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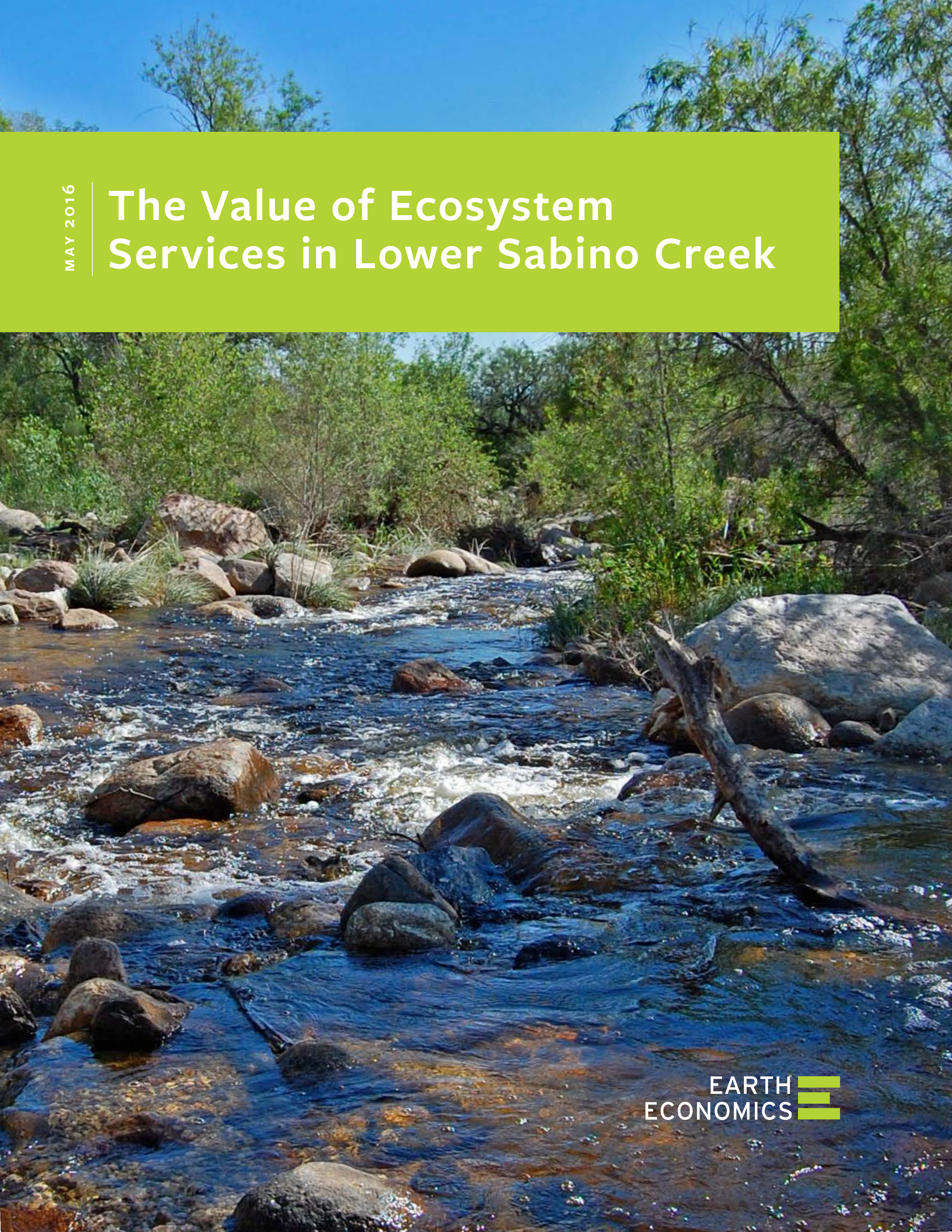
The Value of Ecosystem Services in Lower Sabino Creek



EARTH ECONOMICS

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COVER IMAGE

Watershed Management Group

EXECUTIVE SUMMARY

Tucson, Arizona's Sabino Creek is a critical part of the regional ecosystem and economy. The creek and larger watershed provide water and habitat that supports rich biodiversity, water to recharge the shallow groundwater aquifer, and many other ecosystem benefits from carbon sequestration to erosion control and moderation of flood events. Sabino Creek also provides many 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 that lower Sabino Creek provides.

Across the country, planners and policy makers are starting to include the value of natural capital assets (watersheds, forests, grasslands) and ecosystem services in their analyses. Though the techniques to identify, quantify, and monetize these 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 yields a more complete and accurate understanding of a restoration or stewardship project or policy and ultimately fosters more practical and, often, more cost-effective outcomes.

> *This analysis finds that lower Sabino Creek provides the local economy with $1.4 million to $2.1 million in ecosystem service benefits each year.*

This analysis finds that lower Sabino Creek provides the local economy with $1.4 million to $2.1 million in ecosystem service benefits each year. Enhancements including expanding the extent and health of the riparian forest or increased duration of surface flow will increase the value of ecosystem benefits provided each year by the system. Sabino Creek can also be viewed as a natural capital asset that provides a flow of benefits over time, similar to a building or bridge. When measured like an asset with a life-span of 100 years with a three percent discount rate, **lower Sabino Creek has a net asset value between $46 million and $81 million**. With sufficient stewardship to maintain the health and function of Sabino Creek, this economic contribution will continue in perpetuity. These are highly conservative estimates that will grow as new data and economic methods are developed.

Photo provided by Watershed Management Group

INTRODUCTION

Photo provided by Watershed Management Group

For many years, our natural capital (rivers, watersheds, forests) have 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 nearly always considered as costs 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). Today, with advances in ecological economics and a rapidly growing cache of primary academic data on the value of natural systems and functions, nature's contribution can be estimated. More importantly, this value can be combined with traditional, dollar-based 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 communities to build facilities to replace lost ecosystem services. For example, to make up for lost water management capability of a healthy riparian and floodplain corridor, communities fund stormwater systems, flood control districts, and levees, and they often pay for expensive flood cleanup activities. Real on-going costs are incurred to replace services that nature previously provided for free.

> *When ecosystem services are lost, communities pay.*

This study focuses on the ecosystem services within the lower Sabino Creek study area. Sabino Creek is located just north of Tucson, Arizona in the Santa Catalina Mountains and the Coronado National Forest. The creek captures water from Sabino Canyon, with a peak elevation of 9,157 feet and 12 inches of annual precipitation that includes some snow in the higher elevations.[1] The watershed provides habitat for many animals, including mountain lions, javelinas, bobcats, foxes, coyotes, roadrunners, canyon tree frogs, and many kinds of snakes. The riparian areas provide habitat for a variety of trees and plants, including cottonwood, walnut, sycamore, and ash trees, while the foothills host mesquite, palo verde, saguaro and many other cactus.[1] From the protected Sabino Canyon Recreation Area, the creek winds through foothill subdivisions to join the Tanque Verde River.

STUDY OBJECTIVES

The Sabino Creek Study was conducted by Earth Economics in partnership with the Watershed Management Group (WMG) in Tucson and with funding from The Walton Family Foundation. The study's purpose was to estimate ecosystem service values along Sabino Creek for use by WMG and the many local stakeholders to better inform creek management and restoration policy and project alternatives. The values in this report can also be used to inform related efforts along the Tanque Verde River and in the larger Santa Cruz River watershed.

The study objectives are as follows:

- Identify and describe the ecosystem services within the study area
- Calculate the dollar value of benefits that Sabino Creek provides to people
- Illuminate the connections between natural systems and the local economy
- Provide a conceptual model for aligning economic advancement, recreation and tourism, water supply, and resilience-building objectives

VALUATION APPROACH

The ecosystem services within the Sabino Creek study area include water supply, water quality, water storage, air quality, climate stability, aesthetic information, food, habitat, recreation, soil retention, and disaster risk reduction. All these services are freely provided by natural systems (natural capital) as long as the ecosystem is robust and healthy. Some of the benefits, such as climate stability, are realized outside of the region as well.

The valuation process involves four major steps:

1. **Identification and Quantification of Land Cover Classes:** Geographic Information Systems (GIS) data was used in conjunction with the National Land Cover Database (NLCD-2011) to calculate the number of acres of each land cover type (e.g. forest, wetland, shrub) within the study area.

2. **Identification and Valuation of Ecosystem Services:** The value of each ecosystem service/land cover combination (e.g. water storage/wetlands) was estimated using the benefit transfer method (described in detail below) to find and transfer 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.

3. **Annual Value of Sabino Creek:** The total high and low annual values of ecosystem services for a particular land cover class were multiplied by the acreage of that land cover class within the study area to arrive at total high and low annual values. The total high and low values of all land cover classes were then summed to generate a total annual value.

4. **Net Present Value Calculations:** Net present values were calculated for Sabino Creek over 100 years at two discount rates: zero percent and three percent. The present value calculation and application of a discount rate allows benefits accrued over many years to be combined into a single project value in current year dollars.

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" and is used to indirectly estimate the value of ecological goods or services.[3] BTM is frequently used because it can generate reasonable ecosystem service 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.[4]

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, lower Sabino Creek.[5] The BTM process is similar to a home appraisal, in which the value and features of comparable, neighboring homes (two bedrooms, 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.

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The process begins by finding published primary studies with comparable climate and land cover classifications (wetland, forest, grassland, etc.) 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. To recognize the range of values, high and low dollars per acre values are included for each value provided in this report.

In some cases, the published values can be adjusted to more accurately reflect conditions in the study area. Beneficiary income is one factor that greatly affects people's ability and willingness to pay for ecosystem services.[6] For example, residents' willingness to pay for ecosystem services (recreation, for example) at a small rural park will differ greatly for an identical park located in the heart of New York City. Adjusting ecosystem services for differences in income between study sites improves estimates.

For this analysis, the median household income from Pima and Pinal counties ($48,241) and the average per capita income ($23,254) were used.[7] Incomes from the primary studies were derived directly from each study itself or gathered from the U.S. Census Bureau. Our estimate of income elasticity came from several meta-analyses on ecosystem services and averaged 0.48, with a minimum of 0.1, a maximum of 1.16, and a standard deviation of 0.33. An adjustment equation was then applied to each value in the benefit transfer dataset.

STUDY FINDINGS

Identification and Quantification of Land Cover Classes

The study area comprised a 1,769-acre section along lower Sabino Creek and the surrounding area as shown below in Figure 1. Using the National Land Cover Database (NLCD), the project team identified different land covers occurring within the study area with the majority of land characterized as either developed or shrub as shown in Table 1.

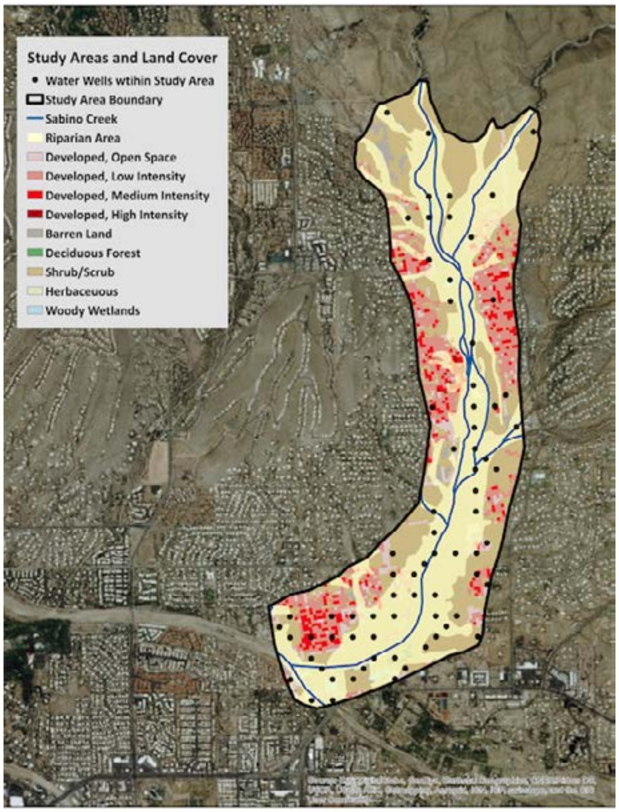

Figure 1: Lower Sabino Creek Study Area

LAND COVER DESCRIPTION	Acres	%
Open Space	114	6.4%
Developed: Low, Medium, High Intensity	368	20.8%
Barren Land (Rock, Sand, Clay)	44	2.5%
Deciduous Forest	3	0.2%
Shrub/Scrub	1,198	67.7%
Grassland/Herbaceous	15	0.8%
Woody Wetlands	12	0.7%
Sabino Creek Bed Area	15	0.8%
TOTAL ACREAGE	1,769	100%
TOTAL STUDY AREA (Excluding Developed & Barren)	**1,357**	

Table 1: Acres by Land Cover Type

Valuation of Ecosystem Services Across Land Cover Classes

This study identified a total of 11 ecosystem services that could be valued across each land cover types; this analysis does not value barren land and developed acreage due to the low level of services anticipated. Each land cover class is known to provide humans with its own suite of economically valuable goods and services. For example, wetlands provide services such as habitat for wildlife, climate stability, and recreation opportunities like birdwatching.

Table 2 provides a matrix of the ecosystem services present in each land cover type. Values were assigned wherever data was available; certain ecosystem services are assumed to be present, but no data was available to quantify or monetize their benefits. In these cases, the box is shaded to indicate a service is likely present, but not valued in this analysis. Clearly, filling in these knowledge gaps would significantly increase the overall values.

	Forests		Grasslands		Shrublands		Water		Wetlands		Open Space	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Aesthetic Information	$ 349	$ 7,172	$ 59	$ 59			$ 5	$ 5	$ 85,001	$ 85,001		
Air Quality	$ 30	$ 1,068			$ 1	$ 1						
Climate Stability	$ 1,487	$ 1,946	$ 134	$ 150	$ 15	$ 24			$ 77	$ 77		
Disaster Risk Reduction					$ 42	$ 58						
Energy & Raw Materials												
Food			$ 13	$ 91								
Habitat							$ 4,135	$ 4,839				
Recreation	$ 43	$ 59			$ 46	$ 65			$ 8,897	$ 10,604	$ 738	$ 738
Soil Retention	$ 21	$ 131			$ 10	$ 10						
Water Capture, Conveyance, & Supply	$ 10	$ 136										
Water Quality	$ 671	$ 2,088										
Water Storage					$ 31	$ 527	$ 4	$ 5				
TOTAL	**$ 2,612**	**$ 12,601**	**$ 206**	**$ 300**	**$ 145**	**$ 685**	**$ 4,145**	**$ 4,850**	**$ 93,975**	**$ 95,682**	**$ 738**	**$ 738**

Ecosystem service expected but data not available to quantify and monetize

Table 2: Annual Ecosystem Service Values by Land Cover ($/Acre/Year)

Annual Value of Sabino Creek

Using the values identified in Table 2, a summation of all ecosystem services present for each land cover type is provided in Table 3 and Table 4. 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 lower Sabino Creek is estimated to be between $1.4 million and $2.1 million.**

		($/Acre/Year)		($/Year)	
	Acres	Low	High	Low	High
Forests	3	$ 2,612	$ 12,601	$ 7,835	$ 37,802
Grasslands	15	$ 206	$ 300	$ 3,092	$ 4,493
Open Space	114	$ 738	$ 738	$ 84,108	$ 84,108
Shrublands	1,198	$ 145	$ 685	$ 174,229	$ 820,590
Water	15	$ 4,145	$ 4,850	$ 62,173	$ 72,744
Wetlands	12	$ 93,975	$ 95,682	$ 1,127,703	$ 1,148,190
TOTAL	**1,357**			**$ 1,459,139**	**$ 2,167,927**

Table 3: Ecosystem Services in Sabino Creek by Land Cover

	($/year)	
	Low	High
Aesthetic Value	$ 1,022,020	$ 1,042,488
Air Quality	$ 1,278	$ 4,391
Climate Stability	$ 25,972	$ 37,542
Disaster Risk Reduction	$ 50,230	$ 69,462
Energy & Raw Materials	$ –	$ –
Food	$ 195	$ 1,366
Habitat	$ 62,032	$ 72,588
Recreation	$ 246,009	$ 289,526
Soil Retention	$ 12,009	$ 12,341
Water Capture, Conveyance, & Supply	$ 31	$ 408
Water Quality	$ 2,014	$ 6,265
Water Storage	$ 37,350	$ 631,550
TOTAL	**$ 1,459,139**	**$ 2,167,927**

Table 4: Ecosystem Services in Sabino Creek by Service

Net Present Value Calculations

If Sabino Creek's natural capital were treated like a traditional economic asset, the asset value of the natural systems (Table 5) would be between **$46 million and $81 million, valued at a three percent discount rate over the next 100 years. At a zero percent discount rate, Sabino Creek's asset value is estimated between $146 million to $230 million.** Calculations of the net present value of the flow of ecosystem services indicate that intact natural systems of Sabino Creek provide enormous value to society in the short and long term. Importantly, these values can be considered highly conservative estimates since many services could not be monetized at this time. In addition, this asset value analysis considers a 100-year analysis period. With stewardship, this ecosystem should continue to provide benefits far into the future.

	Asset Value ($)	
Discount Rate	Low	High
0%	$ 146M	$ 230M
3%	$ 46M	$ 81M

Table 5: Total Asset Value of Sabino Creek

Discussion

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

- **The Values are Highly Conservative:** As indicated in Table 2, there are many land cover/ ecosystem service combinations that cannot yet be valued due to a lack of data appropriate to this ecosystem. As new data is produced for the arid southwest, these values will continue to improve, and the total recognized value would likely grow.
- **Restoration will Increase Value:** Enhancements including expanding the extent and health of the riparian forest or increased duration of surface flow will increase the value of ecosystem benefits provided each year by the system.
- **The Link Between Surface Water and Shallow Aquifers is Complex:** Surprisingly little work has been done on the national level to generate economic values for the complex interactions between surface water and underlying aquifers. In the Tucson area, shallow aquifers are critical sources of water supply and, perhaps more importantly, they are critical to the long term health and survival of riparian vegetation. Additional research in this area will add great value to discussions of ecosystem restoration and water supply management.
- **Sabino Creek and Sabino Canyon Recreation Area Contribute Substantially to the Local Economy:** Sabino Canyon and Sabino Creek have a substantial economic impact on the regional economy through tourism, recreation, and property values. This study only touches on this broader value.
- **A Strong Link Between the Economy and the Natural Environment is Needed for Resilience:** As weather and precipitation patterns change over the coming years, the region will experience a new set of challenges. More robust and integrated natural, economic, and social systems will be expected to demonstrate more resilience when facing the uncertain future.

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, benefit-cost analysis (BCA) and return on investment (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 stormwater controls and paying an increasing amount for flood damages mirrors the loss of function along the riparian corridor due to impervious development, flood plain disconnection, and vegetation loss.

> *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.*

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 moderate the 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. This work 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 the lower Sabino Creek area and the interconnection between the Creek 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 the Creek and the region.

APPENDIX A – STUDY LIMITATIONS

Valuation exercises have limitations, although these limitations should not detract from the core finding that ecosystems produce significant economic value to 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 being studied.
- 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 wetlands, forests, pastureland, 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 to be "too high" or "too low." Also, 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.
- 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 seems better to be approximately right than precisely wrong.

APPENDIX B – VALUATION DATA SOURCES

Land Cover Type	Ecosystem Service	Reference	Low Value	High Value
Forests	Aesthetic Information	McPherson and Simpson 2002	$ 349	$ 1,763
Forests	Aesthetic Information	Nowak et al. 2002	$ 4,867	$ 7,172
Forests	Air Quality	McPherson 1992	$ 238	$ 238
Forests	Air Quality	McPherson et al. 1998	$ 30	$ 30
Forests	Air Quality	McPherson et al. 1999	$ 1,068	$ 1,068
Forests	Air Quality	McPherson and Simpson 2002	$ 79	$ 137
Forests	Climate Stability	McPherson 1992	$ 1,403	$ 1,403
Forests	Climate Stability	Smith et al. 2006	$ 84	$ 543
Forests	Climate Stability	Smith et al. 2006	$ 2,912	$ 14,541
Forests	Recreation & Tourism	Weber and Berrens 2006	$ 43	$ 59
Forests	Soil Retention	Yoo et al. 2014	$ 21	$ 131
Forests	Water Capture, Conveyance, & Supply	Hill et al. 2014	$ 34	$ 136
Forests	Water Capture, Conveyance, & Supply	McPherson 1992	$ 10	$ 10
Forests	Water Capture, Conveyance, & Supply	McPherson and Simpson 2002	$ 90	$ 103
Forests	Water Quality	Hill et al. 2014	$ 671	$ 2,088
Grasslands	Aesthetic Information	Sengupta and Osgood 2003	$ 59	$ 59
Grasslands	Climate Stability	DeLonge et al. 2013	$ 134	$ 150
Grasslands	Climate Stability	Liu et al. 2012	$ 696	$ 1,532
Grasslands	Food	Shaw et al. 2009	$ 13	$ 91
Shrublands	Air Quality	Delfino et al. 2007	$ 1	$ 1
Shrublands	Climate Stability	Liu et al. 2012	$ 15	$ 24
Shrublands	Climate Stability	Graham et al. 2004	$ 131	$ 10,621
Shrublands	Disaster Risk Reduction	Zavaleta 2000	$ 42	$ 58

Land Cover Type	Ecosystem Service	Reference	Low Value	High Value
Shrublands	Recreation & Tourism	Richer 1995	$ 65	$ 65
Shrublands	Recreation & Tourism	Weber 2007	$ 46	$ 46
Shrublands	Soil Retention	Richardson 2005	$ 10	$ 10
Shrublands	Water Storage	Zavaleta 2000	$ 31	$ 527
Water	Aesthetic Information	Sengupta and Osgood 2003	$ 5	$ 5
Water	Habitat	Berrens et al. 2000	$ 4,135	$ 4,135
Water	Habitat	Berrens et al. 1996	$ 4,839	$ 4,839
Water	Water Storage	Delfino et al. 2007	$ 4	$ 5
Wetlands	Aesthetic Information	Colby and Wishart 2002	$ 85,001	$ 85,001
Wetlands	Climate Stability	Liu et al. 2012	$ 77	$ 77
Wetlands	Climate Stability	Liu et al. 2012	$ 915	$ 3,592
Wetlands	Recreation & Tourism	Solby and Smith-Incer 2005	$ 168	$ 224
Wetlands	Recreation & Tourism	Creel and Loomis 1992	$ 7,549	$ 8,021
Wetlands	Recreation & Tourism	Creel and Loomis 1992	$ 8,729	$ 10,380
Open Space	Recreation & Tourism	Brander and Koetse 2011	$ 738	$ 738

ENDNOTES

[1] Friends of Sabino Canyon. www.sabinocanyon.org

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