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An Economic Assessment of the Sonoran Desert Conservation Plan

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ABSTRACT

Riparian corridors supply many environmental and aesthetic services in the arid and semi-arid regions world wide. Riparian ecosystems provide water filtering, bank stabilizing, flood mitigating benefits, and habitat for native birds, bats, fish, and other wildlife. The juxtaposition of lush herbaceous and treed areas with upland desert also makes these corridors an aesthetic resource. In Arizona, urban homeowners are one of the primary "consumers" of the riparian corridor. Recent research demonstrates that riparian corridors are capitalized into nearby home values. Specific to this research, urban and suburban homebuyers are willing to pay high premiums to live near sections of riparian corridors that support dense, species rich, and perennial-water-dependent habitat.

In this study we calculate the estimated increases in property values and property tax revenues associated with proximity to healthy urban riparian corridors. These property premiums are then compared to the estimated costs of water leases necessary to support water-dependent habitats as detailed in the Sonoran Desert Conservation Plan (SDCP). The plan aims to protect open space in the Sonoran Desert in southern Arizona, specifically in Pima County. The property premiums are estimated at between $126.54M (Million) and $253.08M and generate an estimated $1.23M–$2.46M per annum in incremental property tax revenues; whereas, the annual cost of water leases to support the vegetation is $0.54M. This partial economic analysis demonstrates that urban riparian habitat preservation and restoration with the allocation of renewable water supplies can be financially

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self-supporting. In addition, the estimated property price premiums indicate potential benefits to modifying current well-spacing rules in Arizona.

INTRODUCTION

Arizona is one of the fastest growing states in the United States. Not only are the cities of Phoenix and Tucson expanding rapidly but so too are rural areas. Consequently, strong growth in water demand has hastened not only the conversion of agricultural water rights into municipal water rights but aquifer overdraft as well. This resulting deficit between natural recharge and use is estimated to be an annual 2.5M acre feet (AF)[1] statewide.[2] Drought has also aggravated this shortfall. In many areas, the decline in the groundwater table has severed the hydrologic connection between ground water and surface water and transformed once flowing rivers that supported riparian habitat into dry riverbeds. For example, in Tucson, the groundwater table in some areas is now more than 200 feet below the surface under much of the city.[3]

Water demand has fueled interest in "new" water, such as fully utilizing Colorado River water and reclaimed water. Arizona's Colorado River water allocation, as per the 1928 Boulder Canyon Project Act,[4] is 2.8 MAF annually. Arizona has an incentive to use or store all of its Colorado River allocation; otherwise, it is lost to the next priority, which is the downstream state of (southern) California.

In this article, we examine the economics of dedicating some renewable water to support urban riparian conservation and restoration projects. We note that such a use is compatible with Arizona's Public Water Code[5] and that it would provide significant private property benefits in addition to flood control and recreation benefits.

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1. An acre foot of water can support an average 2.7 single-family residence (SFR) household for a year. This is based on the following data: average gallons per capita per day (GPCD) for an SFR is 120 GPCD, CITY OF TUCSON WATER DEP'T, WATER PLAN: 2000–2050: FINAL DRAFT MAYOR AND COUNCIL 3–6 (Nov. 22, 2004), *available at* http://www.ci.tucson.az.us/water/docs/waterplan.pdf, and 2.8 persons per SFR, SHARON B. MEGDAL & KELLY MOTT LACROIX, WATER RESOURCE AVAILABILITY FOR THE TUCSON METROPOLITAN AREA 20 n.21 (July 2006), *available at* http://ag.arizona.edu/azwater/presentations/Megdal.az.water.resource.avail.for.tucson.pdf.

2. Ariz. State Univ., *Investing in Arizona's Future*, http://www.asu.edu/president/azfuture/1.htm (last visited May 20, 2006).

3. City of Tucson, Tucson Water [Dep't], Long Range Water Resource Planning, http://www.ci.tucson.az.us/water/docs/groundwater.pdf (last visited May 20, 2006).

4. Bounder Canyon Project Act (1928), Pub. L. 70-642 § 4(a).

5. ARIZ. REV. STAT. ANN. §§ 45-101 to 45-2712 (2003 & Supp. 2005).

Riparian habitat in Tucson, Arizona, is highly varied. This heterogeneity is in part a response to water availability, elevation, and geomorphic channel processes,[6] but it is also the result of flood control infrastructure and urbanization.[7] Hydroriparian species such as cottonwoods and willows rely on stable and shallow ground water:[8] habitat conditions that are no longer common in the Tucson metropolitan area. Many sections of the riparian corridor are without regular flow and are dominated by fragmented shrubland or bare open space.

Plant biologists and ecologists have studied extensively the decline in riparian habitat. For example, Levine and Stromberg note twofold changes resulting from interruption of natural stream flows: native plant recruitment declines and "functional gaps" open that are ripe for invasion by exotic species.[9] Others have also correlated flow frequencies with vegetation cover.[10] However, one aspect of this decline that has not been adequately addressed is the economic cost of such habitat loss, or alternatively the value of conserving the remaining habitat. In this article we apply property premiums from previous research to value the riparian habitat[11] to Tucson homeowners.

The hedonic property price method can be used to estimate the value of environmental goods such as open space or a lake view. This technique models private property prices as a function of a house's attributes, such as house size, lot size, school district, and coastal access.[12] The method calculates an implicit value or hedonic price for each attribute. For example, a lake view might add 20 percent to a home's value compared to an equivalent home without a lake view in the same study area. A large literature testifies that nearby natural

6. *See* Robert J. Naiman et al., *The Role of Riparian Corridors in Maintaining Regional Biodiversity*, 3 ECOLOGICAL APPLICATIONS 209, 209-10 (1993).

7. Juliet C. Stromberg, *Restoration of Riparian Vegetation in the Southwestern United States: Importance of Flow Regimes and Fluvial Dynamism*, 49 J. ARID ENV'TS 17, 17-29 (2001).

8. Jonathan L. Horton et al., *Physiological Response to Groundwater Depth Varies Among Species and with River Flow Regulation*, 11 ECOLOGICAL APPLICATIONS 1046, 1058 (2001).

9. C.M. Levine & J.C. Stromberg, *Effects of Flooding on Native and Exotic Plant Seedlings: Implications for Restoring Southwestern Riparian Forests by Manipulating Water and Sediment Flows*, 49 J. ARID ENV'TS 111, 111-29 (2001).

10. Francisco Zamora-Arroyo et al., *Regeneration of Native Trees in Response to Flood Releases from the United States into the Delta of the Colorado River, Mexico*, 49 J. ARID ENV'TS 49, 49-64 (2001).

11. In this article we define "riparian habitat" as hydroriparian habitat. That is, we only value the benefits to homeowners of shallow groundwater-dependent habitat. Tree species in this type are broad-leafed, deciduous, cottonwoods, and willow trees.

12. The hedonic property price method is based on Rosen's seminal article. Sherwin Rosen, *Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition*, 82 J. POL. ECON. 34, 34-54, (1974).

resources such as open space, lakefront amenities, visibility, views, urban wetlands, coastal water quality, and ecological diversity and fragmentation[13] are often capitalized into property values.

Proximity to a natural resource is one aspect of value.[14] Other aspects of a habitat value require more detailed modeling to ascertain the source of homebuyer preference. A recent study uses ground-based survey data to investigate how different types of riparian habitat are capitalized into nearby private property values.[15] The authors found that the most highly valued habitats are densely vegetated washes, washes with higher vegetation species richness, and washes that support shallow groundwater-dependent tree species. Specifically homeowners within 0.2 miles of 51 stratified-random surveyed riparian corridors were willing to pay 16 percent more for the mean study area home if it was located next to such a wash.[16] Crucially, preferred washes contain

13. *See, e.g.*, Elena G. Irwin & Nancy E. Bockstael, *The Problem of Identifying Land Use Spillovers: Measuring the Effects of Open Space on Residential Property Values*, 83 AM. J. AGRIC. ECON. 698 (2001); Jacqueline Geoghegan, *The Value of Open Spaces in Residential Land Use*, 19 LAND USE POL'Y 91 (2002); V. Kerry Smith et al., *Treating Open Space as an Urban Amenity*, 24 RESOURCE & ENERGY ECON. 107 (2002); Gayatri Acharya & Lynne Lewis Bennett, *Valuing Open Space and Land-Use Patterns in Urban Watersheds*, 22 J. REAL EST. FIN. & ECON. 221 (2001); Steven D. Shultz & David A. King, *The Use of Census Data for Hedonic Price Estimates of Open-space Amenities and Land Use*, 22 J. REAL EST. FIN. & ECON. 239 (2001); Fiorenza Spalatro & Bill Provencher, *An Analysis of Minimum Frontage Zoning to Preserve Lakefront Amenities*, 77 LAND ECON. 469 (2001); Robert W. Paterson & Kevin J. Boyle, *Out of Sight, Out of Mind? Using GIS to Incorporate Visibility in Hedonic Property Value Models*, 78 LAND ECON. 417 (2002); Earl D. Benson et al., *Pricing Residential Amenities: The Value of a View*, 16 J. REAL EST. FIN. & ECON. 55 (1998); Brent L. Mahan et al., *Valuing Urban Wetlands: A Property Price Approach*, 76 LAND ECON. 100 (2000); Christopher G. Leggett & Nancy E. Bockstael, *Evidence of the Effects of Water Quality on Residential Land Prices*, 39 J. ENVTL. ECON. & MGMT. 121 (2000); Jacqueline Geoghegan et al., *Spatial Landscape Indices in a Hedonic Framework: An Ecological Economics Analysis Using GIS*, 23 ECOLOGICAL ECON. 251 (1997).

14. N.R. Netusil, *The Effect of Environmental Zoning and Amenities on Property Values: Portland, Oregon*, 81 LAND ECON. 227, 242 (2005) (homes within 200 feet of a river enjoy a large premium in Portland, Oregon); Rosalind H. Bark-Hodgins et al., (forthcoming 2006) (premiums found in the semi-arid market of Tucson, Arizona); Rosalind Bark-Hodgins, Daniel E. Osgood & Bonnie G. Colby., *Remotely Sensed Proxies for Environmental Amenities in Hedonic Analysis: What Does Green Mean?*, *in* ENVIRONMENTAL VALUATION: INTERREGIONAL AND INTRAREGIONAL PERSPECTIVES (John I. Carruthers & Bill Mundy eds., 2006) [hereinafter Bark-Hodgins et al., *Hedonic Analysis*].

15. *See* R.H. Bark-Hodgins et al., Understanding Preferences for Environmental Characteristics: Can Homebuyers Distinguish Between Degraded Greenspace and Healthy Habitat (2006) (unpublished manuscript, on file with author) [hereinafter Bark-Hodgins et al., Homebuyers].

16. The model estimated was the following: ln sales, price = β_0 + β_1 lot size + β_2 living area + β_3 house age + β_4 bathroom fixtures + β_5 garage spaces + β_6 pool area + β_7 distance to golf + β_8 walking path + β_9 wash veg. volume + β_{10} wash veg. diversity + β_{11} wash hydro-mesoriparian richness + β_{12} adjacent to wash + β_{13} Catalina Foothills School District + β_{14} Tanque Verde School District + β_{15} FEMA flood zone + β_{16} elevation of house + β_{17}

species that are dependent on shallow ground water[17] and winter and spring flood regimes for survival.[18] These washes are particularly threatened by continued groundwater overdrafting and stream flow diversions. This article applies the results from Bark-Hodgins et al.[19] in order to (partially) evaluate the riparian habitat conservation and restoration section of the Sonoran Desert Conservation Plan (SDCP). That plan seeks to mitigate the degradation of urban riparian habitat by allocating renewable water resources for instream flows.

In the next section we use a geographic information system with georeferenced parcel and riparian corridor data from Pima County[20] to estimate the value to nearby homebuyers of conserved and restored riparian habitat.[21] We then examine the costs of supplying water to maintain such habitats and conclude with a partial economic analysis of SDCP and a discussion.

Note that we do not value other types of riparian habitat, specifically dryland riparian habitat (xeroriparian), even though it is valued by nearby homeowners. This type of habitat is excluded from our analysis because it does not require supplementary water for survival. Nor do we estimate the vegetation density and species diversity benefits from the Bark-Hodgins et al. study.[22] Moreover, we do not estimate the benefits of flood control, bank stabilization, water infiltration, and wildlife habitat provided by riparian zones. For these reasons, this is not a benefit-cost analysis, but rather a partial economic analysis of specific features of the SDCP.

AN ESTIMATE OF THE CAPITALIZATION VALUE OF RIPARIAN HABITAT

A partial estimate of the "value" of the riparian zone is the property price premium accruing to nearby property owners. The hedonic property price method has the advantage that it is based on actual market transactions, or property sales. It is, however, only a partial estimate of the benefits. The values determined in Bark-Hodgins

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appreciation + β_{18} adjct golf + β_{19} distance to wash + β_{20} adjct wash + β_{21} CFS2 + β_{22} CFS3 + β_{23} CFS4 + β_{24} CFS5 + β_{25} CFS6 + β_{26} ε. The hedonic price of one unit of hydro-mesoriparian richness was calculated at $16,252.

17. Horton et al., *supra* note 8, at 1056.
18. Levine & Stromberg, *supra* note 9, at 113.
19. Bark-Hodgins et al., Homebuyers, *supra* note 15, tbl. 4.
20. Tucson is located in Pima County.
21. *See supra* note 11.
22. Bark-Hodgins et al., Homebuyers, *supra* note 15.

et al.[23] are those accruing only to homeowners of single family residences (SFRs) within 0.2 miles of riparian habitat. The value of this habitat to those living in townhouses or condos, to homeowners beyond the 0.2 mile buffers, and to visitors is not estimated in their model. Also, although some aspects of riparian corridor services, such as flood mitigation and water filtration, may not be explicitly valued by homebuyers, they nevertheless provide benefits to the entire metropolitan area. The value we apply in this article is the value of the riparian corridor to nearby homebuyers; it is likely a combination of aesthetic and recreation values and also privacy values afforded by a location adjacent to a wash.[24]

In order to assess the SDCP, we apply the estimated value of shallow groundwater-dependent riparian habitat to nearby homeowners as determined by Bark-Hodgins et al.[25] In their paper, the authors conducted comprehensive field analysis at 51 randomly chosen riparian corridors. These 51 riparian corridors were then protected by a 0.2 mile buffer and all the sales within these buffers in their study period 1998 through 2003 were used in their hedonic property price analysis. They estimated the premium paid by homebuyers for proximity to different types of riparian habitat. Specifically, only five out of their 51 field sites were classified as "shallow groundwater-dependent riparian habitat." The total premium paid for this habitat by all nearby homebuyers in the authors' northwest Tucson study area, in the study period, is estimated at $568,820. For this current article we transfer these house sale premiums[26] to all 746 homes[27] within the 0.2 mile buffers. By applying these premiums to all homes within these buffers we estimate the value of these five stretches of riparian habitat to be around $24.25M.

These benefits represent a lower bound estimate for all SFRs within the buffered zones for three reasons. First, the benefit estimate is modest, as it only includes those SFRs within 0.2 miles of a surveyed or designated shallow groundwater-dependent riparian habitat. That is, it does not include the benefits to other property owners or renters, or the value of other preferred habitat conditions such as overall species

23. *Id.*

24. This privacy results from flood control legislation that prevents building in the floodway. PIMA COUNTY, ARIZ., CODE ch. 16.24, § 16.24.010 (1998) (Uses allowed in the floodway).

25. Bark-Hodgins et al., Homebuyers, *supra* note 15.

26. In the paper, the hydro-mesoriparian richness variable varied from 1 to 4 at the five sites with this type of habitat. For this current analysis, we apply the premium associated with a hydro-mesoriparian richness value of 2 to all of the homes within the 0.2 mile buffer.

27. We transfer the premium to all the homes within the buffers, not only to those homes that sold within the author's study period.

diversity. Second, statistically measurable property value premiums have been documented to extend well beyond the 0.2 miles.[28] For these reasons, our estimate is conservative but is the best available estimate for the value of this habitat.

Next we increase the area of analysis to include a 0.2 mile buffer around all Pima County designated shallow groundwater-dependent riparian habitat in our study area, not just the five sites surveyed (see Map 1). A total of 3,893 homes lie within these new buffers. Using the technique above,[29] an estimate of the current value of these habitats is around $126.54M. Note that this estimate of the value of the water-loving habitat is limited to the study area shown in Map 1, although other sections of such habitat are self-sustaining elsewhere in the county (see Map 2). Using this new dataset, we investigate the economics of riparian conservation and restoration in our study area.

THE SONORAN DESERT CONSERVATION PLAN: BENEFITS

The SDCP[30] is an ambitious open space protection plan. It also incorporates measures to protect and restore riparian corridors in metropolitan Tucson that are threatened directly by development and indirectly by continued groundwater overdraft. To implement this specific policy, Pima County has adopted riparian corridor maps that identify proposed areas for regulation (see Map 2). Landowners developing parcels within regulated areas are required to avoid impacts to the riparian corridor; if impacts cannot be avoided, they are then required to minimize the impact and offset or mitigate any damage by revegetating the area. Map 2 identifies the proposed areas for riparian habitat regulation and also identifies the class of habitat, for example "hydro and mesoriparian habitat."[31] The study area used in Bark-Hodgins et al.[32] is shaded gray.

MAP 1: STUDY AREA WITH PIMA COUNTY DESIGNATED HYDRO/RIPARIAN HABITAT

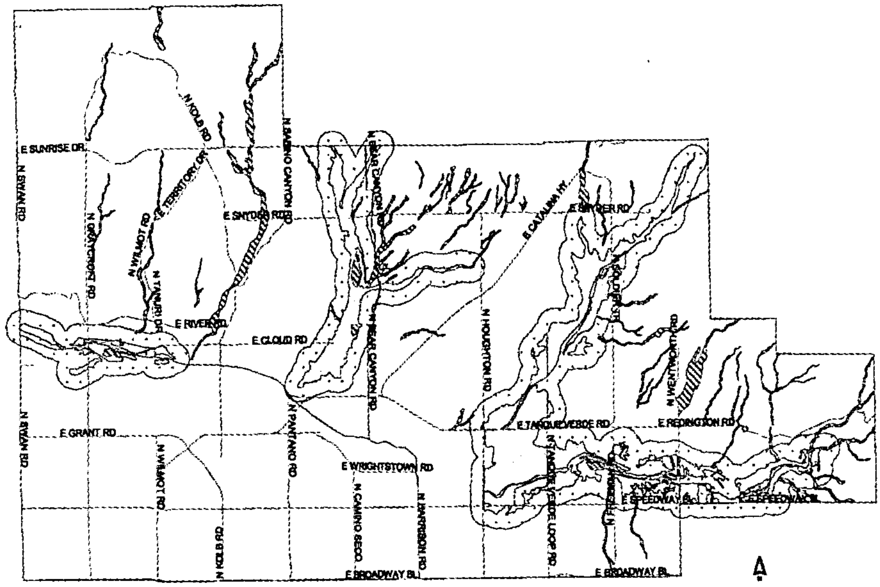
28. Bonnie G. Colby & Steve Wishart, *Quantifying the Influence of Desert Riparian Areas on Residential Property Values*, 70 APPRAISAL J. 304, 304–08 (2002).

29. *See supra* note 26.

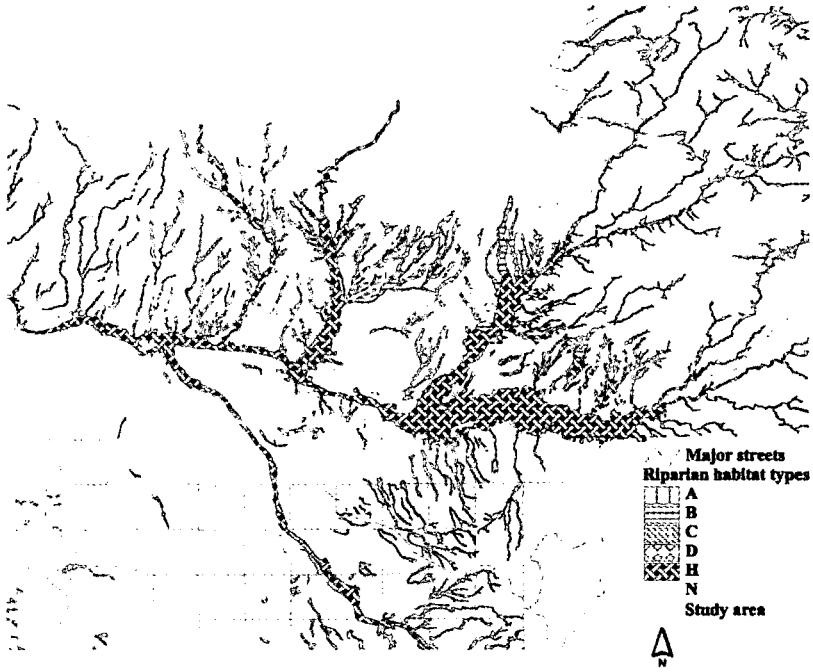
30. Sonoran Desert Conservation Plan, A Vision for Riparian Protection, http://www.co.pima.az.us/cmo/sdcp/Riparian.html (last visited May 20, 2006).

31. We treat "important riparian habitat" as "hydro and mesoriparian habitat."

32. Bark-Hodgins et al., *Homebuyers*, *supra* note 15.


E SUNRISE DR
N RYAN RD
E SNYDER RD
E RIVER RD
E CLOUD RD
E GRANT RD
N WILMOT RD
N KOLB RD
N SABINO CANYON RD
N BEAR CANYON RD
N HOUGHTON RD
E CATALINA HY
E TANQUE VERDE RD
E REDINGTON RD
N PANTANO RD
E WRIGHTSTOWN RD
N CAMINO SECO
E SPEEDWAY BL
E BROADWAY BL

MAP 2: PIMA COUNTY PROPOSED RIPARIAN HABITAT



The other aspect of the plan is to restore vegetation to stretches of the riparian corridor. It is anticipated that restoration interventions will involve importing reclaimed water, or other sources of water, for habitat restoration. The exact areas for restoration intervention have not yet been determined; however, likely criteria for selection are that the riparian corridor must be in an environmentally sensitive area and in an area with a stressed aquifer. The study area chosen for this article meets both criteria. Another condition that is likely to factor into the choice decision is the availability of reclaimed water conveyancy infrastructure. In our chosen study area, Tucson Water, the main water provider in Pima County, is currently extending reclaimed water pipes east along a major east-west road that runs almost parallel to the main riparian corridors in our study area. The rationale for this investment is to switch golf course irrigation from water of drinking water quality to reclaimed water. Although Pima County has not contracted with Tucson Water to use this reclaimed pipeline to deliver its SDCP environmental allocation of reclaimed water to sites along the main Rillito and Tanque Verde washes, it is one possible option and is the option we assess in this article. Another argument in support of our choice is that the SDCP

prioritizes the protection of remaining fragments of urban riparian habitat and the restoration of the main urban degraded corridors: the Santa Cruz, Rillito, and Pantano washes. Large sections of the Rillito and Pantano washes are in our study area.

Incremental property value benefits of the SDCP riparian habitat conservation and restoration plan derive from three distinct areas: preventing degradation of existing habitat threatened by groundwater overdraft, the enhancement of existing habitat, and the geographic extension of this habitat. To calculate these benefits properly, a follow-up site survey would need to be completed to assess post-SDCP habitat condition. A naïve, low-bound estimate of habitat enhancement for the outlined study area shown in Map 2 would double the total property premium benefits to $253.08M, or an incremental increase of $126.54M.[33] However, this approach is naïve because, without implementation of the SDCP, the quality of self-sustaining habitat would degrade. If we assume that without the SDCP half the current habitat would be degraded, then the *incremental* benefits rise to $189.81M. Other scenarios focus on changes in the quantity of riparian habitat. For example, *incremental* benefits rise to $253.08M in the case where we assume half the status quo acreage would degrade without interventions and that the addition of SDCP water would simultaneously increase pre-intervention habitat acreage by 25 percent[34] and enhance habitat quality.[35] In the remainder of this article we use the mid-level estimate of $189.81M as the estimate of property value benefits.

THE SONORAN DESERT CONSERVATION PLAN: COSTS

In this section we address the fixed and variable costs of urban riparian habitat protection and restoration. We have some indication of the range of fixed costs for urban riparian restoration in Pima County. The lower figures represent passive restoration techniques, such as restoring natural water flows and including spring and winter discharges of water and sediment[36] into degraded reaches that would, without planting, favor the establishment of desired native species. For these techniques, the fixed costs are nearly zero. The higher end of the cost range reflects active measures such as revegetation and installing

33. This estimate is based on the doubling of hydro-mesoriparian species richness from 2 to 4. *See also supra* note 27.

34. We assume a straight proportion increase in the number of homes benefiting from the extended habitat. This results in an additional 973 homes (25 percent of the 3,893 homes located in the buffers) for a total of 4,866 homes in this scenario.

35. *See supra* note 33.

36. Zamora-Arroyo et al., *supra* note 10, at 61; Levine & Stromberg, *supra* note 9, at 124.

irrigation systems to restore higher quality habitat. Per acre restoration costs have been between $4,000 and $20,000 per acre, while per riverine mile costs range from $84,000 to $250,000.[37] Using the Geographic Information Systems coverage that is shown in Map 2, we can calculate the proposed acreage of restored "hydroriparian habitat," shaded with hatch marks and with the descriptor "H," at 9,432 acres. Using the cost estimates above, the total cost of this restoration would be between $37.69M and $188.46M.[38] In our smaller study area, the restoration cost is estimated at between $11.68M and $58.42M.

The next step is to estimate the costs of water for urban riparian restoration and conservation. In an agreement with the City of Tucson, the SDCP permanently secured a minimum of 5,000 AF of treated wastewater (conservation effluent pool water) per year for riparian restoration, which then increased to 10,000 AF in 2005.[39] This 10,000 AF/yr of conservation effluent pool water is separate and in addition to the 12,559 AF/yr of reclaimed water the city delivers for use on parks, turf, and golf courses. To understand how this water will be used for different types of riparian habitats, we use initial habitat restoration descriptions from the Pima County Regional Flood Control District provided for the Paseo de las Iglesias project in Tucson.[40] The project developers anticipated that to support shallow groundwater-dependent riparian trees, one-third to two-thirds of all irrigation water used in the entire project would be required to maintain intermittent to perennial flow in the main channel.[41] However, their current proposal anticipates

37. Memorandum Re Mitigation Costs Update to Suzanne Shields, Deputy Director, Pima County Flood Control District, from Thomas Helfrich, Division Manager, Pima County Flood Control District (Apr. 28, 2003) (costs are based on previous projects in southern Arizona completed over the last ten years).

38. We estimate the restoration costs in our smaller study area as a straight proportion of total acreage. This somewhat arbitrary assumption is that the proportion of total costs that would be spent in our study area is based on the proportion of riparian habitat in our smaller area compared to the total area. There are 2,912 acres of shallow groundwater-dependent riparian habitat in our study area (31% of the total SDCP regulated 9,432 riparian acres).

39. Sonoran Desert Conservation Plan, *supra* note 30.

40. Pima County Regional Flood Control Dist., Paseo de las Eglesias: Habitat Explanations, http://www.rfcd.pima.gov/Envrest/PDLIapproaches.htm (last visited May 20, 2006).

41. *Id.* This plan incorporates irrigation for the initial establishment of dry (xeroriparian) habitat of mesquite and palo verde shrubland and Sonoran desertscrub species. Intermittent water-dependent (mesoriparian) habitat restoration would restore mesquite-hackberry bosques merging with dry riparian species. This plan requires the installation of a permanent irrigation system. Finally, shallow groundwater-dependent (hydroriparian) habitat restoration would restore cottonwood-willow galleries bordered by

that all water secured for this project will be used to irrigate vegetation, not to sustain flow.

For our project analysis we assume that two-thirds of the total 10,000 AF of water secured for the SDCP will be used to support shallow groundwater-dependent riparian restoration and preservation. We also assume that water costs are $260.92/AF, resulting in total annual variable costs of $1.74M. As per the restoration cost calculation above, we estimate that the proportion of water that will be delivered to our study area is 31 percent,[42] at a cost of $0.54M.

Although other types of water may be secured for the SDCP, the current water source for the project is priced at the environmental (interruptible) rate specified for riparian rehabilitation projects in a 2000 intergovernmental agreement (IGA) between the City of Tucson and Pima County.[43] This rate is lower than Tucson Water's published commodity rate for uninterrupted reclaimed water of $610/AF. The $260.92/AF is based on the actual operations and maintenance costs of treatment and distribution ($197.23 + $63.69).[44] The inclusion of capital costs would raise water costs to $551.40/AF.

The next step is to consider whether the variable costs (annual water costs) of the SDCP can be self-financed by higher property tax revenues. Netusil et al.[45] did a similar analysis of open space policies in Portland, Oregon. According to their study, the possibility for self-financing only occurs in neighborhoods where homes have high assessed values. Our study area does incorporate some high-income neighborhoods, as well as moderate-income areas.

SONORAN DESERT CONSERVATION PLAN: PARTIAL ECONOMIC ANALYSIS

We now have all of the information necessary to weigh the partial costs and benefits of riparian habitat restoration. We cannot do a full benefit cost analysis, as we have not measured the public good

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the mesoriparian habitat described above. The plan would require instream flows for restoration.

42. *See supra* note 38 (the calculation: 31% of $1.74M = $0.54M).

43. Resolution of the Board of Supervisors of Pima County Relating to Water; Authorizing and Approving the Execution of a Supplemental Intergovernmental Agreement with the City of Tucson and Pima County Flood Control District Regarding Effluent. Pima County Resolution No. 2000-28 § 5.2.2.1 (2000).

44. *Id.* §§ 6.5, 12.3.

45. Noelwah R. Netusil et al., *Can Open Spaces Be Self-Financing?*, CHOICES: THE MAGAZINE OF FOOD, FARM & RESOURCE ISSUES, 2d Quarter 2000, at 21.

benefits[46] of riparian habitat restoration. This partial analysis uses property premiums and incremental property taxes. We previously estimated property value premiums of around $189.81M. If we assume an average tax rate of 14.5 percent[47] on ten percent of a home's assessed value for property tax purposes, and if we assume that assessed values are 66 percent of house sales prices,[48] then the $189.81M property-value-premium attributable to the home's proximity to riparian habitat results in incremental property tax revenues of $1.82.[49] The incremental property tax benefits exceed the annual cost of IGA-supplied water.[50]

The requirement for a "good" project is that the benefits exceed the costs. In Table 1 we summarize restoration and ongoing costs of riparian habitat. The low scenario reflects the lower cost restoration estimates and the high scenario the higher cost restoration estimates.

Table 1: Fixed and Variable Costs of Riparian Habitat Restoration

	Low	High
Costs		
FIXED		
Restoration	$0 to $11.68M	$58.42M
VARIABLE		
Reclaimed water IGA2000	$0.54M	$0.54M
Benefits		
Property premiums	$189.81M	$189.81M
Incremental property tax revenues	$1.82M	$1.82M

We have not calculated the benefits from the entire proposed shallow groundwater-dependent riparian habitat restoration project shown on Map 2. Other stretches of the riparian corridor support such riparian habitat outside of our study area. However, the SDCP can be recommended for approval, based on our partial financial analysis,

46. Public good benefits include flood control and water infiltration into the regional aquifer as well as benefits to recreationists and to habitat.

47. In the 2006 tax year, property tax rates in the study area averaged 14.5 percent. Telephone Interview with Peggy, Budget Analyst, Finance Department, Pima County, Ariz. (Nov. 7. 2006). The tax rate is per $100 assessed value. Tucson Unified School District: 15.3235 percent; Tanque Verde School District: 13.4181 percent;. Catalina Hills School District: 14.6806 percent. We also assume that the property tax rate remains unchanged over the period of the riparian restoration.

48. This percentage is based on the average (and median) assessed value calculated as a proportion of actual sales price of 2,265 homes sold in 2003 in the study area.

49. This calculation is illustrated here in three stages: $189.81M x 0.66 = $125.27M; $125.27M x 0.1 = $12.53M. $12.53M x 0.145 = $1.82M.

50. These property tax revenues are neither currently spent on, nor are they likely to be spent directly on, riparian habitat conservation and enhancement. However, this does not invalidate the comparison of benefits and costs.

because the incremental property tax revenues from our smaller study area alone attributable to the habitat exceed the entire SDCP's annual water costs of conservation. The financial advantages would be stronger still if we added the private property benefits accruing to homeowners living further from the riparian corridor than our 0.2 mile cutoff and to those living in multifamily residences. The case could be further strengthened if we estimated the other considerable benefits accruing from riparian habitat preservation and restoration such as flood control, bank stabilization, water infiltration into the regional aquifer,[51] recreation, and wildlife habitat.

DISCUSSION

The SDCP has three priorities: first, to preserve remaining functioning riparian habitat; second, to sustain water-stressed habitat through the importation of renewable water to the habitat; and finally, to restore degraded riparian habitats.[52] Water is the essential resource necessary to regenerate riparian habitat. The SDCP utilizes earmarked wastewater in an intergovernmental agreement. The security of this water source is an important consideration given that young shallow groundwater-dependent trees are particularly susceptible to groundwater declines.[53] We note that the IGA secures a permanent 10,000 AF annual supply, the price of which is determined by operations and maintenance costs. Our partial economic analysis demonstrates net economic benefits accrue from the preservation and enhancement of the riparian corridor by ensuring hydrologic conditions necessary to support high quality riparian habitat, which in turn preserves private property values and secures property tax revenues. Without projects such as the SDCP, the future for riparian corridors in Tucson is uncertain. Growth and associated increased water demand would likely negatively impact remaining riparian habitat. Recent research shows that as groundwater levels decline riparian tree communities shift from more highly valued shallow groundwater-dependent riparian species to lower value dryland

51. The most common and most economical method of artificial recharge is surface infiltration via dry streambeds. Central Arizona Project, http://www.cap-az.com//recharge/index.cfm?action=What&subSection=70 (last visited June 8, 2006). Thus, we believe Pima County might be able to receive groundwater credits from measurable recharge, which, in turn, would reduce the costs of the program. Recharge might also reduce land subsidence risks and, therefore, potential damage claims.

52. Sonoran Desert Conservation Plan, *supra* note 30.

53. Nadine M. Amlin & Stewart B. Rood, *Comparative Tolerances of Riparian Willows and Cottonwoods to Water-table Decline*, 22 WETLANDS 338, 338–46 (2002).

and invasive species communities.[54] Such a shift would, in turn, significantly impact nearby private property values (and property tax revenues) as well as wildlife habitat and recreation activities. Additionally, if groundwater levels decline further, herbaceous cover also will decline, thereby reducing bank stabilization[55] and increasing the necessity for expensive flood damage and control infrastructure. Our results are relevant to other current policy discussions beyond the SDCP. Three are discussed below.

This research suggests that net economic benefits may accrue from legally limiting or curtailing private wells in exurban Tucson.[56] Wells sunk near riparian corridors create a cone of depression, lowering the water table, which, in turn, can kill neighboring riparian trees relying on shallow ground water and high soil moisture content, species that are highly valued by nearby homebuyers. Revisions to the current interim Arizona well-spacing rules[57] are currently being considered. A number of parties have suggested modifications that would define "damage to surrounding land or (other) water users"[58] to include damage to riparian habitat and surface water rights holders. This analysis provides evidence of the significant property values that could be "damaged" by unregulated groundwater (or subflow) pumping near a riparian corridor.

The study also provides new information that could be disseminated to Pima County homeowners to inform them of the property premiums associated with riparian habitat conservation. Some property owners are concerned about the impact of new riparian protection laws passed in Pima County in 2005.[59] The new policy places limits on the ability of property owners to manage their land, but

54. S.J. Lite & J.C. Stromberg, *Surface Water and Ground-water Thresholds for Maintaining Populus-Salix Forests, San Pedro River, Arizona*, 125 BIOLOGICAL CONSERVATION 153, 153–67 (2005).

55. J.C. Stromberg et al., *Effects of Groundwater Decline on Riparian Vegetation of Semiarid Regions: he San Pedro, Arizona*, 6 ECOLOGICAL APPLICATIONS 113, 113–31 (1996).

56. Colby & Wishart, *supra* note 28.

57. ARIZ. REV. STAT. ANN. § 45-598(A) (2003) (Current well-spacing rules are intended to "prevent unreasonably increasing damage to surrounding land or other water users from the concentration of wells.").

58. *Id.*

59. Pima, Ariz., Code § 16.30 (2005) (This change in the law tripled the size of the riparian buffer that homebuilders and homeowners must protect when developing more than one-third of an acre. Additionally, the new law expanded the acreage protected in unincorporated areas of the county from 26,251 acres to 87,273 acres. Within the regulated areas, developers must replace each old tree removed or protect land elsewhere. A key aim of the new law is to mitigate flood damage through conservation of riparian vegetation within regulated areas. Landowners must replace vegetation volume removed or protect land elsewhere.).

offsetting these restrictions are property value premiums accruing from habitat protection.

Pima County has a program to preserve riparian habitat by direct purchase. Such purchases also support wider access to such habitats. However, there are appraisal obstacles in the Floodprone Land Acquisition Program.[60] Appraisal practices consider floodplain restrictions, which may limit potential uses of parcels in the floodway.[61] Current appraisal practices do not consider the value of the vegetation to private property owners and thereby discount property values in the floodplain fringe. However, the program may allow the use of ancillary data, such as an estimate of the "value" to nearby property owners of the particular type of riparian habitat considered for purchase. Such house price premiums can be large. Nevertheless, without water policies designed to maintain habitat, such as those incorporated in the SDCP, the outright purchase of parcels that contain significant riparian habitat is not a guarantee of the survival of these ecosystems.

In concluding, we consider whether Arizona's water law allows such non-consumptive water use. Arizona's water rights system is based on the doctrine of prior appropriation. This "first in time, first in right" policy was modified with the 1919 Public Water Code (PWC),[62] which manages surface water in the state. From that date, a person had to apply for and receive a permit in order to appropriate surface water for a beneficial use.[63] The PWC lists the following as beneficial uses: "domestic, municipal, irrigation, stock watering, water power, *recreation, wildlife,* including fish, *nonrecoverable water storage*...[and] mining uses."[64] Specifically, the code allows a person to apply for a permit for instream flow maintenance[65] necessary to support and preserve wildlife, fish, and recreation. Additionally, a permitee must demonstrate that he or she is using the instream flow water right in a manner consistent with the terms of the permit or the right will be forfeited. In western Arizona,

60. Pima County Flood Control Dist., Floodprone Land Acquisition Program, http://rfcd.pima.gov/landacq/ (last visited June 8, 2006).

61. Pima, Ariz., Code § 16.24 (2005).

62. ARIZ. REV. STAT. ANN. §§ 45-141 to 45-166 (2003).

63. Arizona Dep't of Water Resources, Surface Water Rights, Public Water Code, http://www.azwater.gov/WaterManagement_2005/Content/WaterRights/default.htm (last visited June 9, 2006).

64. ARIZ. REV. STAT. § 45-151(A) (2003) (emphasis added).

65. Arizona Dep't of Water Resources, Surface Water: Answers to Frequently Asked Question, 5. What types of surface water right filings are made with the Arizona Department of Water Resources to appropriate or claim water rights?, http://www.azwater.gov/WaterManagement_2005/Content/WaterRights/surface_water_faqs.htm#05dot2 (last visited June 9, 2006).

along the Colorado River, the Colorado River Compact's Article I[66] permits restoration and conservation of riparian corridors for flood mitigation.

Perhaps the most difficult riparian protection policy issue is that homeowners fear that riparian habitat protection "may threaten livelihood and lifestyle."[67] Therefore, policy-relevant research needs to investigate how property owners are affected when riparian corridors are preserved or restored.

In this article, we have applied results from a recent hedonic price analysis and demonstrated that a healthy riparian corridor increases nearby property values and that restoration and preservation projects can be self-financing. A fuller benefit cost analysis would seek to estimate the other benefits provided by riparian habitat such as flood control, infiltration to the regional aquifer, bank stabilization, open space, recreation, and aesthetic and ecosystem values. Such a study would improve the benefit-cost argument for riparian preservation and restoration. This research has wider applicability than in Arizona or to riparian resources. There are a whole class of public goods that add to private property values, such as open space, wetlands, and parks, and there are often questions about the economic cost of providing such public goods. Our analysis demonstrates an approach to assessing the property value effects of such programs.

66. Colorado River Compact art. I, 70 Cong. Rec. 324 (1928) (allowing the river to be managed for "the protection of life and property from floods").

67. Joe Gelt, *Managing the Flow to Better Use, Preserve Arizona's Rivers*, http://ag.arizona.edu/AZWATER/arroyo/064rvtxt.html (last visited June 10, 2006).