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Research Paper

Housing location in a Philadelphia metro watershed: Can profitable be green?

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HIGHLIGHTS

- Housing is placed in a Philadelphia-area watershed according to profitability and sustainability under two different zoning schemes.
- Profit, energy use, air pollution, greenhouse gases, water quality and biological integrity are assessed for each scenario-zoning combination and compared.
- Implications of the results are used for policy recommendations.

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ABSTRACT

The objective of this paper was to examine the profit levels, energy use and environmental impacts of two residential development scenarios in a watershed in the Philadelphia region under two zoning assumptions. The two scenarios were based on economic suitability and environmental suitability. A key question was whether these occurred together in the Pennypack Creek Watershed. Suitability analyses in ArcGIS using criteria for profit and for local sustainability parsed out two sets of developable areas. Buildouts to satisfy 2035 population projections in these areas using CommunityViz software were based on actual municipal zoning ordinances. In a unified zoning scheme created by the authors, a density-adjusted number of housing units are placed watershed-wide without municipal restrictions. Profit data for buildings in each zip code were used to compute a Weighted Profit per Square Meter. Household units were associated with a particular type of automobile and average Vehicle Kilometers Traveled in the relevant census tracts. The GREET program was used to compute energy use, air pollution emissions and greenhouse gas emissions. A Weighted Water Quality Index and Index of Biological Integrity were used to assess water-related impacts based on recent monitoring data supplied by the Philadelphia Water Department. It was no surprise that ECON-UNI and ECON-MUNI generated higher profit than ENV-MUNI and ENV-UNI. ENV-UNI had lower energy use and environmental impacts than all others. That ECON-MUNI had the second lowest energy use and environmental impacts, and the highest water quality, was unexpected. Some policy proposals and conclusions end the paper.

1. Introduction

Land use change is considered by some analysts to be the most important human-induced environmental transformation (Wolman & Fournier, 1987). Suburbanization in the US has been a predominant form of land use change that has become increasingly automobile-dependent and has lost ties with central cities. New development has extended into prime agricultural and wooded lands, and other environmentally sensitive areas (Batty & Xie, 2005; Cervero, 2003; Cullingworth & Caves, 2003; Galster et al., 2001; Walker, 2004). Environmental degradation at the suburban fringe includes an increase in the release of greenhouse gases, degradation of lakes and streams and loss of biodiversity (Walker, 2004). Such growth is also thought to cause many socioeconomic ills (Adams, Bartelt, Elesh, & Goldstein, 2008). That some of this can be avoided is the thrust of the present work.

Watershed planning, conducted within watershed boundaries, and land use planning, usually focused on municipal boundaries, are often two different planning processes. A watershed-based planning approach is a "coordinating framework for environmental

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management that focuses public and private sector efforts to address the highest priority problems within hydrologically-defined geographic areas" (Browner, 1996). A multi-municipal program, with governments and watershed associations working together to establish and apply regulations, offers a comprehensive way to manage the natural and built environment. This study examines such an approach, despite the difficulties that exist in states such as Pennsylvania where fundamental land use decisions are made by municipalities (Hershberg, 2003; Kenney, 1997).

Although the integration of local planning processes is increasingly being seen as a critical public policy challenge (Carter, Kreutzwiser, & de Loë, 2005; Mitchell, 2005; Plummer, de Grosbois, de Loe, & Velaniskis, 2011), few studies have analyzed the process of using a watershed-based planning approach to locate residential development. Steiner, McSherry, and Cohen (2000) performed a suitability analysis for four land uses, including housing development, within a large, rural watershed in the western US. The authors found areas suitable for housing, but did not focus on the impacts of development in the areas they found suitable. Tang, Engel, Pijanowski, and Lim (2005) also studied a large watershed in an already urbanized and industrialized area in the US Midwest. They concentrated on the environmental impacts of previous development, but made very general recommendations for future watershed decision making. Brown (2000) proposed using housing density as a water quality indicator in another large US Midwest watershed, but did not estimate the impacts of new residential development. The present study uses suitability analyses to locate areas for housing buildouts in a small watershed in the eastern US, examines the energy use and environmental impacts of four scenario-zoning combinations and makes some policy recommendations based on the results. By comparing economic impacts and energy/environmental impacts of housing location schemes, the present work aims to determine whether profitable and green development can happen together. It is thought that this approach can add a new dimension to planning at the watershed level.

Using a mix of regulations and incentives, municipalities can implement watershed-level plans within their boundaries by channeling development in agreed-upon directions. As Daniels and Daniels (2003, p. 3) write, "Land use planning ... needs to emphasize redevelopment and infill within cities and suburbs, maintaining quality built environments, preserving valuable natural areas and working landscapes, and carefully designing greenfield developments." While the work for this paper is focused on the former objectives, there was no attempt to implement design at the subdivision level.

The next section describes the study area and discusses how the data were used to generate suitable areas for development, to locate buildings in those areas, and to measure the impacts of such location. The third section presents and discusses the empirical results. Policy implications and conclusions follow.

2. Data and methods

The logical sequence by which the analysis proceeds is as follows: After setting the geo-political context, the elements of residential development that comprise economic suitability and environmental suitability are discussed. These elements were operationalized in Geographic Information Systems (GIS) software, ArcGIS from the Environmental Science and Research Institute (ESRI), to create suitable areas for the economically suitable and environmentally suitable scenarios. CommunityViz was used to perform buildouts for the two scenarios under actual and "unified" zoning. The means are described by which profit, energy use, air pollution, greenhouse gases, water quality and biological integrity resulting from the housing location patterns were computed.

2.1. The study area

Located in the Delaware River Basin (Kaufman, Homsey, Belden, & Ritter-Sanchez, 2011), the 90 km^2 Pennypack Creek Watershed (PCW) crosses through 12 municipalities within three counties in southeastern Pennsylvania on its way to the Delaware River. About 328,000 people live within its boundaries according to the 2010 US Census. The Creek is a public amenity, contributing to the public water supply and used extensively for recreation.

From 1950 to 1980 the watershed outside the City of Philadelphia limits experienced significant development. As of 2012, single-family homes made up 38% and multi-family homes 12% of the watershed (Fromuth, 2012). Over the last decade, the PCW has been estimated to be about 30% impervious (PWD, 2003, 2009). The PCW is serviced by public water suppliers, and it is estimated that stormwater collection systems are installed in 65% of it. Many of these systems were designed only to collect runoff and discharge it offsite. This has resulted in increased flooding, destabilized stream channels, severe erosion and sedimentation. A municipal treatment plant contributes a large portion of the base flow in the Creek, resulting in additional nutrients. In the midst of the urbanization within the PCW, there has been significant effort by conservation groups and government agencies to preserve land as open space (Fig. 1) (DVRPC, 2010), Figs. 2 and 3 are intended to give the reader spatial views of the watershed.

Local political independence is evident in Pennsylvania, and plays into land use considerations significantly. In the mid-1970s, the state legislature adopted the Home Rule Charter stating, "A municipality ... may exercise any function not denied by this Constitution, by its home rule charter or by the General Assembly at any time" (PA DCED, 2003). The Pennsylvania Municipalities Planning Code Act of 1968 permits municipalities to make land use decisions. In the PCW, there are 12 different zoning codes regulating land use and (in most codes) dwelling density. Though most municipalities have their own protective measures to conserve floodplains and preserve open space, the end result is often a disconnected set of preserved parcels throughout the watershed. The potential synergies of joint measures across municipalities are thereby not realized.

Section 303(d) of the US Clean Water Act describes the nature of an impaired stream. The Act requires that: "The states identify all waters where required pollution controls are not sufficient to attain or maintain applicable water quality standards, and establish priorities for development of Total Maximum Daily Loads based on the severity of the pollution and the sensitivity of the uses to be made of the waters, among other factors" (US EPA, 2014). The Pennypack Creek is listed by the Pennsylvania Department of Environmental Protection (PA DEP) as an impaired stream for two designated uses, aquatic life and recreation. Total Maximum Daily Loads have been assigned by the PA DEP for a number of pollutants. They include quantifiable reductions for trichoroethylene, fecal coliform, dissolved oxygen-consuming pollutants, phosphorous, and suspended solids. The responsibility to implement the reductions lies with either wastewater treatment operators or local municipalities. Both must apply to the US Environmental Protection Agency (EPA) for a National Pollution Discharge Elimination System Permit for permission to discharge pollutants. Wastewater operators and municipalities have to pay for and administer additional controls to reduce the amount of pollutants in their wastewater or storm sewer systems. These efforts are not done in coordination, reducing pollutants in a piecemeal fashion.

In 1978, the Pennsylvania legislature recognized that flooding and water quality problems existed because regulations were not standardized throughout watersheds. It enacted the Stormwater Management Act (SMA), requiring the PA DEP to designate watersheds, and establish guidelines for the preparation of Stormwater