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Research article

Valuing urban open space using the travel-cost method and the implications of measurement error

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ABSTRACT

Urbanization has placed pressure on open space within and adjacent to cities. In recent decades, a greater awareness has developed to the fact that individuals derive multiple benefits from urban open space. Given the location, there is often a high opportunity cost to preserving urban open space, thus it is important for both public and private stakeholders to justify such investments. The goals of this study are twofold. First, we use detailed surveys and precise, accessible, mapping methods to demonstrate how travel-cost methods can be applied to the valuation of urban open space. Second, we assess the degree to which typical methods of estimating travel times, and thus travel costs, introduce bias to the estimates of welfare. The site we study is Taylor Mountain Regional Park, a 1100-acre space located immediately adjacent to Santa Rosa, California, which is the largest city (~170,000 population) in Sonoma County and lies 50 miles north of San Francisco. We estimate that the average per trip access value (consumer surplus) is $13.70. We also demonstrate that typical methods of measuring travel costs significantly understate these welfare measures. Our study provides policy-relevant results and highlights the sensitivity of urban open space travel-cost studies to bias stemming from travel-cost measurement error.

1. Introduction

Increases in urbanization and urban sprawl have led to increased pressure on urban open space, and greater attention payed to the role of open space in the urban environment (e.g., Johnson, 2001; Thompson, 2002). It is widely acknowledged that urban open space provides a suite of amenities, most of which are not directly valued in markets, that should be considered in cost-benefit analyses associated with development decisions (Brander and Koetse, 2011; Johnson, 2001; Kong et al., 2007; More et al., 1988; Wolf, 2004; Wu and Plantinga, 2003). In particular, conservation of large natural areas in close proximity to cities can provide a compelling value proposition when compared to either small urban parks or large remote ones. They give large numbers of people access to a wide variety of recreational opportunities, including such activities as hiking, trail running, cycling, and horseback riding, that require large areas. Further, such spaces provide values particularly associated with extensive, intact landscapes, such as scenic views, biodiversity conservation, protection of watersheds, and climate stabilization. However, they also involve larger land costs, as the opportunity cost of urban and peri-urban land is much greater than remote land. Therefore, valuation of such landscapes is critically important to efficient development of the urban landscape.

The fact that there are not explicit markets for the amenities urban open spaces provide complicates the cost-benefit analysis associated with urban planning (Wolf, 2004). There are several tools commonly used to assign monetary values to non-market environmental amenities, each of which has its strengths and weaknesses. Heretofore, the most common methods for assessing the value of urban open space have been contingent valuation or hedonic pricing (Brander and Koetse, 2011). The strength of these methods is that both can be designed to capture the full amenity value of the study site. However, numerous criticisms have been leveled at the incentive-compatibility (and other) issues associated with responses to contingent valuation surveys (e.g., Arrow et al., 1993; Diamond and Hausman, 1994), and hedonic pricing

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methods require high-quality data on residential housing markets and strong *ceteris paribus* assumptions. The travel-cost method, however, is all but absent from the literature on the valuation of urban open space (exceptions include Dwyer et al., 1983; Iamtrakul et al., 2005; Liu et al., 2014).

The travel-cost method is used to estimate site-level demand for recreation by modeling the relationship between visitation and the implicit price of visiting the site (the travel cost).[1] Identification of a demand curve hinges, in part, on sufficient covariation between visitation and travel costs. For this reason, the travel-cost method has been used extensively in the context of more remote recreational open space (e.g., state and national parks), where there is ample variation in the cost visitors incur to reach the sites due to their varying points of origin (e.g., Bin et al., 2005; Fleming and Cook, 2008; Liston-Heyes and Heyes, 1999; Mendes and Proença, 2011). Urban open space, on the other hand, tends to draw visitation from relatively proximal populations, raising concerns regarding sufficient variation in visitor points of origin necessary for inference (More et al., 1988). Further limiting the use of the travel-cost method in the urban setting are the methods by which travel costs have tended to be estimated in the past. Travel costs are estimated as a function of, among other factors, time spent traveling to and from the site (Bockstael et al., 1987; Cesario, 1976; Smith et al., 1983). Thus estimated travel costs depend critically on how one locates points of origin, and models distance and travel time to the site. Computational difficulty and the inaccessibility of geographic information systems (GIS) in the past have led to many studies that define point of origin using coarse geographic boundaries (e.g., counties or zip codes) and travel distance and times that are calculated using Euclidian measurements and assumptions about average travel speeds (Bateman et al., 2002, 1999; Brainard, 1999). Such coarse measures will inherently introduce measurement error to the data, and thus bias into the estimator. That bias will likely be more pronounced in data where the mismeasurement (in distance and travel time) is proportionally large in comparison to the overall measurement. In other words, bias will likely be larger in the urban setting. For example, suppose that point of origin is defined as the geographic center (centroid) of a zip code and that the average distance measurement error across zip codes is a constant. Clearly measurement error (and thus bias) will be proportionally larger for visitors that live nearer to the site, a common attribute of urban open space.[2] Therefore, accurate measures of travel distance and cost are particularly important in the urban setting.

We use single-site travel-cost methods to estimate the recreational value of Taylor Mountain Regional Park, a large open space that abuts the city of Santa Rosa in northern California. We address concerns regarding sufficient variation and bias stemming from measurement error by using exact residential location as a measure of visitors' point of origin and highly-precise, easily-accessible methods of measuring travel distance and time, based on Google Maps. We estimate per-trip consumer surplus to be $13.70, on average, which translates to a yearly total consumer surplus of approximately $1.5M. In addition, we compare our primary consumer surplus estimates to those that would be estimated through measurement methods that have typically been employed in travel-cost studies. Specifically, we calculate additional consumer surplus measures by: (1) using the Euclidean distance from visitors' zip code centroids to Taylor Mountain, and various assumptions about average travel speed, and; (2) using zip code centroids as visitors' point of origin, and measurements of travel distance and time to Taylor Mountain based on Google Maps. The first additional analysis mimics the methods that originated prior to the widespread use of GIS, but still persist in research in recent decades (e.g., Bin et al., 2005; Grossmann, 2011; Layman et al., 1996; Mendes and Proença, 2011, for discussion see Bateman et al., 1999; Brainard, 1999). The second mimics more advanced uses of GIS to measure travel distance and time suggested by (Bateman et al., 2002) when exact residential location is unknown. We demonstrate that both of those methods significantly understate the estimated recreational value, which implies that both precise GIS measures and precise point-of-origin measures are necessary for unbiased travel-cost estimates in the urban setting, and likely elsewhere.

2. Background and design

2.1. Site background

Santa Rosa, California, is a city of approximately 170,000 located 50 miles north of San Francisco (see Fig. 1). It is situated in Sonoma County, which has an unusual mechanism for funding the acquisition of open space. The county levies a 0.25 percent sales tax and uses the proceeds to buy property and conservation easements via a public agency called the Sonoma County Agricultural Preservation and Open Space District (SCAPOSD). Much of the land acquired is transferred to either California State Parks or Sonoma County Regional Parks. Among SCAPOSD's objectives is to extend the benefits of open space to lower-income and minority communities. Urban open space is one approach to accomplish that goal.

The Taylor Mountain Regional Park and Open Space Preserve represents a large investment in land conservation near the urban core of Santa Rosa. Between 1995 and 2011, SCAPOSD invested $26 million to acquire the 1100 acres of land. It is one of the larger public open spaces in the area and a defining visual feature of Santa Rosa's landscape. Currently, Taylor Mountain has over five miles of unpaved, multiple-use trails, with plans for the development of 17 additional miles under the master plan (Ferber and Mkay, 2011). Taylor Mountain also has one of only three public 18-hole disc golf courses in Sonoma County and it is the closest course to the major population center of Santa Rosa. Its amenities, proximity, and terrain make Taylor Mountain a popular destination for hikers, runners, disc golfers and equestrians.

There are two entrances to Taylor Mountain, both of which require a parking fee. The fee can be paid on a daily basis ($7) or through the purchase of an annual Regional Park Pass ($69, with discounts for certain user groups). The primary entrance (near Kawana Springs Road) is the older of the two and provides access to two trailheads and the disc golf course. The second entrance (off Petaluma Hill Road) was opened in 2015 and offers access to a single trailhead, which connects to the primary trail system. There are a number of road-side parking spots that lie outside of the Kawana Springs entrance, allowing visitors to avoid paying parking fees. Such an option is not available at or near the Petaluma Hill Road entrance.

The two most popular activities at Taylor Mountain are walking/hiking and disc golf (see Table 1). Based on this and the attributes of Taylor Mountain, we define Annadel State Park (Annadel) and Crane Creek Regional Park (Crane Creek) as potential substitute

[1] Given the primary focuses of this study, we do not provide a formal survey of the travel-cost method. However, the interested reader can find in-depth surveys of the method, and citations of numerous papers from the literature in Champ et al. (2003) and Ward and Loomis (1986).

[2] Similar concerns over lack of *variation* in the urban setting can also be illustrated through use of a logical extreme. If we suppose that point of origin is defined by the geographic center of a county, one might find that all visitors would be defined by a single point of origin. Thus eliminating all variation in travel distance and reducing variation in travel cost.