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Longitudinal analysis of ecosystem services' socioeconomic benefits: Wastewater treatment projects in a desert city

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ABSTRACT

This paper addresses the socioeconomic dimensions and public perceptions of ecosystem services offered by "green" wastewater infrastructure in a desert city over 20 years, taking an in-depth look at the valuation of these services. While there was significant controversy and public conflict over the location of the original wastewater treatment facility and an initial decrease in property values, the average assessed property values in the study area increased relatively quickly. Within five years, they met and exceeded the average property values in the Metropolitan Phoenix Area. Our longitudinal study found that anticipated nuisance effects did not materialize with the operation of the facility and that residents were satisfied or very satisfied with the area's quality of life as well as its environmental quality. The results also show that the co-benefits of artificial wastewater wetlands and green recreational space associated with the use of effluent and groundwater recharge enhanced developments around these facilities, making these places socially acceptable. Finally, we determined that proximity to views of water and parks, especially in desert cities, adds substantial value. Home prices showed remarkable resiliency in neighborhoods around constructed water projects that filter effluent, provide enhanced place-making aesthetics and recharge the groundwater aquifer, the most critical ecosystem service.

1. Introduction

Recently, there has been an upswing in research activity and publications on valuing urban ecosystem services, particularly on methods and approaches to measure their benefits (Boyer and Polasky, 2004; de Wit et al., 2012; Fisher et al., 2011; Gómez-Baggethun and Barton, 2013). Much of this interest falls into discrete areas such as contingent valuation analysis (Mitchell and Carson, 1989); property value benefits from largely aesthetic enhancement of ecosystem features (Ignatieva et al., 2011); the use of measuring the land value effects through hedonic price modeling (Abbot et al., 2015; Klaiber and Smith, 2013); long-term benefits of ecosystem recovery, i.e., wetlands (Bullock et al., 2011); and the utility of using natural resources for urban environmental infrastructure (Cook, 2015; Vymazal, 2010a). For example, there is significant research and literature on urban parks as a community amenity (Kowarik, 2011; Lee and Mahewaran, 2011). Yet, the socioeconomic impacts of these parks as places for providing ecosystem services remain largely unstudied.

This paper addresses the socioeconomic dimensions and public perceptions of ecosystem services offered by "green" infrastructure, namely constructed wetlands and public parks as recharge basins for groundwater recharge, in a desert city. The paper looks at three projects in one city, Avondale, Arizona, and assesses the impacts through public surveys and property values over two decades. By looking at longitudinal impacts, this paper adds value and original contributions to the literature of ecosystem services.

According to the Ecological Society of America (Ecological Society of America (ESA), 2012), ecosystem services are "the processes by which the environment produces resources that we often take for granted such as clean water, timber, habitat for fisheries, and pollination of native and agricultural plants." These processes exist in every ecosystem in which humans live – cities, rural and agricultural areas, forests, and deserts. Services include cultural (e.g. recreation); provisional (e.g. food, water, medicines); regulatory (e.g. air quality, flood control); and supportive (genetic diversity) (Bolund and Hunhammer, 1999; Mooney et al., 1997). In a recent survey of homeowners, cultural values were identified specifically as aesthetics, personal enjoyment,

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and low maintenance (Larson et al., 2016).

While the potential value added in developing artificial lakes and lagoons to provide wastewater effluent treatment and groundwater recharge is recognized, ecosystem service values are not easily measured due to the interconnected intangibles they provide. Timothy Beatley's *Biophilic Cities* (Beatley, 2011) provides ample evidence of the importance of these services to physical and mental health, community resiliency, place making, pollution abatement, and heat island mitigation among other community benefits. None of the previous works, however, specifically discuss measuring nature's value in socioeconomic and cultural terms.

This paper builds on these works as it is grounded in the larger context of valuing urban ecosystem services, specifically the development of human-constructed features that filter and clean wastewater effluent in a desert city (i.e., constructed recharge basins and artificial wetlands), to understand their socioeconomic impacts. It is important to recognize that this study focuses on the larger and longer picture of ecosystem service impacts. Therefore, it does not measure the specific monetary benefits of direct and regulatory aquifer recharge nor the indirect amenity values in maintaining park space and designed residential-based lagoons for groundwater discharge. Rather, the study looks at the direction and magnitude of property values around these facilities as an indicator of public perceptions of value added, quality of life, and community support.

The principal method for wastewater effluent treatment, both in the past and today, is for cities to invest in technological wastewater treatment facilities (WTFs). These facilities are often located at the lowest point of the sewage collection watershed in order to reduce pumping costs or at the edge of the city. Water waste from homes and industry is typically piped to WTF plants through sewer systems. The plant treats this water to remove contaminants such as solids and toxins then the remaining wastewater effluent is further diluted through surface water resources such as lakes, rivers, or more often recently, transferred to places for groundwater discharge.

Lakes, rivers, and wetlands naturally dilute pollutants from wastewater using vegetation, soils, and microbial assemblages. Constructed wetlands are engineered to mimic these natural processes. Investigations into wetland and other aquatic plant systems to treat wastewater effluent were initially undertaken in various European countries by Seidel (1976), Kickuth, (1977), de Jong (1976) and others. By the end of the 1960s, engineering of natural wetlands for wastewater effluent treatment was being explored in North America (Ewel and Odum, 1986; Kadlec et al., 1979; Odum et al., 1977). Since then, it has evolved into an effective wastewater effluent treatment technology (Vymazal, 20102010b).

Treating wastewater effluent through wetlands and recharge basins can greatly benefit cities, especially those in dry desert regions, by augmenting and replenishing groundwater aquifers. Other benefits captured in this study include cost savings from reduced operations of WTFs; establishment or enhancements of parks and open spaces and their recreational co-benefits; aesthetic enhancements; and land value enhancements (Department for Environment, 2007; de Wit et al., 2012). Another potential benefit for urban areas is the development of neighborhoods around these derived ecological system assets.

Residential developments emerged around two of our sites adding considerable tax revenues to the city. The importance and resiliency of these places can be measured in long-term property value impacts. This paper looks at this socioeconomic benefit for properties around urban constructed wetlands as an indicator for valuing ecosystem services.

Beyond the potential benefits of alternative wastewater treatment options, we know little about the magnitude and direction of changes resulting from these options and even less about the changes when these options are implemented in desert cities. There are exceptions of course and a few studies are available. Most of these concentrate on how to implement these measures and their various dimensions rather than focusing specifically on impacts, however (Assessment, 2005; Fisher et al., 2011; Howarth and Farber, 2002). Therefore, this paper aims to understand the *community value* that can come from ecosystem services. We look at the socioeconomic impacts using property value increases as indicators of positive public responses to the WTF and the resiliency of surrounding neighborhoods. Using this approach, we can also measure the co-benefits of ecosystem services.

1.1. Objectives

This paper takes an in-depth look at the valuation of ecosystem services by comparing alternative wastewater effluent treatment options in one city. It explores three types of infrastructure—a conventional sewage treatment plant, a multi-faceted recharge basin and open space recreational center, and a constructed urban residential wetland site—in Avondale, Arizona, a city located in the Phoenix Metropolitan Area, and analyzes them longitudinally. Overall, the analysis covers a period of approximately 20 years (1996–2016), providing longitudinal data and demonstrating significant community benefits from groundwater augmentation, the park-based recharge basin, and constructed wetland projects. This study also validates ecosystem services valuation (National Research Council (NRC), 2012). Moreover, some of the key questions for urban planners and designers concerning the socioeconomic effects of ecosystem design alternatives are answered in this paper. These questions center on the public acceptance of wastewater treatment via community built ecological systems or green infrastructure.

We hypothesize that alternative WTFs in desert cities offer park-like and water-based features that attract people to them, create a sense of place, and are socially acceptable. We explore the public acceptance of these ecologically designed infrastructure projects despite the perception of potential risks. Finally, we verify that the co-benefits of these types of projects result in property values increasing, as the literature suggests, thus adding to the area's attractiveness, place-making identity and resiliency (Polyakov et al., 2013). Having three distinct ecological features in separate locations of the same city that respond to different needs provides important triangulated data and cases to support our hypotheses (Benford et al., 1993; Zhang et al., 2010).

1.2. Background

Some land uses such as sanitary landfills, hazardous waste management facilities, recycling plants, nuclear waste sites, and certain manufacturing industries and infrastructure often face strong community opposition, especially by residents living in the vicinity of the proposed development. This not-in-my-backyard (NIMBY) phenomenon can play a significant role in the public's negative attitude towards these types of land uses, as they are perceived to present local risks and nuisances while their benefits are distributed throughout the community. Among the list of unwanted land uses are sewage treatment plants (STPs) and (WTFs) (Fitchen, 1991), such as the Avondale Wastewater Treatment Plant built in the mid-1990s in the southern part of the city. This WTF is included as one of the three types of infrastructure in this study, acting as a control case.

Although these facilities provide benefits to the entire community, critics point to disamenities and negative externalities that impact the areas where they are sited, i.e., posing risks and threats to nearby residents (Bell, 2008). Among the most common perceived threats are adverse health impacts, noise pollution, vector-born diseases, noxious odors, traffic congestion, and declining property values. STPs and WTFs are often looked at as noxious facilities and as such create “risk amplification” effects due to their risk and disamenity perceptions. Risk amplification was coined by Kasperson et al. (1988) to illustrate how the public perceives risk at much higher levels than what the scientific risk analysis would suggest.

Transcripts of the Avondale WTF public hearings regarding its siting mention numerous concerns including nuisance effects (noise,