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Estimating impacts of population growth and land use policy on ecosystem services: A community-level case study in Virginia, USA

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ABSTRACT

Despite advances in decision-making tools and frameworks, the consideration of ecosystem services in local, regional, and national scale planning remains limited. In this study, we address two broad goals: (1) By using "off the shelf" data and tools, we provide a practical example for how local policy makers can incorporate considerations of ecosystem services in land use planning; and (2) To understand the complex and non-linear relationships between population growth, land use change, land use policy, and ecosystem services. Focusing on Albemarle County and Charlottesville, VA, we assess impacts on a range of ecosystem services using a land consumption ratio that links the land use to population density patterns. Varying levels of population growth were modeled and impacts to ecosystem services quantified given current land use policies. With increasing population growth, ecosystem services that exist within areas targeted for growth are initially compromised. However, once growth pressures reach a threshold, ecosystem services across the region are dramatically degraded. These findings point to the tradeoffs that community-level planners face when ecosystem services are considered in the context of population growth. Our results also highlight the importance of maintaining permanent protection on lands with high natural and cultural value.

1. Introduction

Despite advances in techniques for economic valuation of ecosystem services (Tallis et al., 2010; Burkhard et al., 2012), and advances in other arenas, including the development of decision-making tools and frameworks (Seppelt et al., 2012; Ranganathan et al., 2008), the consideration of ecosystem services in land use planning and management efforts remains limited (Daily et al., 2009; de Groot et al., 2010; Chan et al., 2006; Goldstein et al., 2012; Ranganathan et al., 2008). In the USA, there are some notable regional and state-level examples of the explicit incorporation of ecosystem services into conservation planning. For example, in the Chesapeake Bay Watershed a nascent conservation marketplace exists that allows landowners to develop ecosystem service credits that can be sold to buyers for regulatory compliance (primarily related to protection of water resources or for habitat conservation) or to voluntarily support conservation action (U.S. Environmental Protection Agency, 2011; Bay Bank, 2013). Similarly, the Willamette Partnership in Oregon is moving from the pilot phase to broader implementation with the Counting on the Environment Program, a conservation marketplace similar to the Bay Bank (Willamette Partnership, 2012a). In both of these cases, the most successful markets are linked to regulatory compliance. In addition, standardized, transparent tools for developing ecosystem service credits are critical for widespread adoption (Willamette Partnership, 2012b).

At the local level, there are few concrete examples where community-level land planning efforts explicitly incorporate ecosystem services (de Groot et al., 2010). Examples that do exist often illustrate an incomplete implementation. For example, the City of Damascus, Oregon completed an ecosystem service evaluation, the outcome of which was a map of natural resources intended for conservation planning (Yap et al., 2009). The current draft comprehensive plan (City of Damascus, 2013), however, acknowledges that natural areas can provide stormwater management, recreation opportunities, etc. but the concept of ecosystem services is not introduced as a component of the planning framework. Similarly, in the Canadian state of Ontario, where an ecosystem approach to local land use planning has been encouraged since 1994 (Ontario Ministry for Environment and Energy, 1994), "the conventional land use planning model remains fundamentally intact and unchallenged" (Tucker, 2010, p. 1). A review of ecosystem management approaches in Florida likewise found that factual information regarding ecosystems is lacking, providing no firm basis for management decisions, and that narrowly focused traditional planning tools remain entrenched in local planning

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culture (Brody, 2003). TEEB (2011) echo these statements and argue that local land use planning is often an effort that is compartmentalized based on specializations, such as transportation, housing, economic development, etc. While the comprehensive plan should ostensibly unite these efforts, policy recommendations are often made without considering the connections between these sectors. TEEB (2011) recognize the sectoral nature of local land use planning as a key institutional barrier and recommend strong stakeholder engagement and the use of science-based knowledge to inform public discourse and decision making.

Given this background, this study provides an important example for a community in the state of Virginia, USA. We use data, tools, and methods that are widely available, well-documented, and transparent in order to explore the relationship between population growth and land use change in the context of existing land use policies, and the impacts on ecosystem services. We address two broad goals. First, by using "off the shelf" data and tools, and assumptions that are both transparent and grounded in local planning approaches, we provide a practical example for how local policy makers can realistically incorporate considerations of ecosystem services in land use planning, particularly for growth management. Second, we use this case study to quantify the complex and non-linear relationships (e.g. Liu et al., 2007) between population growth, land use change, land use policy, and ecosystem services. This study addresses several key issues raised by de Groot et al. (2010) and TEEB (2011). By taking a spatially explicit approach, we are able to present the current status of ecosystem services within our study area and map and visualize the impacts of population growth and land use change in the context of current land use policy. This provides an important baseline scenario for decision makers to consider trade-offs and alternatives. Furthermore, de Groot et al. (2010) specifically note that while global and regional modeling tools are available for assessing the impacts of economic and environmental factors on natural resources, local scale models that are relevant to local land use management are relatively rare.

1.1. Study area

The City of Charlottesville and the predominantly rural Albemarle County, VA are located at the foot of the Blue Ridge Mountains on the Piedmont of central Virginia. Interstate 64 runs east to west, connecting the major north–south transportation corridors of Interstate 81 to the west and the highly urbanized Interstate 95 corridor to the east. It is located roughly 100 miles southwest of Washington, DC – just outside of the Washington, DC-Baltimore, MD metropolitan area – and 70 miles west of Richmond, VA (Fig. 1). Its accessibility to several major population centers on the East Coast of the United States, coupled with its many natural and cultural amenities, make it a desirable destination for tourists and for those seeking a residence that is proximate to urban centers but that maintains a rural character.

The population of the city of Charlottesville itself has remained fairly stable over the past 50 years at roughly 40,000 residents (U.S. Census, 2010b); the county's rate of growth has led to a doubling of the population in the last four decades and in 2010 the county's population reached 98,970 (U.S. Census, 2010a). By 2040, the population for the region is expected to increase by another 64% (Weldon Cooper Center for Public Service, 2012).

Ecosystem services and sustainability are concepts that are already explicitly incorporated into local planning documents, which is a relatively unique aspect of the planning culture of this locality. The Albemarle County comprehensive plan recognizes the importance of ecosystem services as being critical to the "economy, health, safety, and welfare, and quality of life" (Department of Community Development, 2007a, p. 1), specifically mentioning regulating services such as the purification of air and water and flood mitigation. Furthermore, the County has committed to support several accords produced by the Thomas Jefferson Sustainability Council, a regional planning body, including "Strive for a size and distribution of human population that will preserve the vital resources of the Region for future generations" and "Ensure that water quality and quantity in the Region are sufficient to support the human population and ecosystems" (Department of Community Development, 2007a, p. 4; Thomas Jefferson Sustainability Council, 1998). Implementing these goals is the next challenge.

2. Objectives

Our study was designed to address the relationship between land use change and ecosystem services. As important drivers of land use change in this study area, both population growth and existing land use policies are considered as key components of the land use system. To address these issues, our specific objectives are as follows:

1. Identify and quantify a set of ecosystem services that are locally influenced, relevant to local stakeholders and policy makers,

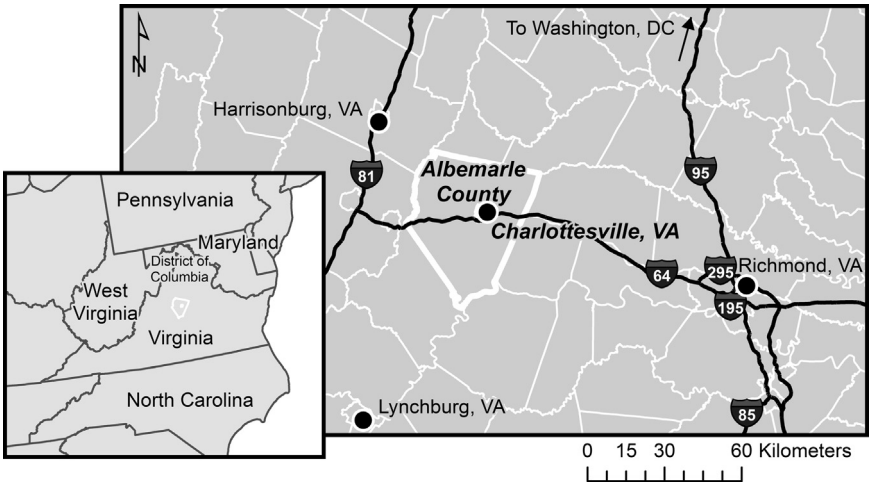

Fig. 1. Study area.