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SOCIAL DEMAND FOR ECOSYSTEM SERVICES AND IMPLICATIONS FOR WATERSHED MANAGEMENT[1]

Antonio J. Castro, Caryn C. Vaughn, Jason P. Julian, and Marina García-Llorente[2]

ABSTRACT: We performed a sociocultural preference assessment for a suite of ecosystem services provided by the Kiamichi River watershed in the south-central United States, a region with intense water conflict. The goal was to examine how a social assessment of services could be used to weigh tradeoffs among water resource uses for future watershed management and planning. We identified the ecosystem services beneficiaries groups, analyzed perception for maintaining services, assessed differences in the importance and perceived trends for ecosystem services, and explored the perceived impact on ecosystem services arising from different watershed management scenarios. Results show habitat for species and water regulation were two ecosystem services all beneficiaries agreed were important. The main discrepancies among stakeholder groups were found for water-related services. The identification of potential tradeoffs between services under different flow scenarios promotes a dynamic management strategy for allocating water resources, one that mitigates potential conflicts. While it is widely accepted the needs of all beneficiaries should be considered for the successful incorporation of ecosystem services into watershed management, the number of studies actually using the sociocultural perspective in ecosystem service assessment is limited. Our study demonstrates it is both possible and useful to quantify social demand of ecosystem services in watershed management.

(KEY TERMS: Oklahoma; water resource management; river systems; Native American; perceptions; nonmonetary valuation; water conflicts.)

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INTRODUCTION

Freshwater is vital for both humans and fish/wildlife, but humans have often prioritized freshwater for economic development at the expense of ecosystem health (Vitousek *et al.*, 1997; Baron *et al.*, 2002). Healthy freshwater ecosystems provide essential ecosystem services that benefit society (Brauman *et al.*, 2007). These include (1) provisioning services obtained directly from the ecosystem such as drinking water and irrigation; (2) regulating services such as water regulation and quality, habitat, and air quality; and (3) cultural services, which are nonmaterial ben-

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efits that people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and esthetic experiences (MEA, 2005). The ecosystem service approach is useful for decision-making in conservation actions and natural resource management (Harrison, 2010) because it enables focusing on ecosystems—human well-being interlinkages by translating ecosystem properties into human needs (Castro *et al.*, 2011). Ecosystem service preference assessment encompasses many specialties ranging from biophysical quantifications to sociocultural surveys to economic assessment. While much work has been done on quantifying biophysical properties of ecosystems and their potential economic value, relatively little attention has been given to society's preferences and perceptions for ecosystem services (Castro *et al.*, 2013).

Stakeholders perceive, value, demand, and prioritize ecosystem services in different ways, which can be quantified as the social demand for ecosystem services (Martín-López *et al.*, 2013). Analysis of the social demand for ecosystem services is a new approach to link an ecosystem's capacity to provide services with human needs and desires for those services (Castro *et al.*, 2013; Martín-López *et al.*, 2013) and highlights that the value of healthy ecosystems is dependent not only on ecosystem properties but also on societal needs (Paetzold *et al.*, 2010; Syrbe and Walz, 2012; Paavola and Hubacek, 2013). Social demand for ecosystem services can be explored using nonmonetary indicators including assessment of people's perceptions of the importance of different services (Martín-López *et al.*, 2012).

Watershed management has traditionally maximized the production of one ecosystem service (e.g., energy or agriculture production), resulting in declines in other services (e.g., water quantity and quality) and conflicts between different interest groups (Vermeulen and Koziell, 2002; Gordon *et al.*, 2010). Including *a priori* analyses of the tradeoffs among various ecosystem services as part of watershed management planning should improve the provision of ecosystem services for all stakeholders and decrease conflict. Such analyses should include an assessment of social demand for services, however, studies including a sociocultural perspective in service assessment across watersheds are rare and the techniques are not as formalized as for economic assessments (Morton and Padgitt, 2005; Castro *et al.*, 2013; Kelemen *et al.*, 2014).

Here, we assess the social demand for ecosystem services in a large watershed with intense conflict over water supplies that potentially provide many ecosystem services for competing stakeholders and competing regions. We used the Kiamichi River watershed in the south-central United States (U.S.) as a case study to examine how a sociocultural assessment of ecosystem services across its watershed and future service area (Oklahoma City via inter-basin transfers) could be used to weigh tradeoffs among water resource uses to inform managers for future watershed management and planning. As far as we are aware, this is the first valuation of watershed ecosystem services in this region. We (1) identified and characterized ecosystem beneficiary (ESB) types according to how they use and perceive ecosystem services; (2) analyzed the factors underlying perceptions and preferences for maintaining services; (3) assessed differences in the importance and perceived trends for ecosystem services; and (4) explored the impact on ecosystem services arising from different watershed management scenarios.

METHODS

The Kiamichi River and Water Conflict

The Kiamichi River in southeastern Oklahoma is a major tributary of the Red River, with a drainage area of 4,650 km^2 (Figure 1). The watershed is 64% forest, 18% pasture, 11% grassland/shrubland, 3% urban, and 1% wetlands according to the 2006 National Land Cover Dataset. Open water covers almost 3% of the watershed, with virtually all being Sardis and Hugo reservoirs (detailed below). Urban land use only makes up a fraction of a percent of total land area. While most of the watershed is temperate deciduous forest (primarily oak-hickory), there are several conifer plantation forests across the watershed. Its steep and rugged terrain has limited major row crop agriculture, there are no nearby major cities or interstates, and human population density is low (5.6 people/km^2) (Matthews *et al.*, 2005). This lack of development in the watershed has left the Kiamichi River with relatively pristine water and high aquatic biodiversity, including 86 fish species and 31 mussel species, three of which are federally listed as endangered (Atkinson and Vaughn, 2015; Vaughn and Pyron, 1995; Vaughn, 2000; Matthews *et al.*, 2005; Galbraith *et al.*, 2008). Although the river is considered a major water supply for the south-central U.S., it is particularly vulnerable to droughts and heat waves because it is shallow with high rates of evapotranspiration (Covich *et al.*, 1997; Mulholland *et al.*, 1997) and because organisms such as fish and mussels cannot migrate northward due to the west-to-east drainage (Matthews and Zimmerman, 1990).

The Kiamichi watershed, which lies within a Native American jurisdictional area (the Choctaw Nation), is at the center of intense, regional conflict over water use and governance. The Kiamichi River

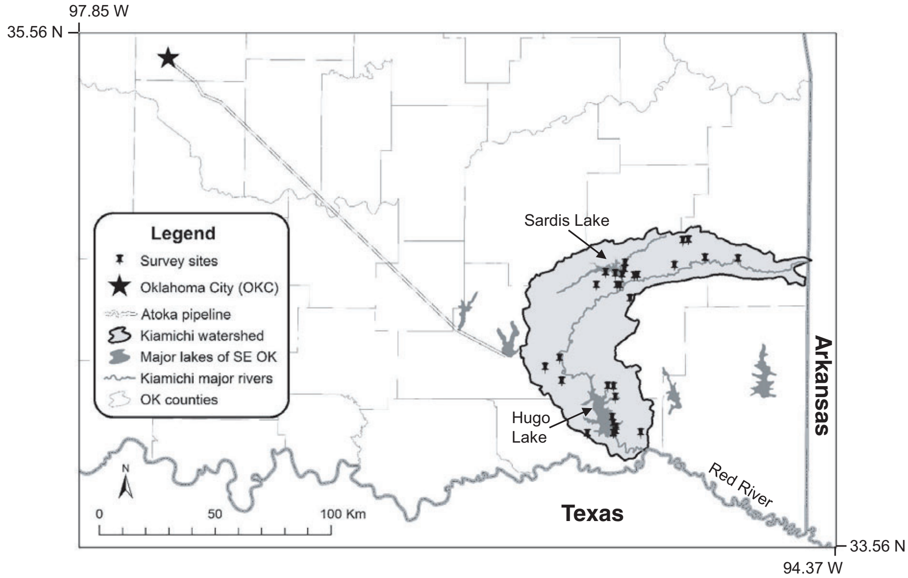

FIGURE 1. Kiamichi River Watershed Study Area. The Atoka Pipeline delivers water from southeast Oklahoma to Oklahoma City. Current extent of pipeline is shown. There are plans to extend it to the Kiamichi River.

and its discharge regime are influenced by two U.S. Army Corps of Engineers dams: mainstem Hugo Dam (operational in 1974 with a maximum storage capacity of 1.572 km^3) and Sardis Dam (operational in 1983 with a maximum storage capacity of 0.908 km^3) which is a tributary impoundment that can provide almost all of the flow to downstream reaches during intense droughts (Figure 1). Together these reservoirs are the water supply for people in 29 Oklahoma counties. Water availability to these reservoirs is predicted to decrease over the next 25 years because of increased drought and increased water usage from an increasing human population. Current and planned interbasin water transfers will extract hundreds of thousands of acre-feet of freshwater per year out of southeastern Oklahoma, with 0.271 km^3/year going to Oklahoma City alone by 2050 via the Atoka Pipeline. Water from these reservoirs is desired by multiple entities (North Texas Water District, Oklahoma City and other central Oklahoma cities, and southeast Oklahoma residents which include Chickasaw and Choctaw nations) and is the subject of multiple, ongoing discussions and litigation over who gets to use and profit from this water. Operation of these reservoirs has negatively impacted aquatic life in recent decades (Vaughn *et al.*, 2015). For example, in drought years, water has been held in Sardis Lake rather than being released to flow downstream. This has occurred during the hot summer months and has led to drying of the lower Kiamichi River, high water temperatures (>40°C), and massive freshwater mussel mortality (Galbraith *et al.*, 2010; Allen *et al.*, 2013; Atkinson *et al.*, 2014).

Sampling Strategy and Questionnaire Design

In summer 2013, we sampled people considered beneficiaries of ecosystem services (ESBs) provided by the Kiamichi River watershed. We conducted 505 individual, face-to-face surveys at 30 sites in the watershed (Figure 1). Individuals were randomly selected from populated areas within the watershed (small towns and tourist locations; total population of 146,000) and Oklahoma City (including public libraries and parks, restaurants, academic institutions, and shopping areas; total population of 700,000) and covered a wide range of ESBs' backgrounds. We had no contact with any of the interviewees in advance of our surveys.

Respondents were asked to participate in the study and to respond to a survey related to environmental issues in the area. We informed them that all responses were anonymous, that we just wanted to know their opinions, and that there were no right answers. Interviewees included stakeholders residing in the watershed, tourists, business visitors, water managers and experts, and potential water users in Oklahoma City. We also conducted interviews at six sites around Oklahoma City, because Oklahoma City uses the water in Sardis Lake. The questionnaire included 27 questions in different sections (Appendix 1): (1) characteristics of the respondent and the purpose of their visit to (or experiences with) the watershed; (2) preferences for ecosystem services and their trends over the last 10 years; (3) perceived impacts of different water flow scenarios on services; (4) environmental attitudes and environmental knowledge; and (5) socioeconomic data. We considered water flow to be the main driver affecting the delivery of ecosystem services, and thus we explored how ESBs perceived services under four different flow scenarios (described below). We showed stakeholders panels illustrating different ecosystem services and water flow conditions (Appendices 2 and 3). Finally, the survey included various case-based follow-up questions.

Identification and Characterization of Ecosystem Service Beneficiaries (ESBs)

To characterize ESB groups, we classified all respondents according to where they reside and/or the reason they were in the watershed. We also interviewed professionals with expertise in the biophysical, social, and economic aspects of the Kiamichi watershed (e.g., biologists, climatologists, hydrologists, ecologists, sociologists, anthropologists, and watershed managers). Then, to characterize each interviewee's sociocultural and economic status, we asked about the nature of their visit, environmental attitude, environmental knowledge, and social and economic characteristics of their households (Appendix 4). We also explored the sense of place of respondents by asking about the geographic location with which they identified most (see the questionnaire in Appendix 1).

Ranking Preferences and Perceived Trends of Ecosystem Services

Social preferences for different ecosystem services can be explored through ranking (Bateman *et al.*, 2002; Agbenyega *et al.*, 2009). Our study included eight categories of ecosystem services in three classes (Appendix 2): provisioning (freshwater provision), regulating (water regulation, water quality, air quality, and habitat for species), and cultural services (recreation, cultural heritage, and local identity).

We asked interviewees if they felt that the Kiamichi River provided benefits that contribute to their well-being and to the population's well-being (very much, much, not very much, and nothing) (Oteros-Rozas *et al.*, 2013), and asked them to provide examples of potential benefits. All respondents were asked to indicate the relative importance and perceived trend of each service (e.g., decreased, the same, increased, or don't know) over the past 10 years. We selected a 10-year window because it is long enough to capture meaningful environmental change (i.e., not just year-to-year variability), yet short enough to accurately reflect respondents' recent memory. To do this, respondents were asked to select from the services panel (Appendix 1) four services most important to them and to rank them from 1 to 4 (important to essential services). From this information, we created an ordinal measure of the importance of each service to each respondent (Winkler, 2006). Then, we analyzed the differences in service perceptions across ESBs groups with a nonparametric Kruskal-Wallis test incorporating the Bonferroni correction followed by Dunn's multiple comparison test as the variables were non-normally distributed (Martín-López *et al.*, *2012*).

Influence of Different Water Flow Scenarios on Ecosystem Services

We explored social perceptions about how ecosystem services might be impacted by different river flows. Based on flow categories that are relevant to stream ecological functioning, recreation, and water management (Richter *et al.*, 1996), we used four water flow scenarios in our survey (Appendix 3) and analyses: no water flow (dry riverbed; 0 m^3/s), low water flow (<25th percentile; 1.4 m^3/s), high water flow (>75th percentile; 32 m^3/s) and floods (>2-year recurrence interval; 685 m^3/s). These flow categories were considered as both historical conditions and future water management scenarios. All respondents were asked how these different water flow scenarios would affect ecosystem services, with the explanation that impacts could be positive, negative, or null. For each scenario, respondents were asked to choose a maximum of two services that were either positively or negatively impacted and assign an intensity score from 1 (minimum intensity) to 10 (maximum intensity). We then used spider (radial) diagrams (Quintas-Soriano *et al.*, 2014) to compare the perceived positive and negative impacts of each water flow scenario on ecosystem services.

RESULTS

Identification and Characterization of Ecosystem Service Beneficiaries (ESBs)

Our characterization of ESBs allowed us to classify the 505 respondents into five groups: (1) watershed residents (44%, respondents residing in the watershed), (2) business visitors (5.5%, respondents in the watershed on business and not residing in the watershed), (3) tourists (10%, respondents visiting the watershed for vacation or recreation), (4) Oklahoma

City (OKC) metropolitan area residents (29%, people who were interviewed in Oklahoma City not in the Kiamichi watershed), and (5) experts (10.5%, professionals with expertise in biophysical, social, or economic aspects of watershed science). Table 1 summarizes the sociocultural and economic characteristics of these ecosystem services beneficiaries groups.

The majority of respondents from each ESB group had visited the Kiamichi watershed before this survey, except OKC residents (Table 1). Overall, 66% of respondents had visited the Kiamichi River watershed before this survey, with most residents living in the watershed for a long period (median = 27 years) and most nonresidents visiting the watershed on multiple occasions for camping, fishing, and boating. These statistics indicate that a majority of our interviewees were familiar with the watershed and its water resources. With respect to the geographical location, the majority of ESBs connected with their home state, particularly OKC residents at 49%. Compared to OKC residents, watershed residents had a stronger connection to their region/county/town. Most out-of-state visitors were from Texas. Most ESBs (64%) participated in either social or work associations, with 17% active in environmental associations. Caucasians (61%) and Native American (22%) were the most common ethnic groups. These percentages approximate the ethnic makeup of the county containing most of the watershed (Pushmataha County: 75% Caucasian, 18% Native American; United States Census Bureau 2008). Sixty-eight percent of respondents had some college education (Table 1).

Perception of Ecosystem Services: Importance and Trends

Of the 505 ESBs, 485 (96%) believed at some level that the Kiamichi River is "providing benefits that are contributing to your well-being and the population's well-being," with 80% of ESBs believing it provides substantial benefits (i.e., very much; Table 2). Only 8 ESBs said that no benefits were provided by the Kiamichi, and 12 ESBs did not answer the question. When asked to give an example of a benefit provided by the Kiamichi, virtually all of those who responded gave an example related to water resources (i.e., drinking water, fishing, recreation). Interestingly, recreation was mentioned by 175 ESBs. These perceptions of how substantial benefits were did vary by ESB groups (Table 2). In general, OKC residents and experts who had less attachment to the watershed (e.g., less time spent in the area), found the ecosystem services provided by the Kiamichi watershed to be less substantial compared to watershed residents, tourists, and business visitors.

When asked to choose between important and nonimportant ecosystem services, the majority of ESBs chose habitat for species, water quality, recreation, and freshwater provision as the most important (Figure 2a). In contrast, local identity and cultural heritage were rarely perceived as important. The ecosystem service with the highest average importance among all groups was habitat for species, followed by freshwater provision, water quality, and recreation (Figure 2b).

Ecosystem service beneficiary groups differed in how they perceived the importance of specific ecosystem services (Table 3). OKC residents and experts ranked freshwater provision as the most important service, while business visitors ranked this service as one of the least important. Habitat for species was the most important service for business visitors, as well as for watershed residents. Tourists ranked habitat for species and recreation (essentially equal) as the most important service. Watershed residents also ranked recreation relatively high, while OKC residents, experts, and business visitors ranked this service relatively low. Significant differences among stakeholders' views were found for freshwater provision (Kruskal-Wallis test, $\chi^2 = 47.48$, $p < 0.001$), water quality ($\chi^2 = 14.41$, $p < 0.001$), cultural heritage ($\chi^2 = 17.94$, $p < 0.001$), recreation ($\chi^2 = 42.97$, $p < 0.001$), local identity ($\chi^2 = 15.37$, $p < 0.001$), and air quality ($\chi^2 = 9.72$, $p < 0.01$). Overall, provisioning services were considered the most important by OKC residents and experts, while regulating services were the most important for watershed residents, business visitors, and tourists (Table 2). These latter three groups also ranked cultural services relatively high compared to OKC residents and experts.

Most respondents perceived that the services they considered most important (habitat for species, freshwater provisioning, and water quality) had declined over the past decade, while those services that were not considered as important (cultural heritage and local identity) had remained stable or increased (Figure 3). Respondents thought that freshwater provisioning had declined the most over the past 10 years, while local identity had increased the most. Recreation, water regulation, and cultural heritage were considered to be relatively stable over the past decade. Air quality was seen as stable by the highest portion of the population.

Water Flow Impacts on Ecosystem Services

ESBs perceived ecosystem service benefits to be affected by flow conditions (Figure 4). Generally, services were perceived as negatively impacted under no

TABLE 1. Description of Socio-Cultural and Economic Characteristics of Ecosystem Services Beneficiaries (ESBs). Mean values are followed by a standard deviation in parentheses (±SD).

Variables		Watershed Residents (n = 226)	Tourists (n = 50)	Business Visitors (n = 28)	Oklahoma City Residents (n = 147)	Experts (n = 54)
Watershed visitation	Visited Kiamichi watershed before?	91%	78%	64%	27%	59%
	Purpose of visit?	Living in the area	Camping 64%, fishing 33%, boating 18%	Working in the area	—	Working in the area
	How many years have you lived at your current residence?	27 (±18)	25 (±11)	26 (±13)	14 (±11)	12 (±13)
Environmental activity	Belong to an association?	Social 38% Work 8% Environmental 7% Other 45%	Work 23% Social 23% Environmental 8% Other 46%	Other 44% Social 33% Work 22%	Social 44% Environmental 15% Work 17% Other 24%	Environmental 45% Work 36% Social 5% Other 14%
Sense of place	Local identity?	Oklahoman 29% From your county/ town 21% American 15% Other 34%	American 26% Oklahoman 26% From your county/ town 12% Other 36%	Oklahoman 32% From your county/ town 21% American 14% Other 32%	Oklahoman 49% From your county/town 16% American 10% Other 26%	Oklahoman 28% American 11% From your county/town 9% Other 52%
Sociocultural	Age in years	44.0 (15.9)	50.0 (18.4)	41.0 (12.1)	34.0 (14.5)	43.0 (13.8)
	Gender	Female 43% Male 57%	Female 54% Male 46%	Female 22% Male 78%	Female 37% Male 63%	Female 52% Male 48%
	Family size (adults)	3.0 (2.1)	2.6 (2.1)	2.5 (2)	2.7 (2.2)	2.4 (1.9)
	Ethnic background	White, Caucasian 59% Native American 28% Multiracial 7% Black, African-American 3% Other 3%	White, Caucasian 65% Native American 27% Multiracial 2% Other 6%	White, Caucasian 69% Native American 19% Multiracial 8% Black, African-American 4%	White, Caucasian 53% Native American 19% Black, African-American 10% Multi-racial 6% Asian Indian 2% Other 10%	White, Caucasian 83% Multi-racial 6% Native American 4% Black, African-American 2% Other 6%
	Level of education	University 56%, High school 43%, Primary school 1%	University 42%, High school 56%, Primary school 2%	University 77%, High school 23%	University 82%, High school 17%	University 100%
Economic	Net household annual income	$41,972	$45400	$44286	$43542	$60200

TABLE 2. The Perception of Ecosystem Services by Different Ecosystem Services Beneficiary (ESB) Groups. *N* is the number of people interviewed in each ESB group.

		Ecosystem Services Perception (% within each group of stakeholders)			
Ecosystem Services Beneficiaries (ESBs)	***N***	**% of ESBs Perceived Kiamichi River Provides Substantial Benefits[1]**	**% of ESBs Perceived Provisioning Services as Most Important**	**% of ESBs Perceived Regulating Services as Most Important**	**% of ESBs Perceived Cultural Services as Most Important**
Watershed residents	226	83.9	27.4	49.1	23.0
Tourists	50	89.8	28.0	42.0	30.0
Business visitors	28	96.5	10.7	60.7	28.6
OKC residents	147	70.6	44.2	40.1	14.3
Experts	54	75.5	46.3	42.6	9.3

[1]These are ESBs that answered “very much” to the question: “Do you think the Kiamichi River and the area around it are providing benefits that are contributing to human wellbeing?”

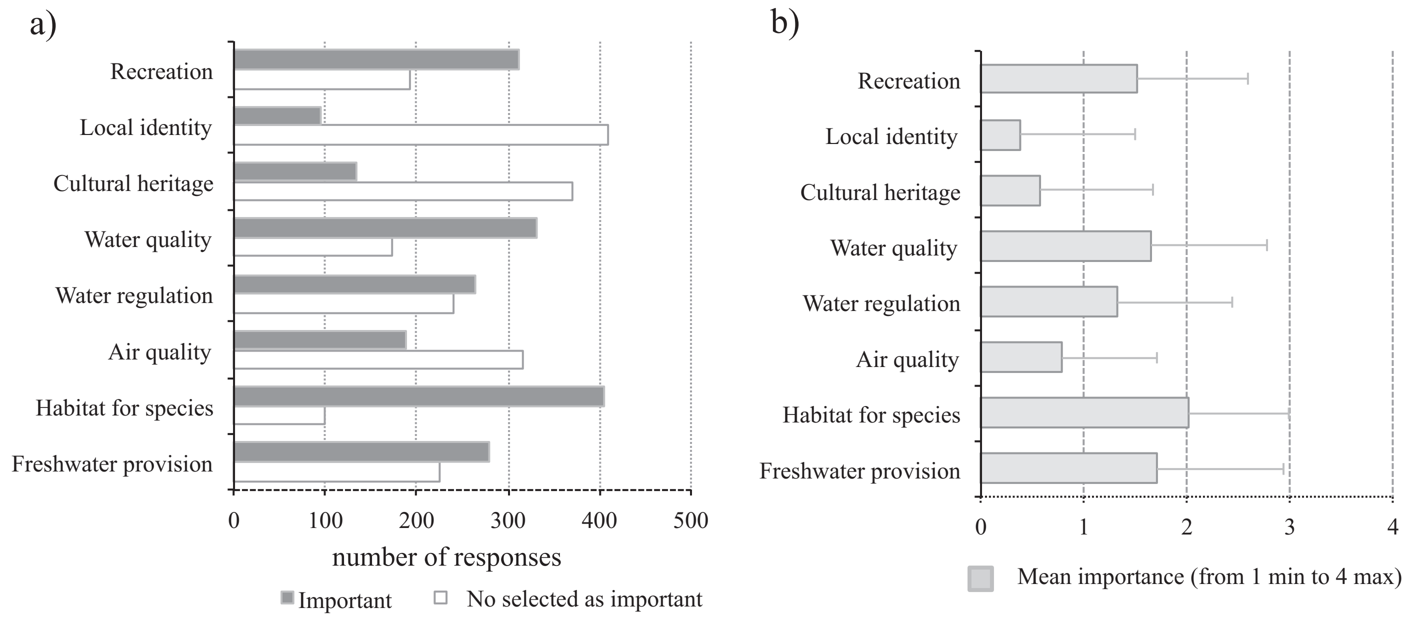

FIGURE 2. Overall Social Importance Perceived on Ecosystem Services Provided by the Kiamichi Watershed.

TABLE 3. Differences in Perceived Importance for Ecosystem Services by Ecosystem Services Beneficiaries (ESBs). Importance is expressed as the sum of scores (i.e., 4 max, 1 min, 0 not selected as important) by the total of respondents. Letters in parentheses represent statistically different groups as identified by the Dunn test.

Ecosystem Services Beneficiaries	**Freshwater Provision**	**Habitat for Species**	**Air Quality**	**Water Regulation**	**Water Quality**	**Cultural Heritage**	**Local Identity**	**Recreation**
Watershed residents	1.38 (A)	2.06	0.75 (A)	1.25	1.39 (A)	0.74 (A)	0.50 (A)	1.85 (A)
Tourists	1.22 (AB)	1.94	0.78 (AB)	1.52	1.62 (AB)	0.56 (AB)	0.40 (A)	1.96 (A)
Business visitors	0.67 (B)	2.25	1.21 (ABC)	1.53	1.75 (AB)	0.286(B)	0.67 (AB)	1.60 (B)
OKC residents	2.27 (C)	1.96	0.85 (BC)	1.35	1.89 (B)	0.40 (B)	0.19 (AB)	1.02 (B)
Experts	2.53 (C)	1.92	0.51 (C)	1.20	2.00 (B)	0.50 (B)	0.16 (B)	0.98 (B)
Kruskal-Wallis Test	**47.48*****	2.04	**8.72***	2.39	14.41***	**17.94*****	**15.37****	**42.97*****

Notes: The Kruskal-Wallis test and Dunn groups were used to compare services importance by ESBs.
*Statistical significance = 10%.
**Statistical significance = 5%.
***Statistical significance = 1%.

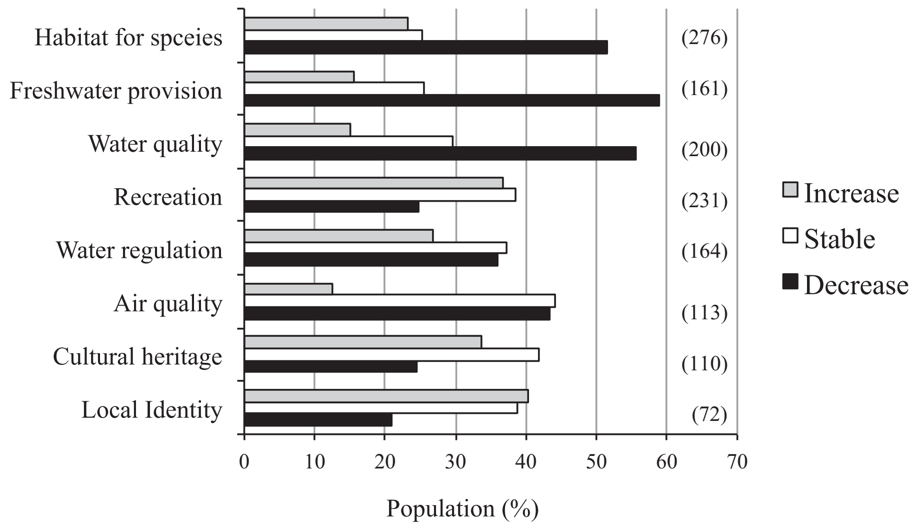

FIGURE 3. Perceived Changes in Ecosystem Services over the Last 10 Years. The total number of respondents expressed as the total % of population who considered negative, positive, or no impacts on services are shown in brackets.

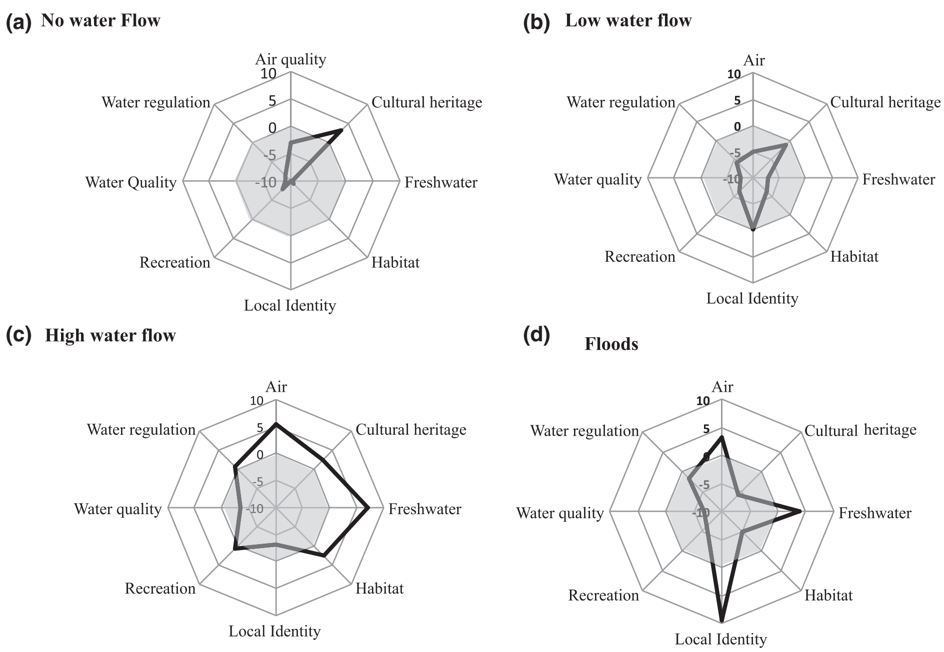

FIGURE 4. Perceived Tradeoffs between Ecosystem Services under Different Flow and Watershed Management Scenarios. The gray area (negative axis) in the spider diagram represents a relative negative impact, as perceived by the respondents. The white area (positive axis) in spider diagrams represents a relative positive impact.

and low water flow scenarios (gray area in spider diagrams), and as positively affected by high water flows (white area in spider diagrams). Perceptions about the effect of floods on ecosystem services were mixed. The services considered the most negatively impacted under no water flow were local identity, freshwater provisioning, habitat for species, and water quality, respectively (Figure 4a). Under low water flows, water quality and freshwater provisioning were considered the most negatively impacted (Figure 4b). High water flows were perceived as having positive effects on freshwater provisioning, air quality, cultural heritage, habitat for species (Figure 4c), and negative effects on water quality and local identity (Figure 4c). Floods were perceived as having a strong, positive impact on local identity and a negative influence on water quality, cultural heritage, and recreation (Figure 4d).

DISCUSSION

Our aim in this study was to assess the social demand for ecosystem services across a large watershed that provides valuable water resources to an environment with high, yet threatened biodiversity (Matthews *et al.*, 2005; Galbraith *et al.*, 2008; Atkinson *et al.*, 2014) and a regional population with various socioeconomic needs for these water resources (Barringer, 2011; Hennessy-Fiske, 2011). Our main instrument was a survey of over 500 ESBs, including stakeholders residing outside of the watershed (78 tourists and business visitors) who plan to use these resources. The practicality of performing sophisticated analyses on survey responses and obtaining meaningful results depends to some degree on the interviewees' knowledge and appreciation of benefits they are receiving from these ecosystem services. We found that 96% of interviewed ESBs thought that the Kiamichi River watershed provides some level of benefits to society, with four out of every five ESBs believing it provides substantial benefits (Table 2). When asked about which benefits were being provided by the Kiamichi River and its watershed, most ESBs gave an example related to water resources (i.e., drinking water, fishing, and recreational water activities). These figures demonstrate that despite varying levels of education, demography, and cultural experiences, there is likely a high level of knowledge and appreciation of the benefits provided by this watershed. While the many recent meetings, litigation, and media coverage of water issues in the region have likely heightened awareness, we believe that most people already had some level of understanding of the benefits provided by healthy ecosystems (Brauman *et al.*, 2007; Castro *et al.*, 2011; Quintas-Soriano *et al.*, 2014). Further, it is typical and intuitive for local residents and frequent visitors to have a heightened awareness of their surroundings, which likely explains the differences in perceptions between residents/visitors and OKC residents (Tables 2 and 3).

Our survey and analyses were designed to assess whether different groups of ESBs perceive ecosystem services differently, and to what degree. In general, visitors to the watershed (tourists and those on business) and watershed residents had a different perception of which ecosystem services (and their capacity) were being provided by the watershed compared to OKC residents. For instance, while visitors considered habitat for species as the most important service, OKC residents perceived freshwater provision as the most important (Table 3). This result could be related to the interviewee's familiarity with the area given that only 27% of OKC residents had visited this region (Table 1). Other studies support this finding that distance to a place or lack of experiences in a place may limit the knowledge or modify the perception about the natural and cultural values of that area (Hein *et al.*, 2006; García-Llorente *et al.*, 2008, 2011).

Identification of ESBs with different ecosystem preferences is important for identifying potential tradeoffs in the use of different natural resources to be implemented in land and water planning. We found significant differences in how ecosystem services were perceived among stakeholder groups (Table 2). In particular, OKC residents judged provisioning services as the most important while watershed residents and business visitors found regulating services to be more important. This result reveals a potential conflict between these two groups of beneficiaries. Indeed, there are hotly contested and litigated disputes among the State of Oklahoma, Oklahoma City, northern Texas water districts, the scientific community, local residents, and the Choctaw and Chickasaw Nations over who owns the water in the watershed and which uses should be prioritized (Barringer, 2011; Hennessy-Fiske, 2011; Chickasaw Nation *et al. vs.* Fallin *et al.*, 2012; Oklahoma Water Resources Board *vs.* Choctaw and Chickasaw Nations of Oklahoma, 2012). (All lawsuits were put on hold in 2012 in hopes for mediation among all parties involved, and water rights continue to be disputed at the time of publication of this article.) Given that central Oklahoma and northern Texas are two of the fastest growing regions in the nation and that they do not have enough water supply to meet future demands (or currently in times of drought), these conflicts will continue until a strategy is developed that meets the needs of all stakeholders. Historically, economic development has been prioritized at the expense of ecosystem health and broader societal needs (Vitousek *et al.*, 1997; Baron *et al.*, 2002). The social demand of watershed residents and visitors who depend on regulating services such as water quality and recreation for their livelihood needs to be incorporated into water management to minimize conflict (Schmitz *et al.*, 2003; Morton and Padgitt, 2005). Our results can inform policy makers about potential conflicts of future water management plans by outlining the tradeoffs between water users' perceptions regarding water-derived services (e.g., differences in perceptions for provisioning services between OKC and watershed residents).

The two ecosystem services that all stakeholders agreed were important were habitat for species and water regulation (Table 3). This is likely because the most important economic and recreational activities in the Kiamichi watershed are hunting, fishing, and water activities such as boating around Sardis and Hugo reservoirs (Figure 1). In addition, people tend to place more value on services that they perceive as vulnerable or declining. Hunting and fishing depend on habitat for species, boating depends on water regulation, and in turn habitat for species is also dependent on water regulation in this system. The water now impounded by Sardis Lake historically provided ~24% of the water flowing into the lower Kiamichi River. However, in recent drought years water has been held in Sardis Lake rather than being released to flow downstream. This has occurred during the hot summer months and has led to drying of the lower river and high water temperatures, which has impacted aquatic life (Vaughn *et al.*, 2015) and decreased tourism in this area.

The ESBs in our survey also acknowledged negative impacts on ecosystem services under no and low water flow scenarios (Figure 4). Water regulation, water quality, freshwater provision, habitat, and recreation were all perceived to be heavily degraded under no/low flow scenarios. Our study region has experienced several severe hydrological droughts and accompanying heat waves over the past 15 years (Vaughn *et al.*, 2015), thus, it is likely that our interviewees had experiences with water shortages and an accordingly high level of knowledge on how ecosystem services and human well-being are affected during these periods (Guo *et al.*, 2000; Ward *et al.*, 2000; Welsh *et al.*, 2013; Quintas-Soriano *et al.*, 2014). Because flow regimes in Kiamichi River can be manipulated via the large dams discussed above, perceptions about water flow scenarios (Appendix 3) will also be useful for water management strategies. Water demands from the Kiamichi River are increasing, especially with the planned interbasin water extractions (OWRB, 2012). Water supplies will continue to decrease during cyclical droughts and heat waves, both of which are expected to become more frequent and more intense (Seager and Vecchi, 2010; Mellilo *et al.*, 2014). Thus, water resources in this watershed will need to be managed more conscientiously and hopefully with a broader perspective on the social demand for ecosystem services.

When asked about perceived trends in ecosystem services over the past decade, ESBs believed the most marked negative trends were in freshwater provisioning, water quality, and habitat for species. These perceptions are likely related to recent severe droughts and water management decisions, when parts of the lower river were allowed to go dry (Allen *et al.*, 2013; Atkinson *et al.*, 2014). Indeed, there were 276 no flow days in the last decade (2003-2012) according to the flow gage at Antlers (USGS 07336200), not far above Hugo Reservoir. In the previous two decades combined, there were only 75 no flow days (Vaughn *et al.*, 2015). Many of the recent no flow days could have been prevented if water had been released from Sardis Dam, and this has been a point of contention among watershed residents, scientists, and the State of Oklahoma. We believe the frustration of watershed residents along with hardships from drought impacts has galvanized local communities against what they perceive to be a social injustice (Appendix 5). The perceived increases in cultural services (particularly local identity and cultural heritage) we observed (Figure 3) could be explained by how adversity, severe drought, and flooding, can bring a community together and instill a sense of pride. Egan (2006) documented a similar response to the severe drought in the South-Central U.S. during the 1930s (i.e., the dust bowl). Other natural disasters such as floods and tornadoes have similar effects on sociocultural responses. Indeed, the perceived negative and positive impacts on local identity under no water flow and floods scenarios can be interpreted with the idea that people perceive the status quo of local identity. Our results support this finding in that floods were perceived to increase local identity and no water flows were perceived to increase cultural heritage (Figure 4). Given that some of the relationships between Figures 3 and 4 are complex (e.g., local identity has increased over the last decade despite the perception that no water flows decrease local identity), follow-up interviews with more open-ended questions may help explain some of these relationships and allow us to further explore the dynamics of social demand for ecosystem services.

CONCLUSIONS

Maintaining sustainable water supplies is a critical, global issue. In the U.S. there is concern about future water supplies not only in the arid southwest (Sabo *et al.*, 2010), but also in moist temperate areas such as the southeast because of growing human populations and increases in drought frequency and magnitude linked to climate change (Pederson *et al.*, 2012). Tradeoffs between water security for human needs and ecosystem health will only become more challenging in the future with increasing human demand for freshwater coupled with impending shifts in the duration and frequency of extreme climatic events and associated alterations in stream flows. This is already being realized with increasing interstate water disputes across the nation (Sneddon *et al.*, 2002; Boehlert and Jaeger, 2010; Mandarano and Mason, 2013). Thus, there is an urgent need to develop models and frameworks that take into account the interdependent social, economic, and biophysical dynamics (including costs) of shared water resources.

This article supports the widely accepted view that the knowledge and diverse needs of all stakeholders, including local residents and tourists, must be considered for the successful incorporation of ecosystem services into conservation and management actions. The most straightforward and comprehensive means of incorporating stakeholder needs in management plans is to conduct surveys in a similar fashion as ours where all stakeholder perceptions of the most relevant management scenarios are assessed. An example of this integration is the European Landscape Convention, which promotes the protection, management, and planning of European landscapes by promoting public participation in the planning process (Scott, 2011). However, despite the increasing attention of ecosystem services as a framework for linking conservation of nature and human well-being, the number of studies applying a sociocultural perspective to service preference assessment is limited. Our study demonstrates the range of data that can be collected and the types of analyses that can be performed to incorporate a sociocultural perspective in service preference assessment. However, we acknowledge some limitations regarding the sampling strategy since no randomization procedure was used for choosing survey locations. This is the case of respondents sampled in Oklahoma City where (1) location choices were based on convenience sampling and potentially subject to location selection bias, and (2) population sampled in comparison with people interviewed in the watershed (147 respondents out 700,000 *vs.* 226 out of 26,000, respectively) can likely affect our results on Oklahoma City respondents' perception of ecosystem services.

In conclusion, a sociocultural preference assessment of services provided by a watershed with intense water conflict is useful for: (1) identifying services considered to be essential for the maintenance of human well-being, (2) identifying potential conflicts among different ecosystem services beneficiary groups, (3) characterizing perceived changes in ecosystem services, and (4) exploring ecosystem services tradeoffs under different watershed management scenarios. While these goals are usually stated in water plans year after year (e.g., Oklahoma Water Resources Board, 2012), water managers rarely carry out the needed assessments. Our study demonstrates that it is both possible and useful to assess social demand of ecosystem services to inform watershed management about stakeholder's perceptions.

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article: a summary of the questionnaire used (Appendix 1), material used in the social sampling (Appendices 2 and 3), variables used in the identification and characterization of services beneficiaries (Appendix 4), and an example of a billboard found in the case study (Appendix 5).

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