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Water quality improvements elicit consistent willingness-to-pay for the enhancement of forested watershed ecosystem services

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ABSTRACT

The aim of this study is to improve understanding of willingness-to-pay (WTP) for the enhancement of selected ecosystem services from forested watersheds. Results from a nationwide survey of over 1000 U.S. households showed limited knowledge of payment for ecosystem service (PES) programs and antagonistic opinions regarding initial WTP for watershed conservation and corresponding PES financial charges. Water quality dominated importance among selected PES attributes used in a discrete-choice experiment followed by provisioning of habitat for threatened plant and animal species, flood control, and landscape aesthetics. Econometric analyses elucidated that environmental attitudes significantly influenced WTP results even more than annual household income. Results show WTP levels for improvements in water quality were homogeneous across the nation but heterogeneous for the enhancement of habitat, landscape and flood control. Findings support the establishment of PES initiatives that enhance forested watersheds conditions across the U.S. primarily driven by improvements in water quality. PES programs should be tailored locally to emphasize the provisioning of other ecosystem services such as habitat for threatened species and flood control.

1. Introduction

Forested watersheds provide a multitude of ecosystem services vital to human wellbeing. These services include purification and preservation of drinking water quality, maintenance of habitat for both aquatic and terrestrial species, protection of landscapes, and flood control, among many others (Brauman et al., 2007; de Groot et al., 2010; Hein et al., 2006; Millennium Ecosystem Assessment 2005; Postel and Thompson, 2005). Plant communities within watersheds play a central role in abiotic processes ranging from precipitation interception and infiltration, to sediment deposition and nutrient retention (Brauman et al., 2007; Calder, 2007; Jose, 2009; Neary et al., 2009; Ong and Swallow, 2003). Vegetation facilitates the provisioning of suitable habitat to sustain diverse ecological communities. For instance, Booth (2000) estimated that at least 65% canopy cover was required to support a healthy aquatic insect community within a forested watershed in the US state of Washington. At a local level, dense vegetation and the presence of trees in particular help ameliorate the magnitude of flooding while simultaneously enhancing aesthetics (Calder, 2007; Calder and Aylward, 2006; Food and Agriculture Organization/Center for International Forestry Research, 2005; Sudmeier-Rieux et al., 2013).

Land management practices can negatively impact forested watershed ecological structure and functions with consequences to the supply of ecosystem services (Brauman et al., 2007; Smartt et al., 2013). For instance, land use change within forested watersheds has major and often immediate effects on water quality (Calder, 2000; Hack et al., 2013; Lee et al., 2009; Ngoye and Machiwa, 2004). Smartt et al. (2013) found concentrations of nitrate, total dissolved nitrogen, soluble reactive phosphorus, calcium, chlorine and barium to be greater in agricultural lands than primary forested lands surrounding spring-fed streams in the US state of Arkansas. Land use change and the degradation of watershed ecosystem structure and functions are often driven by market incentives as alternative uses often offer greater financial returns (Aylward et al., 1995; Richards et al., 2017; Roesch-McNally and Rabotyagov, 2016; Walls and McConnell, 2004). Notably, some of the most fundamental ecosystem services derived from watersheds (e.g. regulating flood protection, water purification, habitat

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provision) are seldom included in market transactions effectively resulting in societal benefits that are external to the landowner (Duncker et al., 2012). This phenomenon stems from the public good characteristics of non-market ecosystem services and is reflected in imperfect or no price signals (Shortle and Uetake, 2015).

Public policy instruments might be instituted to address externalities as a root cause of ecosystem degradation and loss (Black, 1997; Postel and Thompson, 2005; Grima et al., 2016). Financial incentive programs help to internalize the benefits associated with the contribution of ecosystem services to human wellbeing if landowners have the *de jure* or *de facto* right to degrade or change land characteristics (Barbieri and Aguilar, 2011; Greiber, 2009; Kosoy et al., 2007; Milder et al., 2010). Payment for ecosystem service (PES) programs establish a contractual mechanism for the provisioning of non-market ecosystem services that is financially compensated by the opportunity cost of forgoing more financially-profitable land uses (Pagiola, 2008; Fisher et al., 2010; Martin-Ortega et al., 2013). Worldwide, watersheds constitute some of the most commonly-targeted ecosystems that PES mechanisms have been used for the protection of their functions and services (Lin, 2014; Milder et al., 2010; Richards et al., 2015). Multiple watershed PES schemes have been implemented and new ones continue to emerge as evidence strongly supports the cost-effectiveness of this mechanism for forested watershed conservation to mitigate water quality problems (Blanchard et al., 2015; Chichilnisky and Heal, 1998; Ernst et al., 2004; Hack et al., 2013; Kreye et al., 2014; Postel and Thompson, 2005; Stubbs, 2014). The emergence of PES programs point to the acknowledgement of the role watersheds play in protecting and enhancing ecosystem services as well as the potential of PES to encourage preferred land management practices.

Much of the literature to-date has focused on beneficiaries' willingness-to-pay (WTP) for water quality due to its salient role in wellbeing and their localized direct benefits within forested watershed boundaries (e.g. Condon et al., 2007; Holmes et al., 2004; Nelson et al., 2015; Weber et al., 2016). However, beneficiaries might be willing to pay for the provisioning of other complementary ecosystem services too (Gómez-Baggethun et al., 2010; Dendoncker et al., 2013; McAfee, 2012; Kareiva et al., 2007; Raudsepp-Hearne et al., 2010). These complementary ecosystem services range from carbon storage to habitat for plant and animal species and improved landscape aesthetics with the potential to be bundled in a comprehensive PES program (e.g. Blaine et al., 2003; Cooksey and Howard, 1995; Roesch-McNally and Rabotyagov, 2016; Shrestha and Alavalapati, 2004). Nevertheless, studies that have elicited the value of forested watershed benefits other than water quality or in a conjoint fashion are limited. Moreover, a review of the literature on beneficiary-side impacts of PESs shows emphasis on studies of improved water services in developing countries with less focus on other forested watershed attributes as well as in other regions (Lalika et al., 2017; Richards et al., 2015; Whittington and Pagiola, 2012).

The aim of this study is to enhance current understanding of the factors influencing WTP for PES programs in the U.S. and how its population perceives and values different ecosystem services arising from forested watershed ecosystems. We focused on forested watersheds due to the integral role they play in assuring the sustainable supply of quality water, ample geographic distribution nationwide, and the potential to offer complementary direct and indirect benefits (Hall et al., 2015; Kreye et al., 2014; Neary et al., 2009). A stated preferences study was implemented nationwide to (1) determine the relative preferences for selected outcome attributes of forested watershed ecosystem services; (2) examine the impact that socio-demographic characteristics and attitudes towards PES have on WTP for improved watershed ecosystem services; and (3) assess marginal WTP for changes in the level of attributes representing expected outcomes based on perceived economic values of a forested watershed ecosystem.

2. Methods

We implemented a self-reported nationwide survey to gather information regarding knowledge of watershed ecosystem services and attitudes towards PES programs. A discrete choice experiment (DCE) was designed to elicit preferences pertaining to a hypothetical PES program instituted to yield enhanced outcomes inclusive of water quality, flooding control, landscape aesthetics, and habitat for plant and animal species. Our aim to examine preferences nationwide brought up the challenge of creating a DCE that offered a level of abstraction and generalization that would make it relevant across the U.S. We followed the recommendations for contingent valuation studies (Arrow et al., 1993; Johnston et al., 2017) ranging from asking for WTP to multiple choice scenarios with reminders of income effects and available alternatives. Ours, however, was not a valuation of any specific watershed. We emphasize that our findings are not applicable to a specific watershed but to a hypothetical local one. The DCE implementation followed a conjoint design with specific procedures, data collection and analyses described in the following section. The DCE was based on participants' selection of desirable outcomes profiling enhancements in selected forested watershed service attributes or no changes in current conditions. More details of the DCE design procedures and steps followed for data collection and econometric analyses are presented next.

2.1. Discrete choice experiment

DCE methods assume that utility derived from goods or services is a function of the particular attributes and corresponding levels comprising it (Hensher et al., 2005; Heywood and Stephens, 2010; Louviere et al., 2000). In a DCE, participants are asked to choose between two or more alternatives where at least one attribute of the alternative is systematically varied such that information related to preference parameters of an indirect utility function can be inferred (Carson and Louviere, 2011). More formally, the probability of an individual's WTP for a PES program to enhance forested watershed service outcomes can be expressed as:

$$Prob(WTP = Yes, No|Z_{PES}, Z_{statusquo}, w) = Prob(U_{PES} > U_{statusquo}) \quad (1)$$

where the probability of choosing to pay for a PES (Yes, No) is conditional on outcomes from PES implementation captured through a set of attributes (Z_{PES}), current conditions profiled on a *status quo* scenario ($Z_{status\ quo}$) and individual's characteristics (w). An individual is willing to pay for a PES if the utility derived from that choice (U_{PES}) is greater than the utility from no changes at no additional payment ($U_{status\ quo}$). Choices reflect the implicit trade-offs among the different attributes of alternative options and WTP estimates are interpreted as indicators of the change in utility that respondents expect from specified outcomes (Börger et al., 2014; Chaikaew et al., 2017). The *status quo* inclusion helped reduce bias in the WTP estimates and provided a way consistent with demand theory to analyze trade-offs (García-Llorente et al., 2012; Rolfe and Bennett, 2009).

Attributes and levels for a hypothetical PES program (Z_{PES}) that yields improved outcomes and no intervention ($Z_{status\ quo}$) were selected to generate profiles. The selection was based on key ecosystem services provided by forested watersheds (e.g.