Research Article

Ecosystem Services of the Buffalo National River in Arkansas

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ABSTRACT

The Buffalo National River is a scenic and ecologically significant resource located in the Ozark Plateau of Arkansas, USA. As a free-flowing and protected river, the Buffalo offers natural benefits to humanity (e.g., food production, carbon storage, recreation), known as ecosystem services. Using both market and survey data, we performed the first comprehensive valuation of the ecosystem services that the Buffalo National River provides to Arkansas residents. The total ecosystem services benefits in 2018 USD were valued at $20.5 million per year ($550/ha). Most of the value was concentrated in cultural services (i.e., recreation, aesthetics, cognitive development), which were responsible for over 70% of total value at $384/ha. Air quality regulation and the provisioning of water also made important contributions to the total, with values of $103/ha and $36/ha, respectively. Our study highlights the considerable economic value provided by the Buffalo National River in its current state. Recent economic activity, in particular intensive agriculture, has threatened these services and in the process created conflicts between different industries. These values are important to consider when making management and policy decisions that affect the region.

Index terms: agriculture; Buffalo National River; contingent valuation; ecosystem services; tourism

INTRODUCTION

The Buffalo National River is a free flowing, highly biodiverse aquatic resource that is aesthetically and culturally important to the state of Arkansas, USA. The river, located in the north-central part of the state, is considered to be a natural gem and is one of the most popular recreation destinations in Arkansas, with over 1.5 million visitors a year (NPS 2019). The river's establishment as part of the National Park Service also represents one of Arkansas's most famous and public environmental campaigns.

The Buffalo River received national river designation and protection after an intense 10-year dispute, later nicknamed "The Battle for the Buffalo" (Pitchaithley 1989; Foley 2008). In 1961 Congressman James Trimble proposed adding two dams to the Buffalo to better control flooding in the region and generate more hydroelectric power for this impoverished area of the country (Pitchaithley 1989). Over the next decade both state and national groups fought over the future of the river; conservation groups and the National Park Service fought to incorporate the river into the national park system and landowners along the river argued to create the dams and keep the land privately held (Pitchaithley 1989). In 1972, Senator J. William Fulbright and Representative John Paul Hammerschmidt introduced a proposal for the establishment of America's first national river, which was signed into law by President Richard Nixon in 1972 (Foley 2008). This act established the Buffalo River as the first national river and part of the National Wild and Scenic River System, a designation now given to 226 rivers in the United States representing over 20,000 km of flowing waters (National Wild and Scenic Rivers System 2019).

More recently, there has been controversy in the state concerning the agricultural land around the river, specifically the concentrated animal feeding operations (CAFOs; Burkholder et al. 2007) permitted in the Buffalo River watershed. CAFOs often utilize holding manure lagoons to contain liquified animal waste, but these structures are known to be at high risk of failure under extreme weather events (Pierre-Louis et al. 2018) and leakage due to poor construction of holding ponds (Burkholder et al. 2007). Spillage from lagoons and runoff from spraying the waste on agricultural fields as a fertilizer can lead to contaminants entering the environment. The entrance of waste into the watershed of the Buffalo River is a major pollution concern due to the regional karst geology, which would allow one lagoon spill to contaminate a large portion of a watershed. To address this potential, in 2019 the Governor of Arkansas completed a state buyout to close one large CAFO in the watershed and is working toward creating a permanent moratorium against new medium to large CAFOs in the Buffalo River watershed (Walkenhorst 2019, 2020).

Due to the significant attention that the large CAFO in the Buffalo watershed received (and the subsequent state buyout), many Arkansans have been forced to consider the economic impact that the river has on the local and state economy. One way of measuring the Buffalo National River's impact on Arkansans is to calculate the river's ecosystem services. Ecosystem services (ES) refer to the value that ecosystems provide to humanity (Daily 1997; de Groot et al. 2002). While there are many frameworks for understanding and estimating ES, the TEEB framework (de Groot et al. 2002) is common in the literature and it includes provisioning (i.e., services that provide a commodity, e.g., food), regulatory (i.e., services that control biosphere function, e.g., climate), habitat (i.e., services that

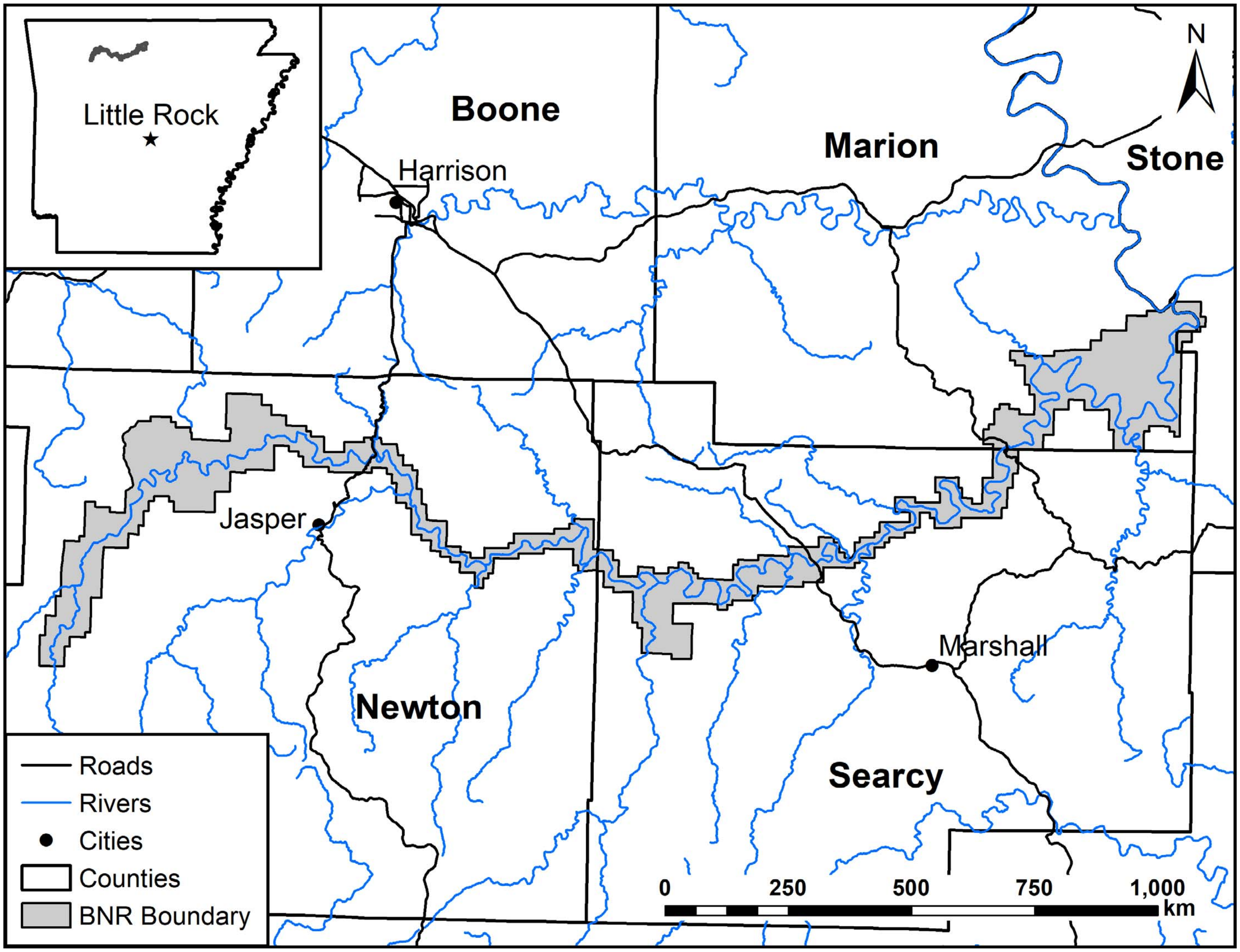

Figure 1.—Map of the Buffalo National River (BNR) across four counties in north-central Arkansas. Location of the BNR relative to the Arkansas state capitol of Little Rock is shown in the inset.

maintain biodiversity, e.g., gene pool protection), and cultural (i.e., services that maintain social and cultural characteristics, e.g., recreation). Any economic activity that modifies natural habitats can be viewed as an externality imposed on society, that is, an economic or social cost that is not paid by the entity causing it. This concept allows economists and conservationists to demonstrate the monetary value of natural habitats and compare it to the costs of modifying an ecosystem for economic purposes. Presumably, this knowledge can help inform governments and citizens when considering development projects that will adversely impact ecosystems. Ecosystem services are increasingly being utilized to help inform conservation decisions and allow for a more holistic cost–benefit analysis of ecosystem modification (Ruckelshaus et al. 2015).

The goal of this study is to estimate a comprehensive value for the ES of the Buffalo National River for Arkansas residents. In particular, ES reliant upon high-quality aquatic habitat, which may be underappreciated currently by the general public and policymakers, could be especially important for this region. Once these values have been estimated, a better understanding can be formulated concerning the trade-offs between preservation and habitat alteration or habitat-risk developments that could alter the river and its ES. This study could serve as a model for how to conduct a local ES estimation to inform conservation in the region.

MATERIALS AND METHODS

General

The Buffalo National River (BNR) is located in north-central Arkansas within the Ozark Highlands ecoregion across Searcy, Marion, Baxter, and Newton counties (Figure 1). The Buffalo River watershed encompasses 342,000 ha (Apel 1996), of which 37,796 ha are protected within the National Park Service (NPS) site boundary along 217 km of river (NPS 2020). The Buffalo River is known for its high water quality, biodiversity, and recreational uses leading to its intense popularity among Arkansans and ecotourists from all over the United States with over one million visitors annually (NPS 2018).

We utilized standard ES methods (de Groot et al. 2002; Sukhdev et al. 2010) to estimate a comprehensive valuation of the BNR. While the river is often considered important for the local economy and public health, there is little information on actual monetary values of ES the BNR provides. All ES values were based on the most recent available data and adjusted for inflation in 2018 USD.

Ecosystem Services Valuation

Food: In order to determine the food services provided by the BNR, we utilized five years of values (2013–2017) from the Arkansas Game and Fish Commission (AGFC) harvest reports for legally harvested deer and turkey (AGFC 2018). Deer meat yield was based on the results of Marchello et al. (1985) and valued as a replacement of steak cut beef. Turkey meat yield was estimated for Arkansas wild turkey average size and valued as a per pound meat replacement for whole frozen turkey (Stangel et al. 1992). Replacement costs were based on USDA Economic Research Service (ERS 2021) meat retail values. Annual fish harvest was determined using the 2013–2014 full year Angler Creel Survey conducted by the Buffalo National River Park authorities (Todd and Hodges 2014). Per pound fish replacement costs were estimated based on USDA Arkansas catfish production values (USDA 2019). Data on provisioning services of other game (e.g., bear, elk, rabbit) were unavailable and likely negligible.

Water: The BNR is a major tributary of the White River, which is an irrigation source for agriculture throughout the Grand Prairie of Arkansas (White River Irrigation District 2016). The Grand Prairie region is one of the most important row crop farming areas in the southern United States, producing a particularly large amount of rice (Gates 2005). We estimated the annual proportional value that the BNR contributes to White River irrigation based on the total contribution of the BNR to the White River at DeValls Bluff, Arkansas (USGS 2019a, 2019b), multiplied that value by the amount of water pumped from the White River for irrigation (USACE 2016), and then multiplied that value by the average price of groundwater pumping in the agricultural region of the lower White River ($80/per acre foot, equivalent to 1233 m^3; White River Irrigation District 2016). We assumed that the ecological integrity of the Buffalo River moderates flow and makes that water available downstream for economic use.

Raw Materials: The only raw material harvested from the BNR area is hay. We determined the number of hectares of land leased for hay and haylage growth per county from data provided by the Buffalo National River Park Service (A. Rodman, pers. comm.). We then multiplied each county's lease area by the value per acre of hay/haylage crops for that county, which was obtained from the USDA's National Agricultural Statistics Service Census of Agriculture (NASS 2018). These county-specific values were then summed for the total raw materials value.

Genetic Resources: To calculate genetic resources, we used the NPS's complete lists of species for the Buffalo National River, which include mammals, birds, fish, reptiles, amphibians, insects, vascular and nonvascular plants, crustaceans, mollusks, and algae. We took the mid-point for bioprospecting (93.63 2018 USD; Nunes and van den Bergh 2001) and multiplied this value by the number of species present. We acknowledge the challenge in calculating the value of genetic diversity, since some organisms can have high value while others do not (Bartkowski 2017).

Medicinal Resources: No plants may be collected from the BNR according to NPS regulations, so we assumed the medicinal value of collected plants was zero. The value of potential medicines from genetic resources of species within the park was included in *Genetic Resources*.

Ornamental Resources: Because plant collection is prohibited in the BNR, there is a lack of data to calculate the number of plants collected for ornamental uses. We do, however, acknowledge that local businesses deal with species and organisms harvested and sold for ornamental purposes (e.g., taxidermy and pelts), but those data are unavailable and their value likely negligible.

Air Quality: The estimated removal (tonnes per km^2) of air pollutants (NO_2, O_3, $PM_{2.5}$, SO_2) by trees was determined for Newton, Searcy, Madison, and Baxter counties based on figure 2 in Nowak et al. (2014) and valued at a rate of $0.1075 kg^{-1}, the estimated value for pollutant removal in rural Arkansas (table 3 in Nowak et al. 2014). Using the area of each county within the BNR boundary, we determined the total annual air pollutant removal value provided by the BNR and adjusted for inflation to 2018 values as:

$$TPR = \sum PRV_i * DV * A_i * I \tag{1}$$

where $TPR =$ total estimated air pollution removal in kg per ha, $PRV_i =$ midpoint of pollution removal range in kg per ha for each county (i) from Nowak et al. (2014), $DV =$ state-level rural average for dollar value per kg of air pollution removed, $A_i =$ area in ha for each county, and $I = 1.06$, which is the inflation adjustment for 2014 to 2018.

Climate Regulation: We used geospatial data of carbon sequestration and total biomass to calculate values for climate regulation using ArcMap 10.2 (ESRI 2012). We obtained raster files for Net Ecosystem Carbon Flux and Total Ecosystem Carbon Stock from the US Geological Survey website for Land Carbon (USGS 2017). The methods for creating these models is described in Zhu et al. (2010). The rasters were based on estimates for 2018 using the A1B scenario, which is an "IPCC emission scenario characterized by moderate population growth, high economic growth, rapid technological innovation, and balanced energy use" (ESRI 2012). We chose this emission scenario because it represents a moderate projection of emissions between the two extremes of the A2 and B1 scenarios (Nakicenovic and Swart 2000), the other two scenarios modeled in Zhu et al. (2010).

The raster layers were converted to integers using the *int* function in the spatial analyst extension and then converted to polygons using the *raster to polygon* function. Finally, we performed an intersect between the boundary of the BNR and the new polygons to generate a new layer from which we could calculate the area covered by each raster using the *calculate* *geometry* function. Then we multiplied the area of each raster by its corresponding carbon value and summed these values to get net ecosystem carbon flux and total ecosystem carbon stock, respectively, for the entire boundary of the river. Next, we converted these values to tonnes of carbon per year to sum them for the final value of climate regulation.

Moderation of Disturbance: We assumed moderation of disturbance values were included in *Water Flow Regulation* and the broader Provisioning Services category.

Water Flow Regulation: The Buffalo River ecosystem and the habitat within the ecosystem moderate water flow and affect flooding frequency downstream. The water from the Buffalo River flows into the White River, which then passes through important farmland, and we included the estimation of this value in *Water*.

To estimate the value of flood protection, we first obtained flood losses in the lower White River counties from crop insurance data for 1999–2018 (USDA 2019). We then utilized the average proportional flow of the Buffalo River into the White River system (USGS 2019a, 2019b) and assumed a 10% increase in frequency and a 25% increase in severity if the Buffalo River system was not in place to moderate water flow (Konrad 2003).

Waste Treatment: Since there are no public sewer facilities within the park, all residents who live within the boundaries of the Buffalo National River utilize septic systems. We assumed the waste treatment value of the ecosystem is therefore zero.

Erosion Prevention: We assumed the values for erosion prevention were previously accounted for in *Water Flow Regulation* and broadly speaking in various provisioning services. *Water Flow Regulation* typically includes the value of flooding-induced erosion.

Soil Fertility and Maintenance: We assumed the value of soil fertility maintenance was previously accounted for in various Provisioning Services, most notably expressed in the hay production values (*Raw Materials* section).

Pollination: There are negligible pollinated crops in the region, so we assumed this value was zero.

Biological Control: We assumed any biological control benefits were included in *Raw Materials*, *Genetic Resources*, and *Medicinal Resources*.

Nursery Services: We know of no substantial measurable populations that breed in the Buffalo River area and migrate elsewhere where they provide ES. Presumably, Neotropical migrants that breed in summer provide benefits in their nonbreeding grounds, but these values are difficult to quantify. We assumed this value was zero.

Genepool Protection: We assumed the values for this service were included in *Genetic Resources* and *Medicinal Resources*.

Total Non-use Value: We conducted a contingent valuation analysis to estimate the average value that Arkansans attribute to the non-use values of the BNR. The survey questions asked respondents to state their willingness to pay (WTP) for the resource, but these values are a function of more than just one's preference for environmental protection (Debra and Levinson 2004). For instance, even someone with strong preferences for environmental protection is limited by their income and that may affect their stated WTP. To isolate the marginal impacts of cultural, spiritual, and artistic values we used multiple regression analysis to control for confounding factors such as income, age, and proximity to the resource. We applied multiple estimation procedures to the survey results to assess their robustness. Our initial estimation method was to use ordinary least squares (OLS) regression to find the marginal willingness to pay for non-use qualities of the BNR. Our preferred model specification is:

$$\ln\,(WTP_i) = \beta_1 + \beta_2 CultVal_i + \beta_3 Inc_i + \beta_4 Age_i + \beta_5 Edu_i + \beta_6 Rural_i + u_i \tag{2}$$

Upon reviewing a number of different functional forms and variable options, this model produced the strongest explanatory power while the qualitative results were consistent with economic theory and all other specifications examined. Forecasting a point estimate of the average Arkansan's WTP for the cultural ES of the river can be found using the coefficient estimate for cultural values:

$$WTP_{AR} = exp(\beta_2) * CultVal_{AR} \tag{3}$$

Scaling the estimate described in above to the adult population of Arkansas will yield the estimated average cultural value for the entire state.

$$BNRCulturalValue = WTP_{AR} * Pop_{AR} \tag{4}$$

The CVM questionnaire asked respondents to state their one-time WTP, so to generate an annualized value the estimate must be divided by the Arkansan life expectancy of 76.1 (Biddle 2016) to find the average yearly donation. And, finally, to get the value on a per-hectare basis, we divide the annual WTP estimate by the area of the Buffalo National River.

$$\frac{WTP}{yr/ha} = \frac{BNRCulturalValue}{ARLifespan * BNRArea} \tag{5}$$

As an additional robustness test, we used the CVM data in a multinomial logistic regression to estimate the probability that Arkansans fall into different one-time WTP categories. The WTP categories were specified as "Zero," "Low," "Average," and "High" (see Supplementary Table 2 for WTP category definitions). The contribution categories ($j = 4$) are stratified around the arithmetical mean ($30) of the WTP responses of the CVM survey. These categories become the dependent variable for our multinomial logistic model and each category will have its own intercept:

$$WTP_{i,j} = \alpha_{1,j} + \alpha_2 CultVal_i + \alpha_3 Dist_i + \alpha_4 Inc_i + \alpha_5 Age_i + \alpha_6 Educ_i + \alpha_7 Vis_i + \alpha_8 Rural_i + \alpha_9 Fem_i + \epsilon_i \tag{6}$$

This model estimates the WTP category that an individual would occupy, conditional on their cultural values and associated control variables. The coefficient estimates can be interpreted as log-odds ratios that describe the log-odds that a respondent reports higher preferences relative to the reference category. To generate a specific contribution value from our data set, we can use the multinomial logit model to estimate the sample probability of a respondent to be found in each of the WTP categories. Summing across the product of the individual sample probabilities and WTP ranges for each category we can generate an expected WTP for the state:

$$E(WTP_{AR}) = pr(WTP_{Zero}) * 0 + pr(WTP_{Low}) * 5 + pr(WTP_{Avg}) * 30 + pr(WTP_{High}) * 50 \tag{7}$$

In this formulation, we have used the midpoint of the WTP range for the low and average categories and the minimum WTP for the high contribution category, which suggests that we may be erring on the side of a conservative estimate.

Recreation: To calculate the recreation value of the river, we again utilized data from the CVM survey. This survey found what portion of respondents had visited the river in the past five years. We assumed that the likelihood of visiting the river would be equal across the five-year span and divided the percentage of survey respondents that had visited the river in the past five years by five to get the probability that a survey respondent (an Arkansan) would visit the BNR in any given year. This percentage was then applied to the entire population of the state over the age of 18 (US Census Bureau 2018) to estimate how many Arkansans visited the river each year.

Next, we estimated the total direct amount of money spent by Arkansans visiting the river each year. We divided the number of Arkansans expected to visit the river each year by the estimated total number of visitors in 2017 (NPS and Buffalo National River Arkansas 2018; NPS 2019) to find what percentage of visitors were Arkansans. It is likely that this estimate is conservative because the NPS survey estimated how many times the river was visited rather than how many individual people visited. It is likely that many Arkansans visited the river multiple times in a year, but as we do not have this information available, we assumed that each Arkansan only visited the river once a year. We then multiplied the percentage of Arkansas visitors by the total amount of monetary cumulative benefit to the economy estimated by the NPS survey (which measured the amount of money spent while visiting the river) to find how many direct dollars Arkansans contributed to the economy in 2017. We then adjusted this estimate for inflation and converted it to 2018 USD. The estimate of what Arkansans spent when visiting the BNR in 2018 USD accounted for the final recreation value. We did not estimate indirect economic and community benefits, so our estimate is likely conservative.

Cognitive Development: Cognitive development can be defined as the value of increased knowledge that is the outcome of an investment and it is commonly measured by totaling the money invested in an area that is aimed at increasing knowledge (de Groot et al. 2002). This ecosystem service consists primarily of scientific experiments that are operated in the BNR as well as the NPS's budget dedicated to education and interpretation. To calculate this value, we utilized a list of ongoing studies in the river (A. Rodman, pers. comm.). We then contacted the head of each study and requested their yearly budgets for their projects. As many of these studies began during or ended after the 2018 year, we calculated the monthly budget of each study by dividing the total budget by the expected length of the study in months. We then found how many months the study was active in 2018 and multiplied months active by the monthly budget to find the total study budget for 2018. These 2018 budget values were then combined to estimate part of the cognitive development value. It is likely that this is a conservative estimate because not all researchers were able/willing to provide information on their experiment's budget.

The NPS utilizes a percentage of its budget for education and interpretation for park visitors, which indicates an investment in increasing scientific knowledge. To calculate this section of the cognitive value, we would normally utilize the river's itemized budget, broken down by five functional areas (resource stewardship, visitor services, park protection, facility operations and management, and park support) and their sub-functions. Education and interpretive programs are included as sub-functions of visitor services. The BNR, as part of the national park system, reports its annual budget but does not make public the itemized budget. To compensate for this, we found the overall NPS annual budget for 2018 (NPS 2019) and the portion of the annual budget dedicated to education and interpretive programs. The percentage that education and interpretation made up of the 2018 NPS budget was applied to the BNR's 2018 budget to find the estimate of how much the BNR spends on education and interpretation. We worked under the assumption that the BNR spent roughly the same percentage on education and interpretation as the NPS did. To find the final cognitive development value, we combined the estimated 2018 BNR education and interpretation budget and the estimated 2018 scientific research budget.

RESULTS

We found that the total annual ecosystem service value for the BNR is about $20.5 million (2018 USD; Table 1), which equals nearly $550 per hectare per year (Table 1). The bulk of the total ES value was concentrated in water, climate regulation, recreation, aesthetic information, and cognitive development, together accounting for over 95% of annual services. The five cultural service values provided for more than 70% of the total value, with recreation being the largest contributor.

Most provisioning and regulation services had little value in this survey. Since there are few legal ways of acquiring provisioning services within the protected area of the National River's boundaries, some of these values were assumed to be zero. Regulation services are largely included in provisioning services. One exception is water, which has high value downstream for agriculture. Climate regulation, however, accounted for almost 20% of the total ES value.

The OLS models did not explain a satisfactory amount of the variation in any of the WTP responses in the data (see Supplementary Table 1 for additional OLS regression WTP data). In spite of this, the results were robust to various specifications including the use of different WTP measures and functional forms. The model provided moderate evidence of joint significance across all explanatory variables, strong positive effects of aesthetic value, and strong positive effects of cumulative cultural value. Weak individual significance might suggest multicollinearity, but VIF values offered little supporting evidence of this problem.

Forecasting an average Arkansan's one-time WTP produces an estimate of $14.32 per year, suggesting that the average

Table 1.—Ecosystem services values (2018 USD) for the Buffalo National River in Arkansas. Valuation methods included: DMP = direct market price, AC = avoidance costs, CVM = contingent valuation method, TC = travel costs. Zeros indicate no value, – indicate valuations included in other categories or not applicable methods.

Service category	Ecosystem service	Value per hectare per year	Valuation method
Provisioning	1. Food	3.48	DMP
	2. Water	36.24	DMP
	3. Raw materials	1.54	DMP
	4. Genetic resources	4.82	DMP
	5. Medicinal resources	0.00	–
	6. Ornamental resources	0.00	–
Regulating	7. Air quality regulation	6.77	AC
	8. Climate regulation	103.13	AC
	9. Moderation of disturbance	–	AC
	10. Water flow regulation	9.33	AC
	11. Waste treatment	0.00	DMP
	12. Erosion prevention	–	–
	13. Soil fertility maintenance	–	DMP
	14. Pollination	0.00	–
	15. Biological control	–	–
Habitat services	16. Nursery service	0.00	–
	17. Gene pool protection	–	–
Cultural services	18. Recreation	346.36	TC
	19. Aesthetics information	17.46	CVM
	20. Inspiration for culture and art	–	–
	21. Spiritual experience	–	–
	22. Cognitive development	18.19	DMP
Total annual value (per ha)		547.22	
Total annual value (entire region)		20,683,154.50	

Arkansan attributed $14.32 to the cultural value of the BNR, when controlling for income, age, education, proximity, and rural status. The US Census Bureau estimated that the Arkansas population was 3,013,285 as of 1 July 2018, with approximately 76.7% being adults over the age of 18 (US Census Bureau 2018). Scaling the average WTP to the adult population gave a statewide average value of approximately $33.1 million. Applying this figure to the size of the protected area yields a per-hectare, per-year estimate of $11.40.

The multinomial logistic regression model produced results broadly similar to the OLS treatment but had added value as inputs to generating sample probabilities for each of the different willingness to pay categories (see Supplementary Table 3 for full results and Supplementary Table 4 for empirical sample probabilities). Using these probabilities, we generated the expected value of a randomly chosen individual's WTP associated with the non-use value of the BNR as $20.95. Scaling the individual value in the same way as described for the OLS model yielded the state and per-hectare values as $16.87 per hectare, per year. These non-use values are summarized in Table 2.

Table 2.—Three estimates of non-use value generated using data from contingent valuation study from ordinary least squares (OLS) and multinomial logistic regression (MLR) models.

	Mean values	OLS	MLR
Individual ($US)	30	14.32	20.95
State ($US)	68.7M	32.79M	47.98M
$ per year per ha	24.1	11.40	16.87

DISCUSSION

Ecosystem Services Context

The ecosystem service value of BNR is relatively low compared to other studies in this biome (temperate deciduous forest; Costanza et al. 2014). Since the entire area we studied is within the park boundaries, traditional income-generating activities, such as agriculture and timber, are prohibited. In addition, the region has a sparse population, so local ES are provided to a small number of people. However, it should be noted that this small human population may be benefitting from fairly high per capita rates of services especially since tourism related to the BNR is a major industry in communities around the park. The importance of this industry is confirmed by reviewing the Bureau of Labor Statistics data on location quotients (LQs), which communicate the importance of a specific industry in a county. LQs compare the proportion of an industry's employment or wage rate in a given area, or state, relative to that industry's proportion of employment on a national level. In 2018, Newton County had the state's third-highest travel accommodation employment LQ at 2.64 and the second-highest travel accommodation wage LQ at 4.49 (US Bureau of Economic Analysis 2018). These values show that people in Newton County were 2.64 times more likely to be employed in the travel accommodation industry than the national average and the wages for this industry were 4.49 times higher than that of the national average for people working in travel accommodation markets.

The park is highly valued by people within the state of Arkansas. The river is one of the most visited natural areas of the state, attracting visitors from both within and outside of

Arkansas. That broad support and interest in the river is evident from the politics of Arkansas where there was recently a bipartisan effort to prohibit industrial animal farms in the Buffalo River watershed (Walkenhorst 2019, 2020). This broad support for protection and conservation of the region demonstrates a high non-use value of the Buffalo River lands. Furthermore, our estimate of non-use values was undoubtedly conservative, since we only surveyed Arkansan adults; this perceived value is bound to extend outside of the state and to those under the age of 18.

The Buffalo River watershed has been under a variety of environmental threats that has recently brought to light the conflicts of competing economic activities that have different effects on ES. Intensive agriculture, notably CAFOs, a type of development that can depress ES values, has regionally expanded in recent years (Bowles et al. 2017). These economic changes have created conflict between those industries that require high levels of ES function (tourism) against one that is more exploitative of the natural world (industrialized agriculture). It also represents an example of a factor that *could* impact ES under certain scenarios, such as a farm waste spill that would imperil water quality and ability of visitors to use the river, hence decreasing current ES values. This conflict has raised the visibility and awareness of the BNR among Arkansas residents, apparently increasing the level of support for preservation of the park. This effort has been bipartisan and resulted in new rules to limit activities that pose a high risk to the river, especially regarding water quality.

Conclusions

The Buffalo National River provides Arkansans with over $20.5 million worth of benefits each year. The river provides a substantial economic boost to local economies through recreation and regulates ES (e.g., water filtration) in an efficient way that mitigates costs that Arkansans would otherwise have to pay. While it is impossible to value every aspect of the river's services, this study is meant to provide an idea of how significant the river is to the state's economy and the residents of Arkansas. This case study of the BNR provides more information for policy makers and the public on the monetary benefits of the river's continued protection, while also acknowledging the significance of non-use values of the river to Arkansans. This comprehensive ecosystem service assessment is intended to be used as a tool to better understand the value that well-functioning ecosystems can offer humans and how ecosystems can impact local and state economies. This approach could be modeled for use in other areas of the world where intact ecosystems are threatened by human development.

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