

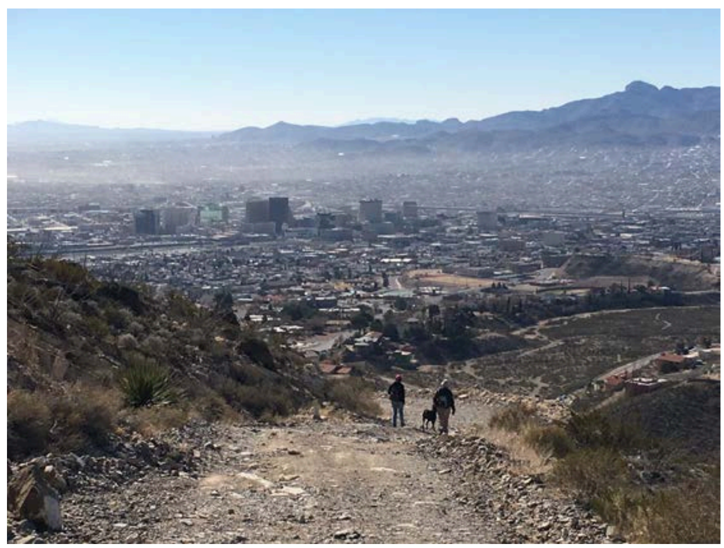
When ecosystem services are lost, communities pay. Loss of natural flood protection, wildlife habitat, and clean drinking water often requires that communities build facilities to replace lost ecosystem services. Shrublands, riparian buffers, and wetlands all provide flood protection. These ecosystems are able to slow, absorb, and store large amounts of rainwater and runoff during storms. Changes in land use and the potential for more frequent storm events due to climate change make **mitigation of extreme events one of the most important services for economic development.** Built structures in the floodplain such as houses, businesses, and wastewater treatment plants all depend on the flood protection services provided upstream. Retaining natural, permeable cover and restoring natural features contributes to flood risk reduction in these areas. Enhanced flood and storm protection can reduce the devastating effects of floods, including property damage, lost work time, and human casualties. Real ongoing costs are incurred by the community and taxpayers to replace services that nature previously provided for free.

Real ongoing costs are incurred by the community and taxpayers to replace services that nature previously provided for free.

Site Overview

El Paso is located in the corner of west Texas between New Mexico and Mexico (Figure 1 and Figure 2). The city has a rapidly growing population of 680,000 residents that is expected to increase to 1.1 million by 2040.[1,2,3] The City of El Paso has been selected to participate in the 100 Resilient Cities (100RC) Initiative, which helps participating cities build resilience and mitigate future shocks and stresses.[4] El Paso's challenges include drought, flooding, economic stagnation, aging / failed infrastructure, rapid urban sprawl and pronounced poverty and inequality. Over the coming years, El Paso will work with local stakeholders and 100RC partners to design solutions to these challenges.

The area evaluated in this report includes a series of parcels owned by the El Paso Public Service Board (PSB) that total 7,756 acres (7,711 which provide ecosystem services) to the east and west of the Franklin Mountains, all within an hour to the north of downtown El Paso. The study area is near Franklin Mountains State Park (27,000 acres), the largest urban park in the nation.[5] Also of interest is the neighboring Castner Range (7,081 acres), a U.S. Army-owned area which is currently being petitioned to be converted into a National Monument to preserve the nearly pristine ecosystems within the protected area.[6]



The Franklin Mountains and surrounding open space provide opportunities for hiking, mountain biking, and rock climbing. The region is also a popular destination for birdwatchers as it provides extensive habitat for birds, including a variety of endangered and threatened species such as the southwestern willow flycatcher and the white-faced ibis.[7] The study area also sits atop the Hueco Bolson aquifer, which provides a third of El Paso's water supply.[8]

EARTH ECONOMICS

Figure 1 - El Paso / Franklin Mountain Region (Google Maps)

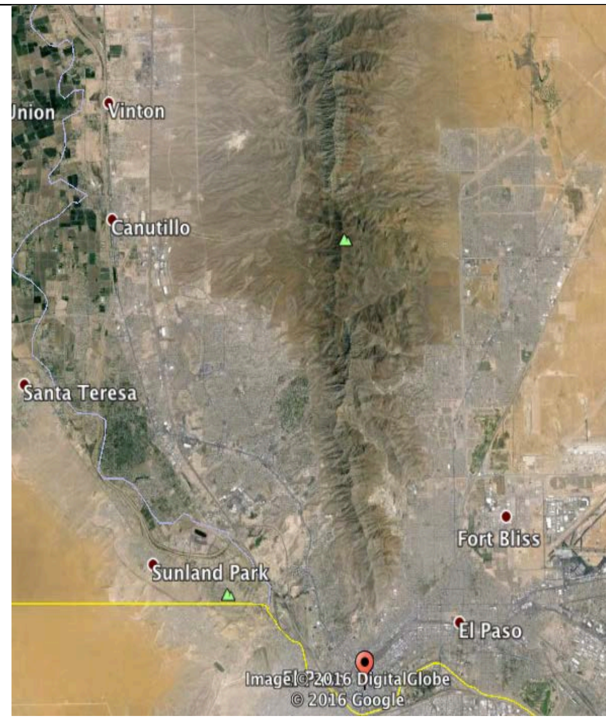


Figure 2. El Paso / Franklin Mountain Region (Google Earth)

Study Objectives

The ***Open Space Benefits in the City of El Paso*** study was conducted by Earth Economics, a 100 Resilient Cities Platform Partner, in collaboration with the City of El Paso. The study's purpose was to estimate natural capital and ecosystem service values in parcels of publicly held land to better inform preservation and development decisions. The study also provides a conceptual model for how El Paso's open space and economy are connected.

Valuation Approach

The study involved four major steps:

Step 1. Identification and Quantification of Land Cover Classes: Geographic Information Systems (GIS) data, including the National Land Cover Database (NLCD-2011), was used to calculate the number of acres of each land cover type (e.g. shrubland, grassland, and developed open space) within the study area.

Step 2. Identification and Valuation of Ecosystem Services: The value of each ecosystem service/land cover combination (e.g. water storage/shrubland) was estimated using the benefit transfer method (described in detail below) to find and apply appropriate values. In many cases, low and high values are provided if included in the original study. In cases where no published studies were available for a particular ecosystem service/land cover combination, no value is provided in this report.

Step 3. Annual Value of Ecosystem Services: The total high and total low annual values of ecosystem services for a particular land cover class were multiplied by the acreage of that land cover class found in the study area to calculate total annual values. The total high and low values of all land cover classes were then summed to generate a total annual value that represents the annual contribution of these lands to the local economy.

Step 4. Net Present Value Calculations: Net present values were calculated for the study site over 100 years at two discount rates: zero percent and three percent. The net present value calculation and application of a discount rate allows benefits accrued over many years to be compared in current dollars.

Ecosystem Services Framework and Valuation Methods

Like other forms of capital, natural capital provides a flow of goods and services. Ecosystem goods and services are the benefits that nature provides to people. These benefits are the basis of all economic activity as they provide a clean water supply, breathable air, nourishing food, flood risk reduction, waste treatment, and a stable climate. Without natural capital, many of the services (benefits) that we generally take for granted (and receive for free) could not exist, or would need to be replaced at a very high cost. Figure 3 illustrates the relationship between natural capital assets, ecosystem functions, and the production of ecosystem goods and services. The natural capital assets in a watershed serve many functions. A watershed collects, stores, and transports water that ultimately provides people with a valuable water supply benefit.

EARTH ECONOMICS

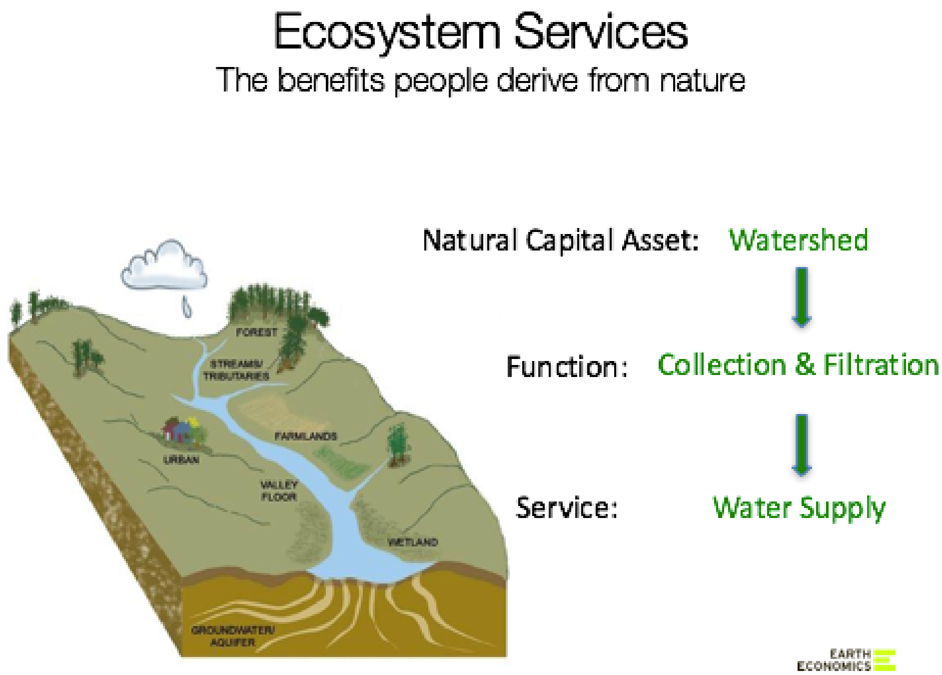


Figure 3 - Ecosystem Services Example

Some of these ecosystem services can be valued in dollars when economists and ecologists work together to identify the presence, quantity, and economic value of a service in a particular location. A variety of valuation techniques can be employed depending on the specific circumstances, including:

- **Market Pricing**: The current market value of items produced in the ecosystem (e.g., cattle feed from rangeland).
- **Replacement Cost**: The cost of replacing a functioning natural system with man-made infrastructure (e.g. natural water filtration versus a water treatment plant).
- **Avoided Cost**: Services allow society to avoid costs that would have been incurred in the absence of those services (e.g. reduction in flood damage due to natural water storage and flood mitigation provided by wetlands and riparian buffers).
- **Production Approaches**: Services that enhance incomes (e.g. productivity of crops after irrigation in agricultural systems).
- **Travel Cost**: Service demands may require travel, which have costs that can reflect the implied value of the service; a recreation area can be valued at least by what visitors are willing to pay to travel to it, including the imputed value of their time (e.g. tourists traveling long distances to visit to cycle or mountain bike in and around El Paso and the Franklin Mountains).

- **Hedonic Pricing**: The change in property value by virtue of being within proximity of a service (e.g., a beautiful grassland or a mountain view typically increases the value of neighboring homes).
- **Contingent Valuation**: Value estimates based on surveys of individual preferences and the value assigned to activities (e.g., people's willingness to pay to protect watersheds).

Valuation of some ecosystem services can be quite straightforward using these methods, while others are still lacking accepted methodology and can only be described subjectively. The service descriptions and categorizations used in this report, shown in Table 1, were derived from work by DeGroot et al. (2002) and Sukhdev et al. (2010). [9,10]

Table 1 - Ecosystem Services Definitions

Provisioning Services	
Food	Producing crops, fish, game, and fruits
Medicinal Resources	Providing traditional medicines, pharmaceuticals, and assay organisms
Ornamental Resources	Providing resources for clothing, jewelry, handicraft, worship, and decoration
Energy and Raw Materials	Providing fuel, fiber, fertilizer, minerals, and energy
Water Supply	Provisioning of surface and groundwater for drinking water, irrigation, and industrial use
Regulating Services	
Biological Control	Providing pest and disease control
Climate Stability	Supporting a stable climate at global and local levels through carbon sequestration and other processes
Air Quality	Providing clean, breathable air
Moderation of Extreme Events	Preventing and mitigating natural hazards such as floods, hurricanes, fires, and droughts
Pollination	Pollination of wild and domestic plant species
Soil Formation	Creating soils for agricultural and ecosystems integrity; maintenance of soil fertility
Soil Retention	Retaining arable land, slope stability, and coastal integrity
Waste Treatment	Improving soil, water, and decomposing human and animal waste and removing pollutants
Water Regulation	Providing natural irrigation, drainage, groundwater recharge, river flows, and navigation
Supporting Services	
Habitat and Nursery	Maintaining genetic and biological diversity, the basis for most other ecosystem functions; promoting growth
Genetic Resources	Improving crop and livestock resistance to pathogens and pests
Cultural Services	
Natural Beauty	Enjoying and appreciating the scenery, sounds, and smells of nature
Cultural and Artistic Inspiration	Using nature as motifs in art, film, folklore, books, cultural symbols, architecture, and media
Recreation and Tourism	Experiencing the natural world and enjoying outdoor activities
Science and Education	Using natural systems for education and scientific research
Spiritual and Historical	Using nature for religious and spiritual purposes

Benefit Transfer Method

The benefit transfer method (BTM) is broadly defined as "...the use of existing data or information in settings other than for what it was originally collected".[11] This method is used to indirectly estimate the value of ecological goods or services, especially as it can generate reasonable ecosystem services estimates quickly and at a fraction of the cost of conducting local, primary studies, which may require more than $50,000 per service/land cover combination. BTM plays an important role in the field of ecosystem services valuation, as it is often the most practical option available for producing reasonable estimates.[12]

The BTM process involves taking ecosystem service values from comparable ecosystems as found in peer-reviewed journals and transferring them to a study site, in this case, the open space bordering El Paso's Franklin Mountains. [13] The BTM process is similar to a home appraisal, in which the value and features of comparable, neighboring homes (two bedrooms, a garage, one acre, recently remodeled) are used to estimate the value of another home. As with home appraisals, BTM results can be somewhat rough, yet the process quickly generates reasonable values appropriate for policy and project analysis.

The process begins by finding published, peer-reviewed primary studies with comparable climate and land cover classifications as those within the study area. Any primary studies deemed to have incompatible assumptions or land cover types are excluded from further analysis. Individual primary study values are adjusted and standardized for units of measure, inflation, and land cover classification to ensure an "apples-to-apples" comparison. Frequently, primary studies offer a range of values that reflect the uncertainty or variability within the research area. As such, high and low dollars per acre values are included for each estimate provided in this report.

In some cases, the published values can be adjusted to more accurately reflect conditions in the study area. Income is one factor that greatly affects people's ability and willingness to pay for ecosystem services.[14,15,16] Adjusting ecosystem services for differences in income between study sites improves estimates. For this analysis, the median household income from El Paso ($42,037) and the average per capita income ($20,050) were used.[17] Incomes of beneficiaries in the primary studies were derived directly from each study itself or gathered from the U.S. Census Bureau.

Study Findings

Identification and Quantification of Land Cover Classes

The study area comprises several parcels bordering the Franklin Mountains that total 7,757 acres (7,711 acres provide ecosystem services) , as shown below in Figure 4. Within the study area, the project team identified six different land covers with the vast majority (97%+) of land characterized as shrubland.

EARTH
ECONOMICS

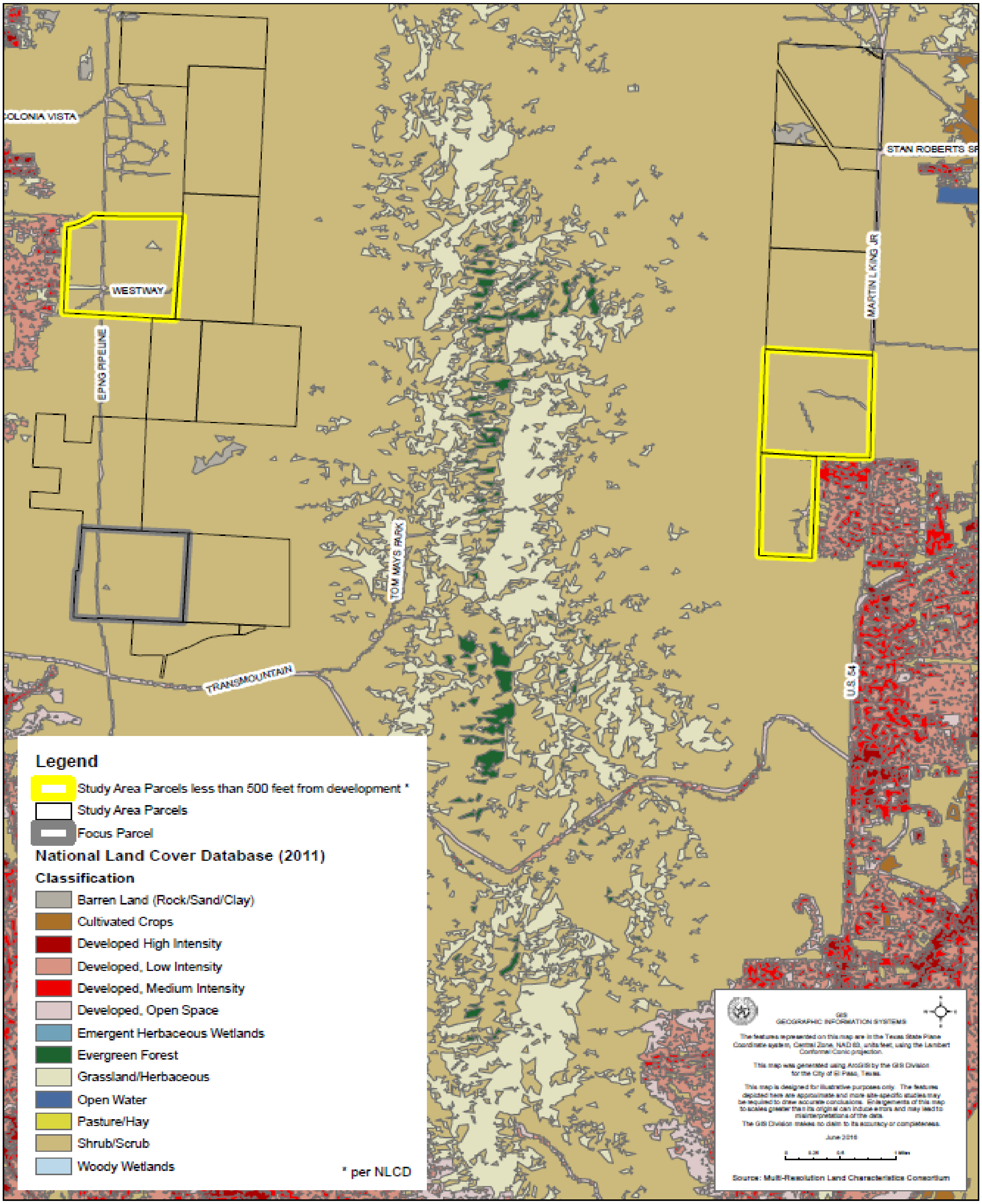


Figure 4: El Paso Study Area and Parcels Within 500 Feet of Development

EARTH ECONOMICS

Table 2: Acres by Land Cover Type

Land Cover Desciption	Proximity to Development w/I 500' (Acres)	Outside 500' (Acres)	Total	%
Grassland	0.25	18	18	0.2%
Shrubland	106	7,449	7,555	97.4%
Developed: Open Space		138	138	1.8%
Developed: Low, Medium, High Intensity		9	9	0.1%
Barren Land (Rock, Sand, Clay)		37	37	0.5%
TOTAL ACREAGE	106	7,650	7,756	100%
TOTAL STUDY AREA (Excluding Developed & Barren)	**106**	**7,559**	**7,711**	

Table 3 - Land Cover Definitions

Grassland	Dominated by grammanoid or herbaceous vegetation
Shrubland	Dominated by shrubs; less than 5 meters tall. Includes true shrubs, young trees in an early successional stage
Developed Open Space	A mixture of some constructed materials, but mostly vegetation in the form of lawn grasses
Developed (low, med, high Intensity)	A mixture of constructed materials (21-79% cover) and vegetation, such as single-family housing units Highly developed areas where people reside or work in high numbers such as apartment complexes, row houses and commercial/industrial
Barren land	Characterized by bare rock, gravel, sand, silt, clay, or other earthen material, with little or no "green" vegetation

Valuation of Ecosystem Services Across Land Cover Classes

Although there are at least 21 known ecosystem services (see Table 1 on page 7), this section focuses solely on those services for which values are available in the literature. Table 4 shows the annual value of ecosystem services by land cover type for the study area. Shaded table cells indicate that a service is likely to be provided by that land cover, but could not be valued in dollars. In addition, it should be noted that only nine of a possible 21 ecosystem services were valued across all land covers, indicating significant gaps in the valuation literature for grasslands and shrublands. Clearly, filling in these knowledge gaps would significantly increase the overall values. Several features of the analysis require additional explanation:

Natural Beauty Values: Also referred to as "aesthetic information", natural beauty reflects the value that people place on having a view of or access to nature. This value tends to be highest for land in close proximity to development and then decreases with distance. In this study, a $13,000 value for natural beauty was applied to each acre of shrubland and grassland within 500 feet of development. A significantly lower value, $0.20 - $59, was applied to land outside of this buffer. The areas of grasslands and shrublands within a 500 foot buffer were therefore valued separately, as reflected in Table 4. In reality, the natural beauty of shrubland does not end abruptly at the 500-foot mark but these were criteria adopted from the original studies. With additional analysis, a more nuanced application of this value may be possible.

Disaster Risk Reduction and Recreation Values: The same per acre values were used for both shrubland and grassland for both disaster risk reduction and recreation. The disaster risk reduction value of $39 - $54 per acre/per year comes from a study that was originally based upon the flood mitigation capacity of shrubland. Given the increased vegetation density and root structure of grassland relative to shrubland, it is assumed that the water absorption (and flood protection) capacity offered by grassland is at least equal to that of shrubland. Similarly, the $30 per acre recreation value comes from research on hiking in shrublands. It is assumed that encountering "grassland" on a hike through what is primarily shrubland would be equally enjoyable, and thus was given the same value.

Table 4 - Annual Ecosystem Service Values by Land Cover ($/Acre/Year)

	Grasslands		Grasslands (w/I 500 ft)		Shrublands		Shrublands (w/I 500 ft)		Open Space (Developed)	
	Low	High	Low	High	Low	High	Low	High	Low	High
Natural Beauty	$ 0.2	$ 59	$ 13,710	$ 13,710	$ 36	$ 59	$ 13,710	$ 13,710		
Air Quality					$ 1	$ 1	$ 1	$ 1		
Climate Stability	$ 134	$ 150	$ 134	$ 150	$ 15	$ 24	$ 15	$ 24		
Disaster Risk Reduction	$ 39	$ 54	$ 39	$ 54	$ 39	$ 54	$ 39	$ 54		
Food	$ 12	$ 85	$ 12	$ 85						
Habitat	$ 35	$ 35	$ 35	$ 35	$ 2	$ 2	$ 2	$ 2		
Recreation	$ 30	$ 30	$ 30	$ 30	$ 30	$ 30	$ 30	$ 30	$ 738	$ 738
Soil Retention	$ 6	$ 6	$ 6	$ 6	$ 9	$ 9	$ 9	$ 9		
Water Storage					$ 106	$ 494	$ 106	$ 494		
TOTAL	**$ 257**	**$ 419**	**$ 13,967**	**$ 14,071**	**$ 238**	**$ 674**	**$ 13,912**	**$ 14,324**	**$ 738**	**$ 738**

Annual Value of the El Paso Study Area

Using the values identified in Table 4**,** a summation of all ecosystem services present for each land cover type is provided in Table 5 and Table 6. The total low and high values for each land cover type (and its sub-categories) was multiplied by the acreage associated with that combination to calculate the total low and high values in dollars per year. As discussed earlier, areas of grassland and shrubland were valued differently depending on their proximity to development. Results are given in both dollars per-acre per-year and the total dollar value of the annual flow of ecosystem services for each land cover type and ecosystem service, respectively. **The annual value of ecosystem services within the El Paso study area is estimated to be between $3.4 million and $6.7 million**.

Table 5 - Ecosystem Services in the Study Area by Land Cover

Full Study Area		($/Acre/Year)		($/Year)	
	Acres	**Low**	**High**	**Low**	**High**
Grasslands	17	$ 257	$ 419	$ 4,442	$ 7,238
Grasslands (w/i 500 ft. of Developed)	0.2	$ 13,967	$ 14,071	$ 3,443	$ 3,469
Shrublands	7,449	$ 238	$ 673	$ 1,772,387	$ 5,014,724
Shrublands (w/i 500 ft. of Developed)	106	$ 13,912	$ 14,324	$ 1,479,901	$ 1,523,662
Open Space: Developed	138	$ 738	$ 738	$ 101,711	$ 101,711
TOTAL	**7,711**			**$ 3,361,885**	**$ 6,650,804**

Table 6 - Ecosystem Services in the Study Area by Service

	($/year) Low	High
Natural Beauty	$ 264,876	$ 443,886
Natural Beauty (500 ft. from Developed)	$ 1,461,752	$ 1,461,752
Air Quality	$ 7,010	$ 7,010
Climate Stability	$ 119,447	$ 182,550
Disaster Risk Reduction	$ 297,323	$ 411,161
Food	$ 213	$ 1,493
Habitat	$ 15,257	$ 15,257
Recreation	$ 330,434	$ 330,434
Soil Retention	$ 68,104	$ 68,104
Water Storage	$ 797,468	$ 3,729,156
TOTAL	**$ 3,361,884**	**$ 6,650,803**

Net Present Value Calculations

In addition to the annual flow of ecosystem service benefits detailed in Table 5 and Table 6, these economic data were used to calculate an "asset value" for the study site's natural capital. Specifically, the value was calculated as the net present value of its expected future benefits (or future flows of ecosystem services). The asset value provides policy makers with a sense of the total worth of an asset over time and helps to plan investment and stewardship activities at an appropriate scale.

The value of stored carbon, carbon stock, is included in the asset value. A forest provides an annual carbon sequestration service via growth that draws carbon from the atmosphere. The forest also holds a great deal of carbon within the trees, the stock. Similarly, shrublands in El Paso hold carbon in the plant material and soil. Table 7 shows this carbon stock value. Carbon sequestration and storage is a critical, natural process that reduces the amount of carbon in the atmosphere and slows climate change. Carbon markets are now emerging around the world where land owners are paid to protect and expand forests to increase the amount of carbon removed from the atmosphere and offset fossil fuel emissions.[18]

Table 7. Value of Carbon Stored in the Study Area

Carbon Storage	Acres	Per Acre Value		Total Value	
		Low	High	Low	High
Grasslands	18	$ 696	$ 1,532	$ 12,533	$ 27,578
Shrublands	7,555	$ 126	$ 126	$ 952,794	$ 952,794
TOTAL	7,573	-	-	$ 965,327	$ 980,372

The asset value of the of natural capital in the study area (Table 8) is between **$107 million and $211 million when valued at a three percent discount rate over the next 100 years. At a zero percent discount rate, El Paso's asset value is estimated between $337 million and $666 million.**

The discount rate represents what economists call the "time preference for money". In short, this preference reflects the fact that a person would typically prefer to have a dollar in-hand today rather than a dollar promised at a later time. A stronger preference for today's dollars suggests a higher discount rate. On the other hand, a zero percent discount rate indicates that a benefit today would be equally valued as a future dollar. A three percent discount rate used here is in the range proposed by many economists for valuation of natural capital. The purpose and application of discount rates is a topic of much debate in the field and further discussion is beyond the scope of this study.

Table 8: Total Asset Value of the Study Area's Natural Capital

Discount Rate	Asset Value ($)	
	Low	High
0%	$337 M	$666 M
3%	$107 M	$211 M
4.25%	$81 M	$159 M

Natural capital assets within the study area, such as shrublands and grasslands, provide enormous value to the regional economy and the local community. Importantly, these values are highly conservative estimates due to the many data gaps. Furthermore, while this asset value analysis considers a 100-year analysis period, this ecosystem should, with appropriate stewardship, continue to provide benefits far into the future.

Valuation Discussion

The findings of this study can be considered a starting point for further discussion and research on the connection between El Paso's natural capital and the local economy. The following observations should be considered as these numbers are put into practice and future research is planned:

- **Natural Capital in El Paso Provides Significant Value to the Local Economy**: Even though shrubland is less valuable than land covers like forests and wetlands, El Paso's vast shrubland landscape nevertheless contributes substantial economic value to the regional economy. This study only touches on this broader value.

- **These Values are Highly Conservative**: As indicated in Table 3, many land cover/ecosystem service combinations cannot yet be valued due to a lack of values appropriate to the arid southwest. Primary research and values related to arid shrubland are especially sparse. As new data for the region emerges, these values will continue to improve, and the total recognized value will increase.

- **Population Growth Increases Ecosystem Service Values:** As the population of El Paso grows, more people will benefit from the ecosystem services within the study area. As urban areas expand and suburban sprawl increases, access to open space will become more precious. A small riparian park near the city center provides more access to recreation, more aesthetic value, and most likely more valuable flood protection than a similar tract of land in a remote area.

- **Contiguous Habitat and Habitat Corridors Provide Many Co-Benefits**: Much research has been done on the value of contiguous habitat and the preservation of corridors that allow birds, animals, and even plants to migrate to obtain resources, mix populations, and mitigate climate change. [19,20] Functional, regional ecosystems are especially important as climate and precipitation patterns change. The dollar value of these features is highly dependent on the complex interactions of many local variables, and monetization via benefit transfer is difficult.

- **A Strong Link Between the Economy, the Community, and the Natural Environment Builds Long-term Resilience:** As temperatures rise, rainfall intensifies, and droughts deepen, ecosystem services become an even more vital tool for adaptation. Without the services nature provides, an increasing percentage of taxpayer dollars will be required to replace lost services with built infrastructure, which is often costlier and less resilient.

- **The Impact of Development on Water Supply and Aquifer Health is Challenging to Value**. The complex physical nature of aquifers and their relationship to surface waters makes valuation using benefit transfer difficult. Conversion of shrubland to impervious surfaces will most likely reduce infiltration and overall water supply from the aquifer. Localized research will be needed to estimate the cost of lost shrubland in terms of water supply and ecological health of riparian areas and other water-dependent ecosystems.

Opportunities for Additional Economic Analysis

This analysis provides a framework for discussing ecosystem services and valuation data available through published studies by applying the benefit transfer method. Further economic analysis may enable policy makers to build a more detailed and holistic picture of the shrublands' value and connection to the local economy.

Generate More Values Using Function Transfer

One way to compensate for the lack of primary data applicable to El Paso's shrubland is to identify opportunities to transfer values from published work using function transfer. Function transfer is an approach that combines a function defined in a published study with local information about the new study site to estimate the value of an ecosystem service at the new site. A function transfer involves analysis that is more detailed, but it can fill in important holes in existing data.

Economic Impact Analysis of Recreation

Formal recreation areas such as Franklin Mountains State Park and informal recreation such as walking and birding throughout the surrounding shrublands play a significant role in the local economy. User-day recreation data and specialized economic impact models can be used to model the flow of direct and indirect dollars from recreation opportunities. For example, a family visiting El Paso for bird watching may buy lunch, gas, and perhaps a hotel room. These investments will have a trickle-down benefit to local businesses and residents in the form of increased business sales and employee earnings. This type of study can be very helpful to illustrate how preservation and stewardship of open space can have wide-ranging benefits in different economic sectors. This is especially true as a region becomes a destination recreation area with visitors and dollars flowing into the region.

Holistic Benefit-Cost Analysis (BCA) of Development Options

Traditional BCAs have often had a narrow scope, only including items such as home construction costs, sale prices, tax revenue, and other common project measures. A holistic BCA attempts to capture a much wider range of project or land use policy implications, and it can help in comparing the benefits and costs of different options.

In addition to the ecosystem services described in this study, other benefits of open space may include reduced healthcare costs via better access to outdoor recreation, reduced stormwater management costs, reduced heat island impacts, and increased home values. Amenities like trails can even provide better employment opportunities by easing the cost and time of commuting, especially for low income residents. Some of these benefits can be monetized and others can be described qualitatively.

A holistic benefit-cost analysis gives decision makers more complete data to inform their project and policy options. In 2015, the Department of Housing and Urban Development (HUD) pioneered this type of analysis with their $1 billon National Disaster Resilience Competition that required holistic BCA analyses from all applicants.

Health Benefit of Open Space Analysis

Substantial data is available that correlates access to open space with physical and mental health. Economically, these benefits translate into lower healthcare costs for individuals and the community as a whole. Economic methods are now becoming available to put dollar values, often substantial, to these benefits.

Analysis of Open Space for Groundwater Recharge

Pioneering work in Santa Cruz County, California has shown that carefully constructed rapid infiltration zones and open space preservation can provide a high return on investment (ROI) for utilities in the form of increased water supply. This analysis captures both the value of water added to the aquifer for water supply and the reduction in flooding and runoff from severe weather events.

Better Data Yields Better Long-term Decisions

For many decades, decision makers have been missing critical data: the contribution of their natural capital and ecosystem services to the local economy. When natural capital is undervalued, BCA and ROI calculations show natural capital restoration and stewardship projects to be relatively less worthy of investment. Insufficient investment begins a long cycle of natural system decline that, in turn, compromises local economic and social function and productivity. ***For example, when natural systems are compromised, communities must pay a larger proportion of their tax revenue to compensate for the services that nature no longer provides for free.*** Building levees and storm water controls and paying an increasing amount for flood damages mirrors the loss of function along the riparian corridor due to impervious development, floodplain disconnection, and vegetation loss.

Communities throughout the nation are seeking the best ways to restore balance and save tax dollars over the long term. In many instances, the solution is to restore the environment to the state it was in 50 or 100 years prior. Within riparian areas, this often means restoring river flow, rebuilding riparian vegetation, and reconnecting floodplains to mitigate the damage due to increased frequency of extreme precipitation events. ***In many cases, this return to fully functional natural systems offers the most cost-effective, resilient, and durable solution to these critical problems.*** Anecdotal evidence indicates that healthy natural capital is good for business and helps to attract and maintain a highly skilled, engaged workforce. Work to protect and steward open space requires ingenuity, persistence, access to emerging data and techniques, and collaboration amongst partners that have not typically worked together.

The values included in this report are highly conservative, but still demonstrate the substantial value of El Paso's natural capital and the interconnection between the undisturbed land and the region's economy. These values can immediately be integrated into a variety of policy and planning efforts to provide decision makers with the most comprehensive data available to inform the best long-term choices for El Paso.

Appendix A - Study Limitations

Valuation exercises have limitations, although these limitations should not detract from the core finding that ecosystems produce significant economic value for society. Like any economic analysis, the benefit transfer method (BTM) has strengths and weaknesses. Some arguments against benefit transfer include:

- Every ecosystem is unique; per-acre values derived from another location may be of limited relevance to the ecosystems under analysis.
- Even within a single ecosystem, the value per acre depends on the size of the ecosystem; in most cases, as the size decreases, the per-acre value is expected to increase and vice versa. (In technical terms, the marginal cost per acre is generally expected to increase as the quantity supplied decreases; a single average value is not the same as a range of marginal values).
- Gathering all the information needed to estimate the specific value for every ecosystem within the study area is not currently feasible. Therefore, the full value of all of the shrubland, grassland, et cetera in a large geographic area cannot yet be ascertained. In technical terms, far too few data points are available to construct a realistic demand curve or estimate a demand function.
- The prior studies upon which calculations are based encompass a wide variety of time periods, geographic areas, investigators, and analytic methods. Many of them provide a range of estimated values rather than single-point estimates. The present study preserves this variance; no studies were removed from the database because their estimated values were deemed too high or too low. In addition, only limited sensitivity analyses were performed. This approach is similar to determining an asking price for a piece of land based on the prices of comparable parcels (“comps”): Even though the property being sold is unique, realtors and lenders feel justified in following this procedure to the extent of publicizing a single asking price rather than a price range.
- The objection to the absence of even an imaginary exchange transaction was made in response to the study by Costanza et al. (1997) of the value of all of the world’s ecosystems. Even this is not necessary if one recognizes the different purpose of valuation at this scale–a purpose that is more analogous to national income accounting than to estimating exchange values.[21]

This report displays study results in a way that allows one to appreciate the range of values and their distribution. It is clear from inspection of the tables that the final estimates are not precise. However, they are much better estimates than the alternative of assuming that ecosystem services have zero value, or, alternatively, of assuming they have infinite value. Pragmatically, in estimating the value of ecosystem services, it would be better to be approximately right than precisely wrong.

Appendix B - Valuation Data Sources

Land Cover Type	Ecosystem Service	Reference	Low Value	High Value
Grasslands	Natural Beauty	Sengupta and Osgood 2003	$ 55	$ 55
Grasslands	Natural Beauty	Mast 2002	$ 0.2	$ 0.5
Grasslands	Climate Stability	DeLonge et al. 2013	$ 134	$ 150
Grasslands	Climate Stability	Liu et al. 2012 (Asset Value)	$ 696	$ 1,532
Grasslands	Food	Shaw et al. 2009	$ 12	$ 85
Grasslands	Soil Retention	Gascoigne et al. 2011	$ 6	$ 6
Grasslands	Habitat	Gascoigne et al. 2011	$ 35	$ 35
Grasslands	Recreation and Tourism	Breffle et al. 1997	$ 13,710	$ 13,710
Shrublands	Air Quality	Delfino et al. 2007	$ 1	$ 1
Shrublands	Climate Stability	Liu et al. 2012	$ 15	$ 24
Shrublands	Disaster Risk Reduction	Zavaleta 2000	$ 39	$ 54
Shrublands	Water Storage	Zavaleta 2000	$ 106	$ 494
Shrublands	Recreation & Tourism	Richer 1995	$ 61	$ 61
Shrublands	Recreation & Tourism	Weber 2007	$ 30	$ 30
Shrublands	Soil Retention	Richardson 2005	$ 9	$ 9
Shrublands	Water Storage	Zavaleta 2000	$ 106	$ 494
Shrublands	Climate Stability	Wilson 2008	$ 126	$ 126
Shrublands	Natural Beauty	Rosenberger & Walsh 1997	$ 36	$ 59
Shrubland	Habitat	Sala et al. 1998	$ 2	$ 2
Open Space	Recreation & Tourism	Brander and Koetse 2011	$ 738	$ 738

[1] The City of El Paso. 2016. Economic and International Development - Population. Retrieved from elpasotexas.gov: https://www.elpasotexas.gov/economic-development/business-services/data-and-statistics/population
[2] El-Hage, A., & Moulton, D. W. 1998. Evaluation of Selected Natural Resources in El Paso County, Texas. Austin: Texas Parks and Wildlife.
[3] The City of El Paso. 2016. Economic and International Development - Population. Retrieved from elpasotexas.gov: https://www.elpasotexas.gov/economic-development/business-services/data-and-statistics/population
[4] http://www.100resilientcities.org/cities/entry/el-pasos-resilience-challenge#/-_/
[5] https://en.wikipedia.org/wiki/Franklin_Mountains_State_Park
[6] Castner Range National Monument. http://castnerrangenationalmonument.org/
[7] El-Hage, A., & Moulton, D. W. 1998. Evaluation of Selected Natural Resources in El Paso County, Texas. Austin: Texas Parks and Wildlife.
[8] El-Hage, A., & Moulton, D. W. 1998. Evaluation of Selected Natural Resources in El Paso County, Texas. Austin: Texas Parks and Wildlife.
[9] de Groot, R.S., Wilson, M.A., Boumans, R.M.J., 2002. A typology for the classification, description, and valuation of ecosystem functions, goods, and services. Ecological Economics 41, 393-408.
[10] Sukhdev, P., Wittmer, H., Schröter-Schlaack, C., Nesshöver, C., Bishop, J., ten Brink, P., Gundimeda, H., Kumar, P., Simmons, B., 2010. The Economics of Ecosystems and Biodiversity:
[11] Rosenberger, R., Loomis, J., 2003. Benefit Transfer, in: Champ, P., Boyle, K., Brown, T. (Eds.), A Primer on Nonmarket Valuation. Kluwer Academic Publishers, Boston.
[12] Richardson, L., Loomis, J., Kreoger, T., Casey, F., 2014. The role of benefit transfer in ecosystem service valuation. Ecol. Econ. 8.
[13] Rosenberger, R., Johnston, R., 2013. Benefit Transfer, in: Shogren, J. (Ed.), Encyclopedia of Energy, Natural Resource, and Environmental Economics. Elsevier, Amsterdam, pp. 327–333.
[14] Baumgärtner, Stefan, et al. "Income distribution and willingness to pay for ecosystem services." 19th Annual Conference of the European Association of Environmental and Resource Economists. 2012.
[15] Horowitz and McConnell. 2000. Willingness to Accept, Willingness to Pay and the Income Effect. http://ageconsearch.umn.edu/bitstream/197596/2/agecon-maryland-00-09.pdf
[16] Valuing Ecosystem Services: Toward Better Environmental Decision-Making. By Committee on Assessing and Valuing the Services of Aquatic and Related Terrestrial Ecosystems, Water Science and Technology Board, Division on Earth and Life Studies, National Research Council. http://www.nap.edu/read/11139/chapter/1
[17] Cubit Planning Inc. . 2016. 79915 income statistics. Retrieved from incomebyzipcode.com: https://www.incomebyzipcode.com/texas/79915

[18] USDA. 2013. Carbon Sequestration. Retrieved from fs.fed.us: http://www.fs.fed.us/ecosystemservices/carbon.shtml

[19]Olff, H., & RItchie, M. 2002. Fragmented nature: consequences for biodiversity. Landscape and Urban Planning, 83-92.

[20] Tischendorf, L., & Fahrig, L. 2000. On the usage and measurement of landscape connectivity. Oikos, 7-19.

[21] Howarth, R., and Farber, S., 2002. Accounting for the Value of Ecosystem Services. Ecological Economics 41(3), 421-429.