Land Use Policy 63 (2017) 196–205

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Can environmental attributes influence protected area designation? A case study valuing preferences for springs in Grand Canyon National Park

Julie M. Mueller[a,b,*], Ryan E. Lima[b], Abraham E. Springer[b]

[a] The W.A. Franke College of Business, Northern Arizona University, P.O. Box 15066, Flagstaff, AZ 86011, United States
[b] School of Earth Sciences and Environmental Sustainability, Northern Arizona University, Flagstaff, AZ, 86011, United States

ARTICLE INFO

Article history:
Received 27 October 2016
Received in revised form 17 January 2017
Accepted 23 January 2017
Available online 4 February 2017

Keywords:
Choice experiment
Non-market valuation
Springs
Grand Canyon
Uranium
Groundwater

ABSTRACT

Springs in Grand Canyon National Park (GRCA) provide water to over 6 million visitors per year. In addition to use value for visitors, springs have cultural value to indigenous peoples and provide critical habitat for plants and animals. Finally, base flow to the Colorado River is dependent upon springs and they also provide an important water source for backcountry recreation. Climate change, uranium mining, and increased groundwater pumping threaten the continued viability of Grand Canyon springs. Springs protection is at the forefront of proposed national policy to protect the area of the aquifers contributing to springs of the Grand Canyon outside of the designated boundaries of the national park. To date very little research on the non-market values of springs has been conducted, and no research has estimated non-market values of springs within Grand Canyon National Park using a Choice Experiment (CE). We conduct a nationwide online Choice Experiment to determine willingness to pay (WTP) to protect backcountry springs and attributes including; accessibility, suitability as a back country water source, suitability as habitat for species of concern, aesthetics, and significance to Indigenous Nations. We estimate a Bayesian mixed logit, and find an average willingness to pay of $32.60 per household for a spring with the presence of all five attributes. The habitat attribute produces the highest WTP of $14.80. We find WTP of $4.50 for springs with cultural significance. Results from our study could be instrumental in designation of the Grand Canyon National Heritage Monument. In addition, our results indicate that careful consideration of watershed services on public lands is essential for efficient decision-making regarding protection of public lands.

1. Introduction

1.1. Springs valuation

Springs are places where groundwater discharges at or near the surface of the Earth (Springer and Stevens, 2009). Desert springs and their associated biota are disappearing due to Climate Change and other threats (Unmack and Minckley, 2008; Shepard, 1993). While several studies have focused on the non-market value of wetlands (Ghermandi et al., 2010; Brouwer et al., 1997; Birol et al., 2009; Morrison et al., 1999); and groundwater (Tentes and Damingos, 2015; Hasler et al., 2005; Poe, 1998; Edwards, 1988; Tempesta and Vecchiato, 2013), few studies explicitly value springs. Murray et al. (2006) provides a methodology for valuing groundwater dependent ecosystems for the purpose of prioritization, but does not conduct any estimation of monetary values.

While areas within Grand Canyon National Park (GRCA) are protected from mining and other restricted uses, groundwater basins feeding springs within Grand Canyon National Park are not entirely within the Park borders. Because of potential spillover effects from outside Park borders, in November of 2015, the Grand Canyon Heritage National Monument Act (H.R. 3882) was introduced to the house committee on Natural Resources. The act proposes to develop Grand Canyon Heritage National Monument in part to protect the waters within GRCA. The act acknowledges the interconnected nature of surface and groundwater on the lands near GRCA to the springs, falls, and perennial streams within Park borders. If enacted, the creation of the Grand Canyon Heritage National Monument would require management of water flows, and withdraw the areas surrounding GRCA from new mining claims (HR 3882, 115th Congress, 2015). Our study contributes to the literature by directly addressing the values of springs fed by groundwater contribut-

* Corresponding author at: The W.A. Franke College of Business, Northern Arizona University, P.O. Box 15066, Flagstaff, AZ 86011, United States.
E-mail address: Julie.mueller@nau.edu (J.M. Mueller).

http://dx.doi.org/10.1016/j.landusepol.2017.01.029
0264-8377/

ing areas within the proposed Grand Canyon Heritage National Monument. We conduct a Choice Experiment (CE), a method of stated preference non-market valuation, to estimate willingness to pay (WTP) to protect springs in Grand Canyon National Park and to demonstrate the utility of the CE methodology for valuing springs. In addition to contributing to the literature on threatened desert springs, our study provides land managers with information on values of spring attributes, with the potential to inform budget decisions and prioritizations for land and resource management actions, including the proposed the Grand Canyon Heritage National Monument Act.

1.2. Study area

Grand Canyon National Park attracts nearly 6 million annual visitors. The central feature of the park is the gorge of the Colorado River, a notably scenic waterway cutting through bedrock to over 1400 m deep in places. Grand Canyon is approximately 446 km in length, and 29 km at its widest point. Elevations range from 2700 m on the North Rim to 750 m at river level. Average annual precipitation varies from 625 mm on the North Rim to less than 220 mm at river level. Precipitation is seasonal and variable, with most precipitation occurring during the winter as snow or during the summer monsoons from July to September (Brown and Moran, 1979; Sheppard et al., 2002). Little perennial surface water exists within GRCA other than the Colorado River, and the Colorado river is inaccessible to most life in the park due to steep topography. All of the perennial streams within GRCA are fed by springs, and most of these springs are relatively small. All but 6 of the spring fed perennial streams in GRCA discharge <1 m^3/s, therefore even marginal reductions in flow could have large effects on ecosystem functions (Stevens et al., 1997; Rice, 2012)

1.3. Benefits of springs to Grand Canyon National Park visitors

Since 1970, the sole source of drinking water for visitors has been from Roaring Springs on the North Rim of the Grand Canyon. From Roaring Springs, water is piped across the canyon and pumped up to the park facilities at Grand Canyon Village on the south rim and is pumped up to the park facilities on the north rim through a separate pipeline (U.S. Bureau Of Reclamation, 2002; Brown and Moran, 1979). Due to temperature extremes and rugged terrain, carrying heavy packs in Grand Canyon can be difficult and dangerous. Springs provide a backcountry water source and access to remote areas in the canyon. Many species are concentrated near springs, making them islands of biodiversity. Over 1800 species are found in the Grand Canyon, and 10% of those species are found exclusively in riparian areas (Stevens and Ayers 2002). In additon, springs and the riparian areas around them host between 100 and 500 times the number of plant and animal species found in the surrounding desert (Stevens and Nabhan, 2002; Grand Canyon Wildlands Council, 2004). Despite being islands of biodiversity, springs and their riparian habitats comprise only 0.01% of the landscape in the Grand Canyon.

Springs in the GRCA play a critical role in the culture and religious practices of indigenous peoples in the region. We use the term indigenous peoples in this paper to refer to members of Indigenous Nations of the Grand Canyon Region including but not limited to; Havasupai Tribe, Hopi Tribe, Hualapai Nation, Navajo Nation, Pueblo of Zuni, and several bands of Southern Paiute. Havasupai Creek, fed by springs, is the sole source of water for the Havasupai people. '*Havsuw Baaj'*, the name they use to refer to themselves, translates to *The Blue Creek People* (Hirst, 2006). In Hopi cultur, water plays a central role, and springs are considered the home of water deities who provide life-giving sap to plants, blood to animals and provide water for all other activities. According to Whiteley and Masayesva (1997), no spring in the region is without evidence of ceremonial activities, and every spring is a place of worship (Whiteley and Masayesva, 1997; Eggan, 1966). Similar beliefs in the cultural and religious significance of springs are also shared by the Navajo, who believe that springs should only be approached with reverence and ceremonial preparation (Begay, 2001).

1.4. Threats to springs due to land management policies

Despite the critical role springs play in the culture and economics of the region, springs are threatened. Proposed development in the town of Tusayan south of GRCA's border could lead to increased utilization of groundwater resources. The town of Tusayan currently obtains water from a variety of sources, including boreholes drilled 700 m deep into the Redwall-Muav aquifer, the same geologic strata that feeds many springs on the south rim of the Grand Canyon. Increased groundwater pumping near Tusayan could diminish spring flow affecting riparian habitats, recreational opportunities, wilderness values, and religious and cultural values of indigenous peoples in the region (Rice, 2012; Kreamer and Springer, 2008; U.S. Department of Agriculture, 1999).

Another potential threat facing springs in the GRCA is possible contamination from uranium mining in the breccia pipes of the region. High uranium prices in the mid-1970s sparked a host of exploration on the public lands north of the Grand Canyon. Mining activity nearly halted as the price of uranium dropped in the 1990s, but since 2004 uranium prices have been slowly increasing, sparking new interest in mining in the region (Bills et al., 2011; Wenrich et al., 1994). Thousands of solution-collapse breccia pipes occur in the Grand Canyon region (Bills et al., 2011). The breccia pipes formed when overlying rock collapsed into rainwater dissolved voids in the Redwall Formation. Mineral rich groundwater then moved vertically through the confined collapse material and deposited mineral ores including uranium (Bills et al., 2011; Wenrich and Sutphin, 1989; Wenrich et al., 1994). See Fig. 1 for a map of the Uranium mines near GRCA.

Uranium mining could impact the water quality of springs in Grand Canyon National Park. The breccia pipes in the Grand Canyon region contain some of the highest grade uranium ore in the country (Bills et al., 2011; Wenrich et al., 1994). While nuclear energy has been seen as a mature low-carbon solution to mitigate climate change (IPCC, 2014), mining in this fragile ecosystem poses potential risks. Deep mining could potentially lead to the mobilization of trace elements into perched-aquifers and into the regional Redwall-Muav aquifer (Bills et al., 2011). Decreases in the quantity and quality of water could change the character of springs and riparian areas surrounding springs. Several species like the Mexican spotted owl, bighorn sheep, the endangered Kanab ambersnail, Southwest Willow flycatcher, and Humpback chub could be adversely affected by decreasing stream quality and water quantity (Alpine, 2010; Grand Canyon Wildlands Council, 2000). Furthermore, indigenous peoples with over 12,000 years of history in the region consider GRCA and the surrounding areas as Traditional Cultural Property and extractive mining in the area is inconsistent with the character of the landscape's rich cultural and religious history (Alpine, 2010; Grand Canyon Wildlands Council, 2000).

2. Related economic literature

Several studies estimate the value of wetlands, riparian habitat, and rivers. For example, Earth Economics (2014) released a valuation report for the entire Colorado River Basin, compiling results from hundreds of revealed and stated preference non-market valuation studies. The report provides total ecosystem service values for riparian habitat ($4.6 –$354.7 million dollars/acre/year), river and