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Analysis

The valuation of off-site ecosystem service flows: Deforestation, erosion and the amenity value of lakes in Prescott, Arizona

James Yoo [a,*,1], Silvio Simonit [b,1], John P. Connors [c], Ann P. Kinzig [d], Charles Perrings [d]

[a] The Department of Economics & Business, Bethany College 26032, USA
[b] Global Institute of Sustainability, Arizona State University 80287, USA
[c] School of Geographical Sciences, Arizona State University 80287, USA
[d] School of Life Sciences, Arizona State University 80287, USA

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ABSTRACT

One of the most important services provided by forests is the control of erosion. We investigated the value of forest cover in protecting water quality in five urban lakes around Prescott, AZ. We first estimated the role of forest cover in regulating sediment loadings into each lake via a sediment delivery model. We then used 8301 single-family residential property transactions that occurred between 2002 and 2005 in Prescott, AZ, to estimate a hedonic price function. This yielded an estimate of the marginal willingness-to-pay (MWTP) for avoiding 1 t of sediment per lake-acre, from which we were able to infer the marginal willingness to pay for the erosion control services associated with a 10% change in current canopy cover. We found that the marginal value of the erosion control services of forest cover varies widely across the watersheds depending on the accessibility of affected lakes, the current level of canopy cover, and the number and value of affected residential properties among other factors.

1. Introduction

1.1. Study Background

Since publication of the Millennium Ecosystem Assessment, it is also widely recognized that public lands have a critical role to play in supplying regulating services such as climate regulation through carbon sequestration, pollution buffering, flood mitigation, fire and disease regulation, and the control of soil erosion (Millennium Ecosystem Assessment, 2005). While markets exist for some of these services, recreation for example, most are not transacted in the market and so are not priced. Given this, a recent report by the President's Council of Advisors on Science and Technology (PCAST) recommended the adoption of an ecosystem service-based strategy for managing public lands and, to support this, the development of the methods required to establish the value of those services (President's Council of Advisors on Science and Technology, 2011).[2] The report noted that if it is not possible to determine the contribution of particular ecosystem service flows to human wellbeing, then it is also not possible to manage those flows efficiently.

In this paper, we consider the value of one of the regulating services generated by public lands that benefits private individuals, households and corporations. In particular, we consider a service whose benefits are capitalized into the value of private assets: the control of soil erosion by forest cover in watersheds. While there are many such services provided by public lands, few have been formally evaluated. Yet, understanding the value of the ecosystem services supplied by public lands is crucial to the efficiency of their management.

1.2. Literature Review

Most existing studies of the value of non-marketed ecosystem services from public lands have used stated preference (discrete

* Corresponding author. Tel.: +1 602 705 7311.
E-mail addresses: jyoo@bethanywv.edu (J. Yoo), ssimonit@asu.edu (S. Simonit), jpconno1@asu.edu (J.P. Connors), Ann.Kinzig@asu.edu (A.P. Kinzig), Charles.Perrings@asu.edu (C. Perrings).
[1] James Yoo and Silvio Simonit are equally shared authors.

[2] Specifically, the PCAST report recommended that: "Federal agencies with responsibilities relating to ecosystems and their services (e.g., EPA, NOAA, DOI, USDA) should be tasked with using best available techniques to develop valuations for the ecosystem services affected by their decision-making and factoring the results into analyses that inform their major planning and management decisions."

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choice) methods designed to get people to express their willingness to pay for some ecosystem service, or their willingness to accept to compensation for forgoing some ecosystem service. Stated preference methods have, for example, been applied to the valuation of water quality (Beharry-Borg and Scarpa, 2010; Kosenius, 2010), open space and landscape (Hanley et al., 1998; Huber et al., 2011), recreation (Hanley et al., 2002), and habitat (Christie et al., 2006). Our approach belongs to a different class of valuation methods — those designed to recover peoples' willingness to pay/accept from observed transactions in markets that are related to the non-marketed ecosystem services in some way. The most long-standing of revealed preference methods, the travel cost method, has been used to assess the recreational value of public lands for several decades (Clawson and Knetsch, 1966), whether in isolation or in combination with hedonic methods (Adamowicz et al., 1994; Englin and Mendelsohn, 1991). Hedonic price methods have also been applied to the valuation of neighborhood attributes including forest cover (Mansfield et al., 2005; Sander and Haight, 2012; Sander et al., 2010), air quality (Anselin and Lozano-Gracia, 2008; Smith and Huang, 1995; Zabel and Kiel, 2000), access to parks (Salazar and Menendez, 2007; Troy and Grove, 2008), noise pollution (Clark, 2006), and exposure to hazardous waste (Deaton and Hoehn, 2004; Greenstone and Gallagher, 2000). More relevant to our analysis are the studies that have applied hedonic methods to the valuation of lakes, wetlands and water quality (Boyer and Polasky, 2004; Brown and Pollakowski, 1977; Doss and Taff, 1996; Espey et al., 2007; Kruse and Ahmann, 2009; Leggett and Bockstael, 2000; Lewis and Acharya, 2006).

Previous hedonic studies of lake water quality have shown that the amenity values associated with lake quality are reflected in lake-front residential property prices. One body of research has found that the proximity to lakes, access to lake recreation and the quality of the lake's overall scenic beauty all increase property values (Brown and Pollakowski, 1977; Espey et al., 2007; Kruse and Ahmann, 2009; Landford and Jones, 1995; Seiler et al., 2001). However, this does depend on lake quality. Lewis and Acharya (2006), for example, found that proximity to lakes of poor water quality decreases nearby property prices. Another body of research has explored the impact of water quality improvements by looking at lake water quality measures such as sedimentation loadings (Bejranonda et al., 1999), fecal coliform (Legget and Bockstael, 2000), and water clarity (Michael et al., 1996).

There are, however, no studies of the land use drivers behind lake water quality, nor are there studies of the derived value of watershed management practices that affect lake water quality. To address the challenge posed in the PCAST report on ecosystem services referred to earlier, we extend the literature by connecting a spatially explicit sediment delivery model to a hedonic water quality model. This enables us to derive the value of sediment control functions of forest cover in the watersheds around lakes. Information of this kind is needed if watershed managers are to take due account of this service in their decisions. Since downstream residents are the primary beneficiaries of improved water quality, the same information may be useful in designing payment systems that allow residential property owners to secure upstream forest conservation.

The primary contribution of the paper is thus to estimate the value of the sediment control functions of forested public land (a change in canopy cover) in the watersheds associated with five major lakes around Prescott, AZ. The novelty of the approach lies in the fact that it links the recreational and amenity value of lakes to regulating service generated by forest cover elsewhere in the watershed. We ignore other ecosystem services supplied by forested watersheds, so this is not an attempt to estimate the full value of a marginal change in forest cover. Rather it is an attempt to show how established non-market valuation methods may be used to estimate the value of one important externality of public lands. By integrating hedonic pricing models with sediment delivery models that connect lake quality to land use/land cover (LULC) change across the lake basins, we are able to estimate the capitalized value of sediment control functions to the scenic value of lakes. We hypothesize that the off-site effects of canopy cover change on lake quality are reflected in the value of residential properties with lake access. To the best of our knowledge, there are no previous attempts to use hedonic price methods to estimate the off-site sediment control effects of land cover change in watersheds.

The paper is organized as follows. Section 2 describes the study area and the forest management regime in that area. Section 3 presents the sediment delivery and hedonic price models that were estimated in this study. This is followed by presentation and discussion of results and in Section 4. A final section offers our Conclusions.

2. Lake and Forest Management in the Study Area

Our study area comprises the Prescott metropolitan area in central Arizona and the watersheds around five lake basins in that area (Granite Basin Lake, Willow Creek Reservoir, Watson Lake, Lynx Lake, and Upper Goldwater Lake). Prescott lie in Yavapai County, which has a total area of 8123 mile^2 and an average population density of 26 per square mile (Census, 2010). As of 2010, it had a population of 211,033, with median household income of $43,290. The total number of housing units was 111,093 between 2006 and 2010, and the home ownership rate was about 75%.

The five selected lakes in our study provide a range of benefits to the residents of Prescott. Willow Creek Reservoir and Watson Lake lie in northeastern Prescott, at the southern end of the scenic Granite Dells area. The city of Prescott purchased the lakes in 1998 both to serve the city's water supply needs, and for recreation. Goldwater Lake is located in southern Prescott, within Prescott National Forest. It provides a variety of recreational opportunities including kayaking and canoeing. Lynx Lake, located a few miles southeast of Prescott, is also within Prescott National Forest. It is smaller than Willow and Watson Lakes, but it attracts around 125,000 visitors annually. Finally, Granite Basin Lake is a man-made lake, located in Prescott National Forest adjacent to the Granite Mountain Wilderness Area. It is the smallest of the five lakes.

Each of the five lakes is either adjacent to or in Prescott National Forest, one of six national forests in Arizona. The Prescott National Forest, comprising about 1.25 million acres, is managed and administered by the United States Forest Service under Prescott National Forest Land and Resource Management Plan. The management plan identifies desirable conditions for three different elements: physical, biological, and social/economic resources[3] (Forest Service, 2012). In some cases, a desirable condition matches current conditions, in other cases it does not. Desirable conditions are described at three scales: the landscape scale (10,000 acres or greater), mid-scale (1000 acres or greater), and fine scale (less than 100 acres).[4] The existing plan does not explicitly include the regulation of sediment delivery among the set of desirable conditions at any of these scales. Forests are, however, known to protect landscapes against soil erosion and landslides, preventing the consequences of flooding and maintaining water quality for downstream water users (Millennium Ecosystem Assessment, 2005). In the Prescott area, the protection of water quality for downstream users includes the regulation of the sediment burden

[3] Physical resources relate to non-living, ecosystem components such as climate, airsheds, and watersheds. Biological resources relate to living, growing things such as vegetation and aquatic and terrestrial wildlife. Social/economic resources include recreation and transportation opportunities and cultural characteristics of communities such as ranching, scenic beauty, and open space (Forest Service, 2012; Draft Land and Resource Management Plan for the Prescott National Forest, Prescott, AZ).

[4] For instance, in the description of desirable condition for the Ponderosa Pine–Gamble Oak PNVT, landscape scale descriptions specifies that forest land should be separated from open space, while fine scale description identifies that some of the groups of tree between open space should be formed in tight clumps with interlocking tree crowns (Forest Service, 2012).

to the city lakes. Since sediments are also known to make lakes less desirable for boating, fishing, swimming, and scenic beauty (Bejranonda et al., 1999), we expect differences in water quality in the lakes to be reflected in differences in residential property prices, other things being equal. We also expect that an understanding of the capitalized value of the sediment control functions of the forest can usefully inform forest management.

3. Methodology

We estimated the value of changes in forest cover affecting the amenity value of lake water quality using the hedonic price method. We approached the problem in stages. We first developed a spatially explicit model of sediment flows as a function of watershed forest cover. We then estimated the capitalized value of lake water quality using hedonic pricing methods. Finally, we derived the implicit willingness to pay for the sediment control functions of forests in the upstream contributing area of each lake.

3.1. Sediment Delivery Model

Modeling the LULC-driven sedimentation processes requires several steps. First, we modeled the impact of land cover on on-site soil erosion given a set of landscape variables (i.e. precipitation, slope and soil characteristics). Then, we estimated the percentage of the eroded soil reaching the stream network, and thus the lakes, using a sediment delivery approach. Erosion was modeled using the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978):

$$A_x = R_x K_x LS_x C_x P_x \tag{1}$$

where A_x expresses soil loss (t ha^{-1} yr^{-1}) for the x pixel; R_x represents rain erosivity (MJ mm^{-1}/ha h^{-1} yr^{-1}); K_x is a measure of soil erodibility (t ha^{-1} h^{-1}/ha MJ^{-1} mm^{-1}); LS_x is the slope length and steepness combined in a single index; C_x is an index of land cover practice; and P_x represents soil conservation (if none is applied $P_x = 1$). The spatial distribution of the rain erosivity index was determined from rainfall data by a 30 arcsec mean annual precipitation raster for the period 2000–2005 (PRISM Climate Group) and following Renard and Freimund's (1994) estimated relationships between mean annual precipitation and rain erosivity.

Soil erodibility values were taken from the 1:250,000-scale U.S. General Soil Map STATSGO Database. The length-slope factor was obtained using the Upslope Contributing Area approach (Mitasova et al., 1996; Moore and Burch, 1986) applying a maximum slope length threshold of 300 m (McCool et al., 1997) to appropriately represent the inter-rill and rill erosion processes. The values for the land cover factor (C) were based on reference tables (Wischmeier and Smith, 1978) applied to the spatial distribution of land cover types provided by the 2001 National Land Cover Database (NLCD). For Shrubland, Grassland and Pasture, a classification scheme was applied (Wischmeier and Smith, 1978: Tab.10, pag.32), based on four sub-factors: the vegetative canopy type and height, the vegetative canopy percent cover, the type of cover that contacts the soil surface, and the percent ground cover. The vegetative type for Shrub/scrub was assumed as “Tall weeds or short brush with average drop fall height of 20 in., with 25% canopy cover and 60% grass ground cover”; for Grassland/herbaceous and Pasture/hay, we assume 60% and 40% grass ground cover respectively. For forestland, we measured the spatial variation in canopy cover by overlapping the 2001 canopy cover map at 30 m resolution and the forest area identified by the 2001 NLCD. Assuming that the area not covered by canopy in each forest pixel was represented by grasslands we then applied the following function for the estimation of the land cover factor for forest:

$$C_{x,\text{forest}} = C_{x,\text{NLCD}=42} + (1-\beta_x) C_{x,\text{NLCD}=71} \tag{2}$$

Table 1
Assigned *C*-factors to NLCD categories.

NLCD	Land cover type	*C*-factor
11	Water	0.000
21	Developed, open space	0.003
22	Developed, low intensity	0.001
23	Developed, medium intensity	0.001
24	Developed, high intensity	0.000
31	Barren land	0.700
42	Evergreen forest	0.0001
52	Shrub/scrub	0.038
71	Grassland/herbaceous	0.042
81	Pasture/ray	0.100
82	Cultivated crop	0.240
90	Woody wetland	0.003
95	Herbaceous wetlands	0.003

where $0 \leq \beta_x \leq 1$ defines the percent canopy cover of the xth forest pixel and where subscript NLCD = 42, 71 refers to the National Land Cover Dataset index for forest and scrubland respectively, as reported in Table 1. It is acknowledged that land cover is variable within and across watersheds, and changes seasonally. The C-factors used for the model were intended to represent typical annual conditions at a coarse scale, shown in Table 1.

Applying Eq. (1), we obtained the spatial distribution of soil erosion. In relatively large watersheds, most sediment gets deposited within the watershed and only a fraction of soil that is eroded from hill slopes reaches the stream system or watershed outlet. This fraction or portion of sediment that is available for delivery is referred to as the Sediment Delivery Ratio (SDR). This ratio was then multiplied by the predicted erosion rate to estimate the percent of eroded material/sediment/pollutant reaching the watershed outlet. We adopted the SEDD model proposed by Ferro and Minacapilli (1995), which assumes that the transport capacity of stream flows is not a limiting factor and considers each pixel as a morphological unit. The SDR_x, the fraction of the gross soil loss from pixel x that actually reaches a continuous stream system, was estimated as a function of run-off travel time (Ferro and Minacapilli, 1995), calculated by adding the travel time for all the pixels located along the flow path (Jain and Kothyari, 2000). Following this approach we estimated the spatial distribution of the SDR using a digital elevation model (DEM) raster. Multiplying this ratio by the predicted soil erosion we obtained the sediment yield from location x arriving at the lake at the outlet of the basin.

3.2. Hedonic Price Method

We then used the hedonic price method to explore the impact of sediment loading to the lakes on the price of neighboring residential properties. We suppose both that the value of LULC change varies across lake basins and sediment loading, and that it can be recovered from residential property transactions within a given distance of the lakes. Residential properties consist of a bundle of attributes described by a vector of characteristics, z, that includes: [A] structural characteristics such as age of property, lot size and square footage of living area; [B] locational characteristics such as proximity to lake and major highway; [C] neighborhood characteristics including surrounding land uses; and [D] environmental characteristics such as sediment loads. A hedonic price function, $P(z)$, refers to the market equilibrium price schedule that varies with the changes of z, holding all the levels of other characteristics constant. This schedule is determined by the demand and supply of the houses in the real estate market, and is expressed as a function of characteristics or attributes of property

$$P(z) = P(z_1, \ldots, z_n). \tag{3}$$

The coefficients of the estimated Eq. (3) define the marginal willingness to pay for the attributes of the property.

The selection of the functional form for the hedonic price function has been a controversial issue. Palmquist (1991) and others suggest that economic theory generally does not provide any guidance for specifying the appropriate functional form for the hedonic price function (Faux and Perry, 1999). A recent study (Kuminoff et al., 2010) shows that more flexible specification such as Box–Cox model outperforms the simpler semi-log model, however, we selected the semi-log functional form given the interpretability of its marginal effects, and given the evidence that simple functional forms tends to outperform more complex specifications in recovering the marginal implicit price in the presence of model misspecification (Abbott and Klaiber, 2010; Cropper et al., 1988). The simplest OLS semi-log function is expressed as:

$$\text{Log}P = b_0 + \sum b_k L_k + \sum b_l D_l + \sum b_m E_m + \varepsilon \tag{4}$$

where P is represented by a vector of residential property prices, and L_k is a matrix of structural characteristics, D_l is the matrix of location characteristics, and E_m is a matrix of environmental characteristics. b_0, b_k, b_l, and b_m, are the estimated parameters associated with constant, structural, locational, and environmental characteristics, and ε represents the unobserved error terms.

The simplest OLS semi-log model produces unbiased and efficient estimators if there exists no spatial autocorrelation in unobserved error terms or neighboring property prices. However, it has been recognized that the influence of location and spatial dependency on house prices are prevalent in housing sales data. For example, a house that is surrounded by expensive neighboring houses is worth more than the same house that is surrounded by cheaper house. Failure to correct for spatial autocorrelation in unobserved error terms or neighboring property prices has unpleasant implications from an econometric perspective. OLS still produces unbiased estimators in the presence of spatial autocorrelation in the error terms, but at the cost of efficiency (Kim et al., 2003). When ignoring the influence of neighboring house prices, OLS estimators are biased and inconsistent.

The spatial lag model (SLM) assumes that neighboring housing prices partially explain local housing price (Kim et al., 2003). It can be written as follows:

$$Y = \rho WY + X\beta + \varepsilon \tag{5}$$

where ρ is a lag parameter for neighboring property prices, and W is an n × n spatial weights[5] matrix. There are several methods used to construct W (Anselin, 1988b; Le Sage and Pace, 2009), but the most widely and conventionally used method is a row-standardized weights matrix.[6]

The underlying assumption of the spatial error model (SEM) is that property price generation is influenced by omitted variables or measurement errors that affect neighboring observations as well, so that errors are spatially correlated. The model is expressed:

$$Y = X\beta + \varepsilon, \text{ and } \varepsilon = \gamma W\varepsilon + u, \ u \sim iid\left(0, \sigma_u^2\right) \tag{6}$$

where γ is an autoregressive parameter, and u is a n × 1 vector of iid errors with zero mean and variance of σ_u^2. Both SLM and SEM were estimated via maximum likelihood methods.

We estimated marginal willingness to pay for the attributes of the ith lake from the sub-set of properties having that lake as the nearest water body. Such properties could or could not be located within the lake's watershed. Specifically, marginal willingness-to-pay (willingness-to-accept) for a marginal decrease (increase) of 1 t of sediment loading per lake acre for OLS, SLM, and SEM models was calculated as follows:

$$MWTP_i = \beta_{\text{sedimentation}} \overline{P}_i \tag{7}$$

(OLS and SEM models)

$$MWTP_i = \beta_{\text{sedimentation}} \overline{P}_i \left(\frac{1}{1-\sigma}\right) \tag{8}$$

(SLM model)

where σ is the estimated parameter for spatial autocorrelation, $\overline{P}_i$ represents the average property price attached to the ith lake, and $\beta_{\text{Sedimentation}}$ is the coefficient on sedimentation estimated from OLS, SEM, and SLM models.

Since sediment loading into each lake is driven by forest cover, we were then able to estimate the marginal value of the sediment control functions of forest cover according to the following equation:

$$MV_{\beta_{ix}} = MWTP_i \frac{\partial Y_{ix}}{\partial \beta_{ix}} \tag{9}$$

where β_{ix} is percent canopy cover of the xth forest pixel in the ith basin; Y_{ix} is the sediment yield (tons) produced by pixel x as the product of soil erosion $A_{ix}(\beta_{ix})$ and sediment delivery ratio ($0 \le SDR_{ix} \le 1$), and $MWTP_i$ is an average marginal willingness-to-pay (willingness-to-accept) for reducing (increasing) 1 t of sediment loading per lake acre. This gives the marginal value of a 1% canopy cover variation at each forest pixel in the ith basin, measured in terms of the marginal variation in the average market price for the sub-set of properties for which the ith lake is the nearest water body.

3.3. Data

The database was constructed from multiple sources. First, information on residential property prices, parcel ground area, the year of sale, patio area, and full cash, improved value, and city boundary were collected from the Yavapai County Assessor. It is conventional to include other important structural characteristics such as living square footage, basement area, lot size, and number of bed/bath rooms. However, many such variables were not available. These were proxied by the 'full cash value' of the feature characteristics of residential properties used by the Yavapai Assessors Office to estimate tax liability. After cleaning up non-arms-length transactions and missing data, we ended up with 8301 residential property transactions covering the period 2002–2005. House prices were deflated to 2002 baseline year using the Arizona House Price Index from the Federal Reserve Bank of St. Louis (FRED). We also created 10 spatially fixed city dummy variables to capture within-city variations in sedimentation impact.

Second, demographic characteristics such as median household income (MHH_Inc), population density (Popdensity), and the number of people with at least college degree (College_Sqml) were collected from 2000 Census data. Such measures were aggregated to the census tract level.

Third, using the sediment yield (tons) produced by pixel x calculated from sediment delivery approach, we estimated sediment loading into

Table 2
Estimated sediment loading (source: author's calculation in GIS).

Lake name	Lake area (acres)	Sediment loading (ton/year)	Sedimentation/lake acre (ton/lake acre/year)
Granite Basin Lake	7.36	916.1	124.52
Willow Creek Reservoir	294.45	2438.82	8.28
Watson Lake	151.85	4617.43	30.41
Lynx Lake	49.19	3691.07	80.53
Upper Goldwater Lake	20.69	216.83	10.48

[5] A row-standardized spatial weights matrix has row sums of unity with zero diagonal values because a housing unit cannot be a neighbor of itself. Off-diagonal values take the value between 0 and 1 when the jth observation is located within cut-off distance D meter.

[6] A row-standardized spatial weights matrix has row sums of unity with zero diagonal values, because a housing unit cannot be a neighbor of itself. Off-diagonal values take the value between 0 and 1 when the jth observation is located within cut-off distance D meter.

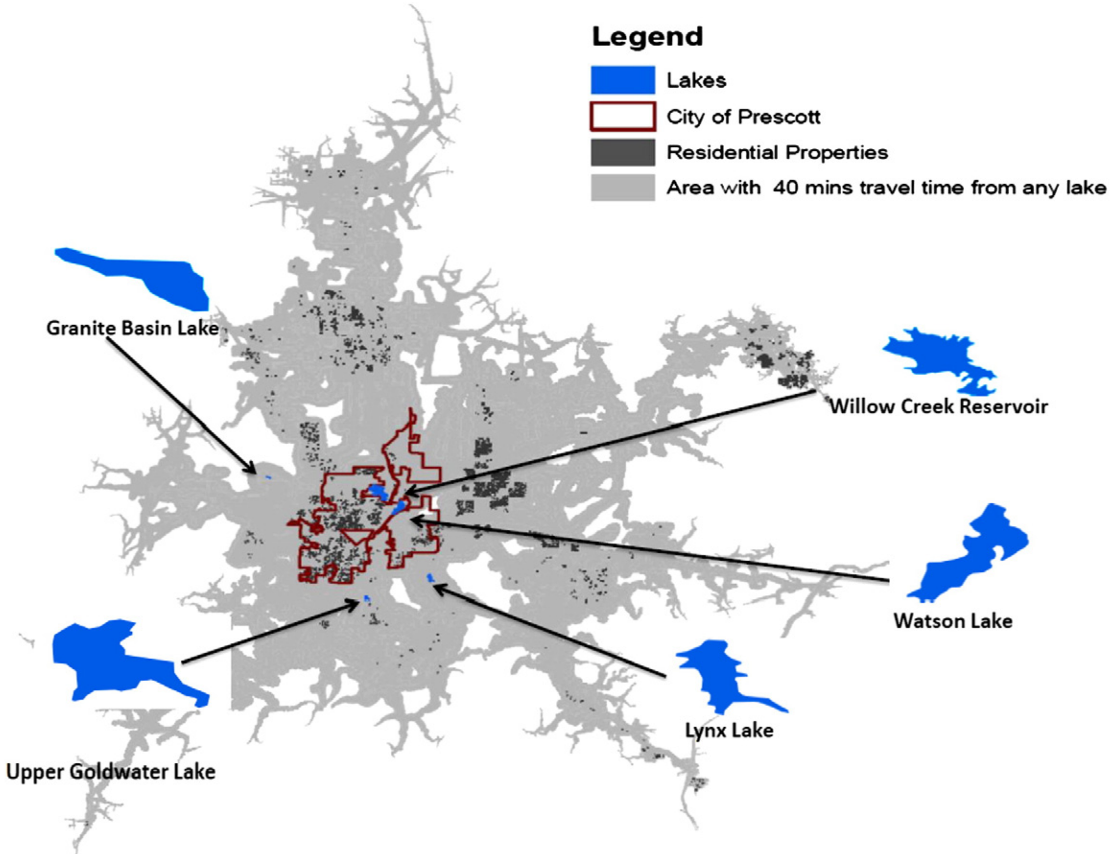

Fig. 1. Properties within 40 min to the nearest lake (created by authors in GIS).

the lakes by summing up sediment yield across all the pixels in their basins based on the combination of both 2001 LULC and percent forest canopy cover maps. Sediment loading was then standardized by lake area, expressed in tons of sediment yield per acre of lake surface. The summary statistics of sediment loading into 5 major lakes in Prescott area is shown in Table 2.

Finally, we weighted household interest in the nearest lake by a measure of travel time to each lake, by applying a cost distance approach in ArcGis using a weight raster representing the cost of traveling through a pixel. The weight raster was obtained by assigning a specific average speed to each road category class obtained from a road network map. The weight was calculated by dividing pixel size (30 m) by average speed (in meters/h), thus obtaining the time necessary to cross a 30 m pixel at that speed. After calculating the travel time to each of the 5 lakes for every property, we selected a sub-set of properties within a 40 min[7] driving distance to their nearest lake (Fig. 1).

Table 3 shows the summary statistics of selected variables in our study. The average price of residential properties sold between 2002 and 2005 was $256,765 (in 2002 value), ranging from $100,600 to $1.5 million. Approximately 65% of property transactions occurred in city of Prescott or Prescott Valley. The average age of properties was about 11 years. The average ratio of total land full cash value to sale price was about 0.62, showing that most of properties were sold at price higher than assessed full cash value, which is usual in housing market.

[7] The selection of travel distance was on an ad-hoc basis. We could have selected different size of travel distance boundary, however, choosing shorter distance reduce the number of property transactions significantly.

4. Results and Discussion

The semi-log OLS, SLM, and SEM models were estimated. The spatial models require the construction of spatial weight matrices. The row-standardized spatial weight matrix was used, in which each row sums to unity. There is no clear-cut rule for selecting the cut-off distance for the spatial weight matrix, and a decision must be made on an ad-hoc basis. However, the size of Lagrange Multiplier statistics (Anselin, 1988a) is frequently used for selection of the approximately best cut-off distance. The LM statistics peak at around 1800 m for SEM, and around 500 m for SLM. Hence, 500 m was selected as the threshold for constructing the spatial weights matrix for SLM and 1800 m for SEM.

Table 4 shows the estimated coefficients from the OLS, SLM, and SEM models. The LM test showed that the null hypothesis of no spatial lag correlation and no spatial error correlation was rejected, indicating that the spatial models provided a statistical improvement over the OLS model. The results show that all structural and environmental characteristics had the expected signs across all models although there were slight differences in terms of magnitude in coefficients. Consistent across all models, the coefficients on sediment loadings/lake acre, which is the variable of the most interest, were negative and statistically significant, indicating that increasing sedimentation loads in the nearest lake was a disamenity for nearby residents. We also found that the negative impact of sedimentation was sensitive to lake size due to dilution effect. The coefficient on travel time was negative, showing that property values decrease with distance from lakes. The square of travel time was included to capture the decreasing marginal effect of time. It was found to be positive and significant, showing that the further away from the nearest lake, the smaller the effect of an increase in travel time. We also interacted sediment load with travel time and travel

Table 3
Summary statistics of selected variables (8301 property transactions).

Variable	Description	Mean	Min	Max
Structural characteristics				
Property prices	Deflated property price in acre (2001)	$256,765	$100,600	$1,524,263
Age	The age of property	11.48	0	104
Age^2	The square of the age of property	961.18	0	10,816
Ground_Area	The area of ground floor (sq)	1676	341	5167
Patio_Floor	The ratio of patio area to floor area	0.1178	0.0712	0.2874
Land_FCV	Land full cash value	$30,928	$1000	$350,000
IMP_FCV	Improved full cash value	$91,199	$0	$665,774
Sale_Ratio	The ratio of total land full case value to sale price	0.6205	0	3.3984
Demographic characteristics				
Med_HH_Inc	Medium household income in 2000 (census tract)	$35,419	$24,452	$44,882
Popdensity	Number of population/$mile^2$ in 2000 (census tract)	704.42	4.05	2736.9
College_sqml	Number of people with at least college degree in 2000	97.64	0.58	346.86
Lake size	Lake size in acre	210.69	7.36	294.45
Sedimentation	Ton of sediment loads/lake acre in the nearest lake	29.08	8.28	124.52
Time	Traveling time to the nearest lake	15.68	1.35	40.54
$Time^2$	Traveling time to the nearest $lake^2$	341.71	1.82	1643.49
Int_Sed_Time	Interaction between Time and Sedimentation	426.07	14.14	3205.76
$Int\_Sed\_Time^2$	Interaction between $Time^2$ and Sedimentation	7658.35	19.09	127,621.4
City dummy				
Cottonwood	1 if property transacted in Cottonwood, else 0	0.0830	0	1
Prescott	1 if property transacted in Prescott, else 0	0.0084	0	1
Sedona	1 if property transacted in Sedona, else 0	0.0084	0	1
Camp_Verde	1 if property transacted in Camp Verde, else 0	0.0008	0	1
Cheno_Valley	1 if property transacted in Cheno Valley, else 0	0.0742	0	1
Clarkdale	1 if property transacted in Clarkdale, else 0	0.0225	0	1
Dewey	1 if property transacted in Dewey, else 0	0.0483	0	1
Jerome	1 if property transacted in Jerome, else 0	0.0008	0	1
Prescott_Valley	1 if property transacted in Prescott Valley, else 0	0.3459	0	1
Wickenburg	1 if property transacted in Wickenburg, else 0	0.0008	0	1
Year dummy (Baseline: 2002)				
YR2003	1 if property transacted in 2003, else 0	0.2419	0	1
YR2004	1 if property transacted in 2004, else 0	0.2804	0	1
YR2005	1 if property transacted in 2005, else 0	0.2666	0	1

time squared to explore whether the impact of sedimentation on property value was influenced by travel time to the nearest lake. We found the coefficients on both interaction terms to be positive and negative respectively, and statistically significant across all models, indicating that the disamenity impacts of sedimentation were reduced as travel time increased. This may also imply that an amenity value adds up to the scenic value of water quality for lake-front or nearest properties.

Robust LM tests (Anselin et al., 1996; Bera and Yoon, 1993) were performed to identify which form of spatial process was a significant source of spatial autocorrelation (Sander et al., 2010). We found that both models were significant in terms of a Robust LM test. However, the magnitude of test statistics was higher for SEM than for SLM, indicating that spatial autocorrelation in the error term explained the spatial process of our data better than spatial autocorrelation in the lag of neighboring property prices. This is an ad-hoc but widely used procedure (Sander et al., 2010). Therefore, the rest of this paper relies on the results from SEM.

We then calculated average MWTP (MWTA) for reducing (increasing) 1 t of sedimentation to each lake. First, property-level MWTP for sediment reduction was calculated as follows:

$$MWTP_{ij} = \left(\beta_{\text{sediment}} + \beta_{\text{int-sed-time}} Time_{ij} + \beta_{\text{int-sed-time}^2} Time_{ij}^2\right) P_j \tag{10}$$

where $MWTP_{ij}$ represents willingness to pay for 1 t of sediment reduction to the ith lake captured by property price j, P_j is the market transaction value of property j, and $Time_{ij}$ represents travel time from property j to the ith nearest lake. Then we averaged property-level willingness to pay by each lake as shown in Table 5. We found that the value of reducing sedimentation captured in property values was higher for Willow, Watson and Upper Goldwater Lakes than for Lynx and Granite Basin Lakes. These 3 lakes are located near the city of Prescott where development is more intense, property values are higher, and recreational opportunities are more scarce.

We then matched estimated willingness to pay for each lake to a corresponding lake basin, and estimated the spatial distribution of the marginal value of sediment control through forest cover. Figs. 2 and 3 show the spatial distribution of current canopy cover and the spatial distribution of the value of forest cover change — in terms of the reduced recreational value of the lakes produced by increased sediment loading — generated by a 10% reduction in current canopy cover in each forest pixel across all basins. This is a relative percent reduction associated with the current percent canopy cover of forest at each pixel (i.e. an initial 80% canopy cover was reduced to 72%).

The value of forest cover change across the whole study area was calculated from the following expression:

$$MV_\beta = \sum_i \sum_x MV_{\beta_{ix}} \tag{11}$$

and is shown in Table 6. The values in column f) in Table 6 represent the mean loss to the representative property generated by an increase in sediment loading associated with a 10% canopy cover reduction at each forest pixel. This was obtained by multiplying the marginal willingness to pay for sediment reduction in each lake, column d), by the relative change in sediment yield from its watershed, column e). Column h) shows the value of the sediment control effects of forest cover change, accounting for the total number of properties associated with each lake. The final column presents our estimate of the average sediment control value of a pixel-relative 10% change in forest canopy cover in each basin, which is the loss in aggregate property value divided by the current forest cover (ha) in each basin, column b). For instance, 85% of Granite Lake basin consists of forest cover, but if each forest pixel is thinned by 10%, then the resulting increase in sediment delivery decreases the representative property price near that lake by $861 ($276/t). This aggregates to a total value loss of $1,010,000 for residential properties near Watson Lake.

The sediment delivery cost of forest canopy cover change was found to be significantly higher ($969) for the Lynx Lake basin than for other lake basins. This is due to the combination of high existing canopy cover in the Lynx Lake basin, steep slopes, the large size of the watershed relative to lake area, and to the large number of properties near the lake. At the other extreme, the average sediment delivery

Table 4
Estimated parameter from semi-log OLS, SLM, and SEM (8301 transactions).

Variable	OLS	SLM (1800 M)	SEM (500 M)
Constant	12.1061 (0.0486)***	11.2678 (0.0252)***	12.0509 (0.0376)***
Age	−0.0024 (0.0003)***	−0.0021 (0.0002)***	−0.0021 (0.0003)***
Age^2	2.97e-05 (3.57e-06)***	2.66e-05 (3.62e-06)***	2.27e-05 (3.92e-06)***
Ground_Area	1.39e-04 (1.08e-05)***	1.36e-04 (5.22e-06)***	1.47e-04 (4.93e-06)***
Patio_Floor	−0.6119 (0.1879)***	−0.5709 (0.1476)***	−0.3206 (0.1432)**
Land_FCV	4.83e-06 (2.08e-07)***	4.71e-06 (9.35e-08)***	4.46e-06 (9.77e-08)***
IMP_FCV	4.38e-06 (1.23e-07)***	4.36e-06 (3.25e-08)***	4.31e-06 (8.07e-09)***
Sale_Ratio	−1.0461 (0.0234)***	−1.0385 (0.0088)***	−1.0191 (0.0065)***
Med_HH_Inc	3.54e-06 (5.86e-07)***	3.20e-06 (3.16e-07)***	2.94e-06 (1.99e-07)***
Popdensity	1.08e-04 (2.28e-05)***	−9.31e-05 (2.18e-05)***	−1.35e-04 (3.89e-05)***
College_sqml	6.58e-04 (1.64e-04)***	5.95e-04 (1.61e-04)***	8.57e-04 (2.88e-04)***
Lake size	−1.94e-04 (3.51e-05)***	−2.00e-04 (3.94e-05)***	−1.59e-04 (7.28e-05)**
Sedimentation	**−0.0025 (2.89e-04)***	**−0.0023 (3.29e-04)***	**−0.0025 (6.28e-04)***
Time	−0.01 (0.0012)***	−0.0094 (0.0012)***	−0.0092 (0.0021)***
$Time^2$	1.69e-04 (3.11e-05)***	1.56e-04 (2.96e-05)***	1.77e-04 (4.70e-05)***
Int_Sed_Time	**2.23e-04 (0.0003)***	**1.99e-04 (3.25e-05)***	**2.29e-04 (6.09e-05)***
$Int\_Sed\_Time^2$	**−5.30e-06 (6.77e-07)***	**−4.64e-06 (7.63e-07)***	**−5.71e-06 (1.45e-06)***
City dummy			
Cottonwood	0.0436 (0.0163)***	0.0509 (0.0126)***	0.0103 (0.0132)
Prescott	−0.0023 (0.0062)	−0.0067 (0.0056)	−0.0059 (0.0055)
Sedona	0.0259 (0.0218)	0.034 (0.0186)*	0.0068 (0.0182)
Camp_Verde	−0.0827 (0.0321)***	−0.0784 (0.0491)	−0.0689 (0.0449)*
Cheno_Valley	0.0143 (0.0079)*	0.0179 (0.0078)**	−0.0040 (0.0096)
Clarkdale	0.0814 (0.0159)***	0.0863 (0.0137)***	0.0373 (0.0174)**
Dewey	0.0037 (0.0071)	0.0044 (0.0088)	−0.0008 (0.0103)
Jerome	−0.0216 (0.0288)	−0.0119 (0.0496)	−0.0063 (0.0467)
Prescott_Valley	−0.0197 (0.0058)***	−0.0142 (0.0057)**	−0.0106 (0.0058)*
Wickenburg	0.0317 (0.0503)	0.0298 (0.0486)	−0.0165 (0.0439)
Year dummy			
YR2003	0.07 (0.0036)***	0.0697 (0.0042)***	0.0806 (0.0039)***
YR2004	0.2259 (0.0047)***	0.2269 (0.0042)***	0.2427 (0.0039)***
YR2005	0.5905 (0.0073)***	0.5915 (0.0047)***	0.6052 (0.0043)***
γ	–	0.0679 (0.0017)***	–
σ	–	–	0.577 (4.66e-05)***
$LM_{Spatial\text{-}Lag}$	–	50.225***	–
$LM_{Spatial\text{-}Error}$	–	–	2447.8***
$LM_{Robust\text{-}Spatial\text{-}Lag}$	–	8.8827***	–
$LM_{Robust\text{-}Spatial\text{-}Error}$	–	–	2281.2***

Numbers inside the bracket represent standard errors. Bold entries are significant at the 1% level.
* Significant at 10% level.
** Significant at 5% level.
*** Significant at 1% level.

cost of forest canopy cover change was found to be significantly lower ($105) for Granite Lake than for other lake basins, due to the low accessibility of the lake and the small number of properties affected.

5. Conclusions

In this paper, we estimated a component of the value of one of the most important regulating services provided by forested watersheds: the control of soil erosion and sedimentation. Specifically, we derived the value of sediment delivery control from an estimate of the marginal willingness to pay for water quality in the Prescott lakes. Other components of the value of sediment delivery control include, for example, the effect on the capacity of water storage reservoirs. Since these were not formally considered our estimates should be interpreted as lower bounds only of the value of sediment flow regulation provided by forest. There are also other ecosystem services jointly produced by forests beyond sediment delivery control, some synergistic with and some trading-off against sediment delivery control.

As with other forest ecosystem services, there are no direct markets for sediment delivery control. We nevertheless show how existing property markets can be used to derive peoples' marginal willingness to pay for the service. Specifically, we show how the implicit value of sediment delivery control by forests is not linked to their direct use in-situ, but instead is an off-site effect of their impact on water quality downstream — a missing market. To do so, we combined a hedonic price model and a sediment delivery model, and found that the value of watershed forest cover affecting water quality in lakes, varied widely across the space according to a combination of several factors, of which the current level of canopy cover and the number and value of affected properties were the most important.

We found that size matters. Even though the Lynx basin had the lowest marginal willingness to pay for avoided sediment loading, the value of sediment control through forest management (or value of watershed

Table 5
MWTP for unit decrease (1 t) in sedimentation load/lake acre by lake.

Model	OLS	Spatial lag model (1800 M)	Spatial error model (500 M)
Granite Lake	$142.03	$154.06	$183.06
(88 observations)	($6.46, $392.73)	($31.10, $402.32)	($44.85, $466.39)
Willow Creek	$192.89	$243.47	$285.36
(5005 observations)	($1.62, $2085.61)	($24.37, $3332.43)	($36.89, $3940.39)
Watson Lake	$256.25	$249.38	$275.82
(1178 observations)	($2.14, $1452.75)	($35.97, $1376.31)	($46.85, $1477.57)
Lynx Lake	$93.71	$118.18	$145.72
(1883 observations)	($1.67, $983.15)	($24.13, $933.11)	($35.56, $1031.17)
Upper Gold Gate	$319.34	$305.72	$334.33
(147 observations)	($5.90, $1134.07)	($28.08, $1075.25)	($42.81, $1150.71)

Number inside the parenthesis represents minimum and maximum MWTP.

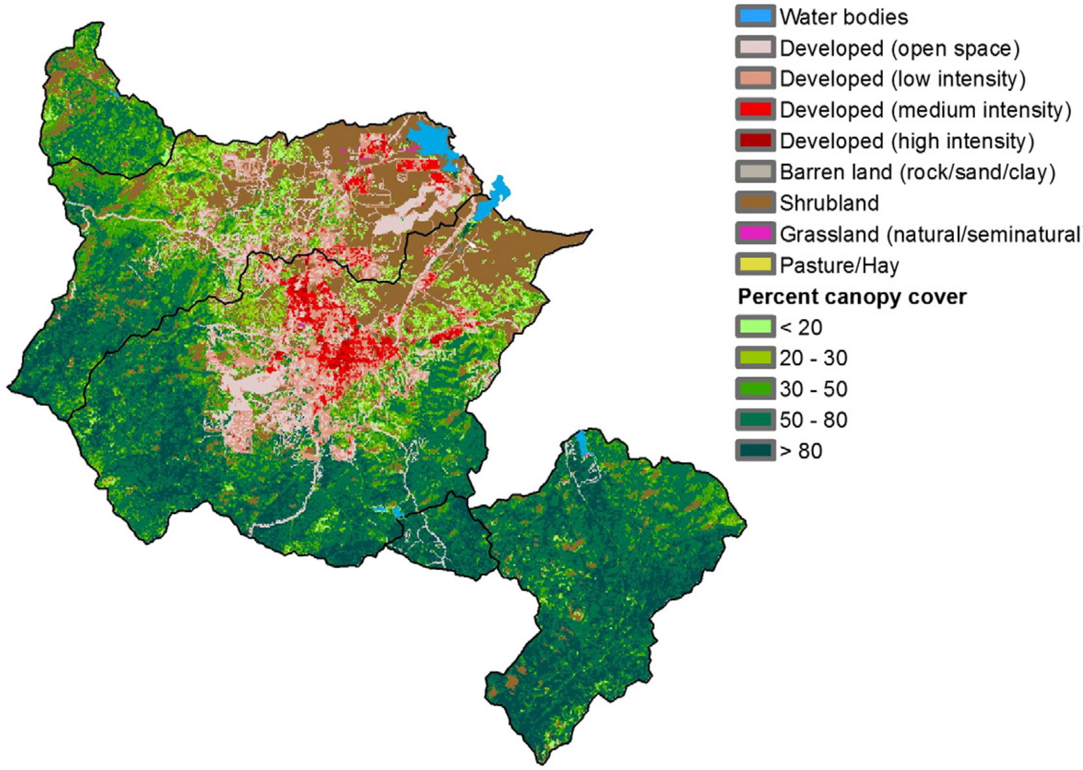

Fig. 2. Spatial distribution of current (2001) LULC and percent canopy cover across the lakes watersheds.

forest cover affecting water quality in lakes) was higher in the Lynx Lake basin than elsewhere due to the large number of properties affected, the extent of current forest cover and topographical characteristics of the watershed. On the other hand, Granite Basin Lake presented the lowest avoided value of sediment control due to the small number of properties affected by lake quality. Specifically, the value of water quality at each lake was increasing in both the accessibility of the lake, and the number of properties affected by the lake.

Methodologically, the approach shows how hydro-ecological production functions can be combined with the hedonic pricing of

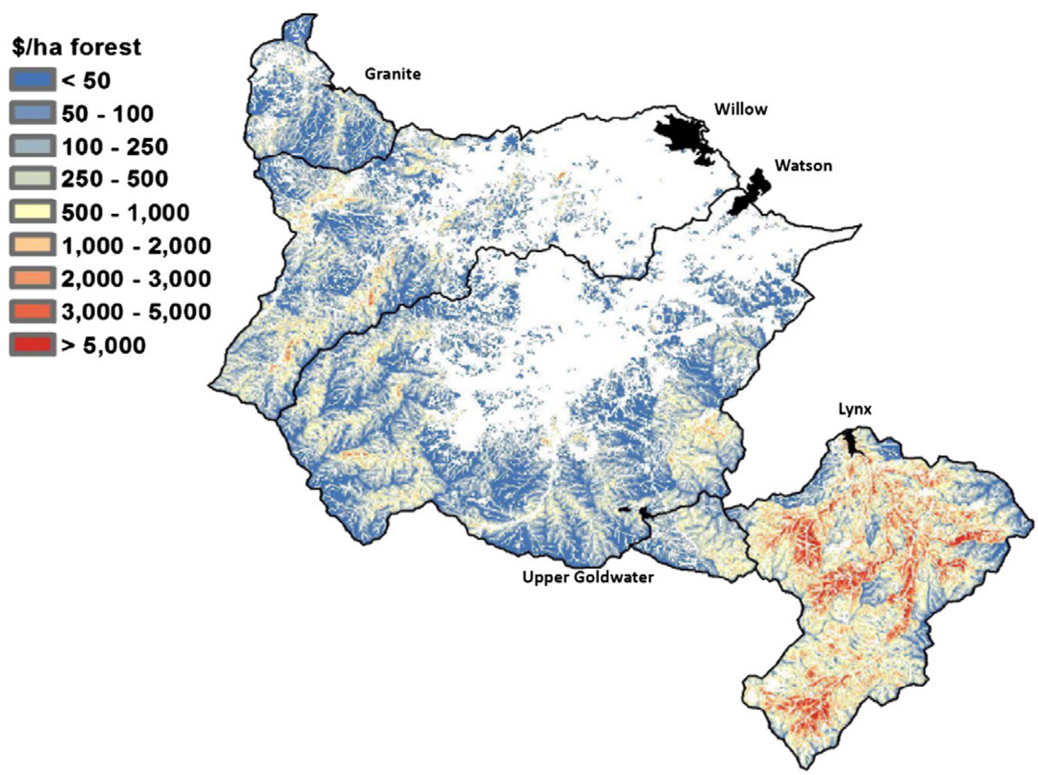

Fig. 3. Spatial distribution of the marginal off-site recreational cost generated by a pixel-relative 10% reduction in current (2001) forest canopy cover across the lakes' basins.

Table 6
Marginal cost generated by a pixel-relative 10% reduction in current (2001) forest canopy cover across the lake's basins.

Lake name	a) Percent of watershed that is forested	b) Forest cover (ha)	c) Pixel-level average percent of watershed that is forested	d) MWTP ($/t)	e) Sediment loading increase (t/lake acre/year)	f) Mean loss to representative property ($)	g) Number of properties assigned to nearest lake	h) Total property value loss[a] ($ million)	i) Mean marginal off-site value of forest[b] ($/ha forest)
Granite Basin Lake	85	1064	47	183	6.94	1270	88	0.11	105
Willow Creek Lake	50	3207	43	285	0.46	132	5005	0.66	206
Watson Lake	61	6629	51	276	3.12	861	1178	1.01	153
Lynx Lake	96	4574	70	146	16.12	2354	1883	4.43	969
Upper Goldwater	95	538	75	334	2.68	893	147	0.13	244
All lakes	67	16,012	–	–	–	–	8301	6.34	396

[a] Total sediment induced loss of lakeside property values after a 10% decline in the forest cover of that lake's drainage basin.
[b] Total sediment-induced loss of lakeside property values after a 10% decline in the forest cover of that lake's drainage basin, per hectare of forested drainage.

non-marketed environmental characteristics to derive estimates of marginal willingness to pay for environmental assets. Our results do, however, have implications for policy. They are of potentially of interest to public bodies concerned with the management both of the water bodies concerned, and of the forest resources of the watershed. They may, for example, inform both the implementation and the further development of the Prescott National Forest Management Plan. By revealing the capitalized value of forest services, they suggest both the form and magnitude of payment mechanisms by which the private beneficiaries of forest management might secure their interest in the regulating services supplied by forested watersheds.

References

Abbott, J.K., Klaiber, H.A., 2010. Is all space created equal? Uncovering the relationship between competing land uses in subdivisions. Ecol. Econ. 70, 296–307.
Adamowicz, W., Louviere, J., Williams, M., 1994. Combining revealed and stated preference methods for valuing environmental amenities. J. Environ. Econ. Manag. 26, 271–292.
Anselin, L., 1988a. Lagrange multiplier test diagnostics for spatial dependence and spatial heterogeneity. Geogr. Anal. 20, 1–17.
Anselin, L., 1988b. Spatial Econometrics: Method and Models. Kluwer Academic Publisher, Dordrecht.
Anselin, L., Lozano-Gracia, N., 2008. Errors in variables and spatial effects in hedonic house price models of ambient air quality. Empir. Econ. 34 (1), 5–34.
Anselin, L., Bera, A.K., Florax, R., Yoon, M.J., 1996. Simple diagnostic tests for spatial dependence. Reg. Sci. Urban Econ. 26, 77–104.
Beharry-Borg, N., Scarpa, R., 2010. Valuing quality changes in Caribbean coastal waters for heterogeneous beach visitors. Ecol. Econ. 69, 1124–1139.
Bejranonda, S., Hitxhusen, F.J., Hite, D., 1999. Agricultural sedimentation impacts on lakeside property values. Agric. Res. Econ. Rev. 28 (2), 209–218.
Bera, A.K., Yoon, M.J., 1993. Specification testing with locally misspecified alternatives. Econ. Theory 9, 649–658.
Boyer, T., Polasky, S., 2004. Valuing urban wetlands: a review of non-market valuation studies. Wetlands 24 (4), 744–755.
Brown, G.M., Pollakowski, H.O., 1977. Economic value of shoreline. Rev. Econ. Stat. 59, 272–278.
Census, 2010. State & County Quick Facts (Washington, D.C.).
Christie, M., Hanley, N., Warren, J., Murphy, K., Wright, R.E., Hyde, T., 2006. Valuing the diversity of biodiversity. Ecol. Econ. 58, 304–317.
Clark, D.E., 2006. Externality effects on residential property values: the example of noise disamenities. Growth and Change, 37 460–488.
Clawson, M., Knetsch, J., 1966. Economics of Outdoor Recreation. Johns Hopkins University Press, Baltimore.
Cropper, M.L., Deck, L.B., McConnell, K.E., 1988. On the choice of functional form for hedonic price functions. Rev. Econ. Stat. 70, 668–675.
Deaton, B.J., Hoehn, J.P., 2004. Hedonic analysis of hazardous waste sites in the presence of other urban disamenities. Environ. Sci. Pol. 7, 499–508.
Doss, C.R., Taff, S.J., 1996. The influence of wetland type and wetland proximity on residential property values. J. Agric. Resour. Econ. 21 (1), 120–129.
Englin, J., Mendelsohn, R., 1991. A hedonic travel cost analysis for valuation of multiple components of site quality. J. Environ. Econ. Manag. 21, 275–290.
Espey, M., Fakhruddin, F., Gering, L.R., Lin, H.Y., 2007. Living on the edge: residential property values in the urban–rural interface. J. Agric. Appl. Econ. 39, 689–699.
Faux, J., Perry, G.M., 1999. Estimating irrigation water using hedonic price analysis: a case study in Malheur County, Oregon. Land Econ. 75, 440–452.
Ferro, V., Minacapilli, M., 1995. Sediment delivery processes at basin scale. Hydrol. Sci. 40, 703–717.
Forest Service, 2012. Draft Land and Resource Management Plan for the Prescott National Forest, Prescott, AZ.
Greenstone, M., Gallagher, J., 2000. Does hazardous waste matter? Evidence from the housing market and the superfund program. Q. J. Econ. 123, 951–1003.
Hanley, N., Wright, R.E., Adamowicz, V., 1998. Using choice experiments to value the environment. Environ. Resour. Econ. 11, 413–428.
Hanley, N., Wright, R.E., Koop, G., 2002. Modelling recreation demand using choice experiments: climbing in Scotland. Environ. Resour. Econ. 22, 449–466.
Huber, R., Hunziker, M., Lehmann, B., 2011. Valuation of agricultural land-use scenarios with choice experiments: a political market share approach. J. Environ. Econ. Manag. 54, 93–113.
Jain, M.K., Kothyari, U.C., 2000. Estimation of soil erosion and sediment yield using GIS. Hydrol. Sci. 45, 771–786.
Kim, C.W., Phipps, T.T., Anseling, L., 2003. Measuring the benefits of air quality improvement: a spatial hedonic approach. J. Environ. Econ. Manag. 45, 24–39.
Kosenius, A.K., 2010. Heterogeneous preferences for water quality attributes: the case of eutrophication in the Gulf of Finland, the Baltic Sea. Ecol. Econ. 69, 528–538.
Kruse, S.A., Ahmann, J., 2009. The value of lake adjacency: a hedonic pricing analysis on the Klamath River, California. Ecotrust Working Paper Series. Ecotrust, Portland, OR.
Kuminoff, N.V., Parmeter, C.F., Pope, J.C., 2010. Which hedonic models can we trust to recover the marginal willingness to pay for environmental amenities. J. Environ. Econ. Manag. 60, 145–160.
Landford, N.H., Jones, L.L., 1995. Recreation and aesthetic value of water using hedonic price analysis. J. Agric. Resour. Econ. 20, 341–355.
Le Sage, J., Pace, K.R., 2009. Introduction to Spatial Econometrics. CRC Press, Boca Raton.
Legget, C.G., Bockstael, N.E., 2000. Evidence of the effects of water quality on residential land price. J. Environ. Econ. Manag. 39, 121–144.
Leggett, C.G., Bockstael, N.E., 2000. Evidence of the effects of water quality on residential land prices. J. Environ. Econ. Manag. 39, 121–144.
Lewis, L., Acharya, G., 2006. Environmental quality and housing market: does lot size matter? Mar. Resour. Econ. 21, 317–330.
Mansfield, C., Pattanayak, S.K., McDow, W., McDonald, R., Halpin, P., 2005. Shades of green: measuring the value of urban forests in the housing market. J. For. Econ. 11, 177–199.
McCool, D.K., Foster, G.R., Weesies, G.A., 1997. Slope length and steepness factors (LS). Chapter 4 In: Renard, K.G., Foster, G.R., Weesies, G.A., McCool, D.K., Yoder, D.C. (Eds.), Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE). Agricultural Handbook, 703. U.S. Department of Agriculture.
Michael, H.J., Boyle, K.J., Bouchard, R., 1996. Water quality affects property prices: a case study of selected Maine lakes. Main Agriculture and Forest Experiment Station Miscellaneous Report 398.University of Maine.
Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: General Synthesis. Island Press, Washington, D.C.
Mitasova, H., Hofierka, J., Zlocha, M., Iverson, L.R., 1996. Modelling topographic potential for erosion and deposition using GIS. Int. J. Geogr. Inf. Syst. 10, 629–641.
Moore, L.D., Burch, G.J., 1986. Physical basis of the length-slope factor in the universal soil loss equation. Soil Sci. Soc. Am. 50, 1294–1298.
Palmquist, R.B., 1991. In: Braden, J.B., Kolstad, C.D. (Eds.), Hedonic Method in Measuring the Demand for Environmental Quality. Elsevier Science Publishers.
President's Council of Advisors on Science and Technology, 2011. Sustaining Environmental Capital: Protecting Society and the Economy. Executive Office of the President, Washington, D.C.
Renard, K.G., Freimund, J.R., 1994. Using monthly precipitation data to estimate the R-factor in the revised USLE. J. Hydrol. 157, 287–306.
Salazar, S., Menendez, L.G., 2007. Estimating the non-market benefits of an urban park: does proximity matter? Land Use Policy 24, 296–305.
Sander, H., Haight, R.G., 2012. Estimating the economic value of cultural ecosystem services in an urbanizing area using hedonic pricing. J. Environ. Manag. 113, 194–205.

Sander, H., Polasky, S., Haight, R.G., 2010. The value of urban tree cover: a hedonic property price model in Ramsey and Dakota Counties, Minnesota, USA. Ecol. Econ. 69, 1646–1656.
Seiler, M.J., Bond, M.T., Seiler, V.L., 2001. The impact of world class Great Lakes water views on residential property values. Apprais. J. 69 (3), 287–295.
Smith, V.K., Huang, J.-C., 1995. Can markets value air quality? A meta-analysis of hedonic property value models. J. Polit. Econ. 103, 209–227.
Troy, A., Grove, J.M., 2008. Property values, parks, and crime: a hedonic analysis in Baltimore. MD. Landsc. Urban Plann. 87, 233–245.
Wischmeier, W.H., Smith, D.D., 1978. Predicting Rainfall Erosion Losses — A Guide to Conservation Planning, In: Agriculture, U.S.D.o. (Ed.), Agricultural Handbook 537, 537th ed.
Zabel, J.E., Kiel, K.A., 2000. Estimating the demand for air quality in four US cities. Land Econ. 76 (2), 174–194.