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Consumer demand for urban forest ecosystem services and disservices: Examining trade-offs using choice experiments and best-worst scaling

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ABSTRACT

Many studies value urban ecosystem service benefits using residents' willingness to pay and supply-side analyses of ecosystem attributes. But, few studies account for consumer demand and ecosystem disservices. To address this gap we surveyed 1052 homeowners eliciting consumer demand for key urban forest ecosystem attributes and service-disservice levels in both their properties and surrounding neighborhood. We use an approach integrating focus group, field data, and surveys to identify consumer preferences and trade-offs between urban forest ecosystem structure-functional attributes and their level of services and disservices. This method, called best worst choice, produces more estimates of utility while reducing the likelihood of introducing biases associated with human cognitive tendencies. Results indicate that consumer choices for property value were highest followed by tree condition, a structural proxy for minimizing disservices, and tree shade, a functional proxy for temperature regulation. We also found evidence of trade-offs in demand for different ecosystem services, significant scale effects, and that willingness to pay for ecosystem disservices was negative. Findings suggest that management, and studies that value and map ecosystem services, using fixed scales should account for end-user demand and functional traits, as consumers can discern trade-offs in benefits and disservices across different cognitive and spatial scales.

1. Introduction

Urban forest ecosystems provide a wide range of quasi-public goods and services (ES), but these are often produced at socially inefficient levels (Gómez-Baggethun and Barton, 2013). Some of these urban ES benefits include property value premiums, outdoor recreation opportunities, energy use savings, environmental pollution and climate regulation (Siriwardena et al., 2016). However, combined with several ecosystem disservices (ED) such as maintenance costs and related pollution emissions, allergies, litter fall, and fear of crime (Escobedo et al., 2011), the net outcomes can be negatively affected. The effect of scale (e.g., local-scale property value premiums versus basin-scale water regulation) and context (e.g., tropical versus arid climates) of ES bundles coupled with costs has also been little studied.

This lack of including costs and trade-offs might lead to underperforming public provision programs and not accounting for context-relevant ES (Escobedo et al., 2011). In addition, the role of socio-ecological scale and spatial dynamics in valuation studies of these quasi-public services have been consistently overlooked in previous studies (Bertram and Rehdanz, 2015). Accordingly, investigating residents' choices of site and context-specific urban forest attributes and provision levels for both ES and ED bundles in their private properties or neighborhoods could address this void in the literature.

Understanding residents' demand for urban forest attributes and related ES and ED provision is important given the differences in ownership and incentives to maintain such forests. Urban forests are ecologically heterogeneous and often composed of non-natives and invasive plant species that require high maintenance that can lead to pollution emissions (Horn et al., 2015). Similarly, while governments manage larger populations of trees along rights-of-way, in parks, or natural areas, urban trees also grow on private lands owned and managed by a diverse assemblage of stakeholders and citizens (Zhao et al., 2010). The extent to which

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urban tree cover contributes to temperature regulation and property values has previously been investigated in studies in the US, Europe, and China (Chen and Hua, 2015; Pandit and Laband, 2010; Giergiczny and Kronenberg, 2014). Also, the link between urban forest structure and improved air quality, carbon sequestration, hurricane debris generation, wood waste production and property values have also been investigated in a few studies in the subtropics (Dobbs et al., 2011; Escobedo et al., 2009, 2015; Timilsina et al., 2014).

Previous studies have also valued these economic benefits of natural forest ecosystem services (Kreye et al., 2016) and assessed consumers' environmental concerns and willingness to pay (WTP) for residential landscape attributes such as water-saving plants or plantable/compostable pots (Khachatryan et al., 2014). However, little is known about preferences for – and the economic value of – ES from urban forests (i.e., the sum of all trees and woody plants in and around cities). As mentioned above, these forests also incur social and economic costs, known as EDs (Dobbs et al., 2011). Thus, any decision regarding the supply of, and demand for, ecosystem outputs should weigh the trade-offs in both their benefits and costs (Gómez-Baggethun and Barton, 2013).

Studies in Europe, Asia and North America have used stated preference valuation of urban trees in different contexts. Giergiczny and Kronenberg (2014) found that residents were willing to pay more for greening streets with "few to no trees." Lo and Jim (2015) and Chen and Hua (2015) reported overall positive WTP, but with contradictory results (i.e., positive and negative response to urban tree benefits), often in the form of protest responses; indicating citizen distrust for government programs. Bertram and Rehdanz (2015) found an inverted U-shape effect on the amount and distance to urban green space on "life satisfaction" for residents. Latinopoulos et al. (2016) found that people living within 20 min of a reference site are WTP significantly less for urban greening projects. Local-scale attributes can also affect WTP for urban forest attributes. Escobedo et al. (2015) used hedonic valuation to assess the effect of urban forest structural attributes on property value premiums in Florida, USA; on average, more trees with greater Leaf Area Indices (LAI) add to property value, while biomass and tree–shrub cover have a neutral effect, and replacing tree with grass cover lowers property values. Urban forest maintenance costs and related emissions (i.e., ED) have also been studied at the plot-level in Florida (Horn et al., 2015). But, rarely have these been compared against the beneficial ES tradeoffs of these same urban plot-level attributes.

The aim of this study was to determine consumers' demand for urban forest ES/ED attributes using context specific data and information across socio-ecological scales. Such an approach can facilitate the analyses of trade-offs in preferences of ES bundles among homeowners at the private property and community/neighborhood scale. To do this, we implement a relatively new survey method, called Best Worst Choice (BWC), which combines best worst scaling (BWS) and binary discrete choice experimentation (DCE) to produce more estimations of utility while decreasing survey length, exhaustion, and choice task complexity. Specifically, the study builds on the following four research questions. First we identify what urban forest ES (i.e., utility) and ED (i.e., utility-of-avoidance) are most important to homeowners and second, we determine what ES and ED attributes and levels do homeowners demand from private property versus neighborhood urban forests. Third, we estimate how much are homeowners willing/unwilling to pay for ES (or not pay for ED) when considering trees in local-scale private properties versus community-scale neighborhoods. Finally, we assess if the implementation of a hybrid method that combines BWS and DCE will yield more estimates of utility.

2. Methodology

We employed two separate surveys of homeowners who answered questions about ES bundles at two socio-ecological scales, the local private property scale and surrounding neighborhood, community scale. The ES bundles were presented using BWC, a hybrid choice experimentation method that yields two types of data from a single profile of attributes: BWS and binary choice. The application of BWC in these types of urban ecosystem service studies is to our knowledge, novel. The choice modeling experiments we propose based on BWS, forces respondents to make direct trade-offs between ES attribute levels. Findings from this type of approach can be used to better understand what specific landscape design and forest structures homeowners and managers prefer for a more sustainable provision of ES from these heterogeneous and complex socio-ecological systems.

2.1. Best-worst choice modeling

Choice modeling is a popular economic valuation method (Adams et al., 2011), used in marketing research to inform new product development (Khachatryan et al., 2014; Soto et al., 2016) and can identify product attributes or combinations that influence a consumer's choice decision. It does so by presenting study participants with competing hypothetical bundles of goods and services, and then asking them to choose their most preferred bundle – a cognitive exercise that is similar to shopping. When a payment vehicle is included and a 'none of these' choice option is presented, the approach is known as DCE, as opposed to Conjoint Choice, which has been shown to be inconsistent with economic theory (Louviere et al., 2010). The DCE can be used to assess consumer WTP or producer willingness to accept (WTA) payments within hypothetical markets. Since we often lack adequate markets for ES, and market data is normally used to assess economic value, this hypothetical market approach is viewed as a viable practice for valuation of resources and services (e.g., Allen and Moore, 2016; Barrena et al., 2014). Choice modeling approaches have been used to gauge consumer interest in a range of environmentally sustainable ornamental production and landscape management practices (Khachatryan et al., 2014; Khachatryan et al., 2016), water related ES from forests (Kreye et al., 2016), and to assess park visitors' WTP to control invasive plants (Adams et al., 2011).

A relatively newer alternative to discrete choice-based experimentation is best-worst choice (BWC; Flynn et al., 2007) and has been applied in the health, business, and forest management sciences (Coast et al., 2006; Louviere et al., 2015; Soto et al., 2016; Kreye et al., 2016). As BWC adds a best-worst scaling (BWS) component to DCE, it provides more robust information on respondent preferences. In particular, this method adds a BWS task to the traditional DCE binary choice method (i.e. Binary hereafter) – offering a complementary alternative to the limitations of both BWS and Binary (i.e., direct utility measurements of attribute levels; Louviere et al., 2015). The BWC method provides two survey choice tasks: 1) select a best and a worst attribute from a given profile of attribute levels; and 2) choose to accept or reject the scenario as a whole (see Fig. 1). This method places all attribute levels on a common utility scale (i.e., BWS estimations), while also producing measurements of traditional discrete-choice experimentation approaches (i.e., Binary; Louviere et al., 2015). The BWC design requires the identification of attributes, or factors that drive consumer preferences, and varying provision levels of these attributes, which are then presented to respondents as questions in a survey.

As seen in Fig. 1, by asking respondents to perform two tasks: 1) choose a "most important" (best) and "least important" (worst)