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Mapping ecosystem services: Practical challenges and opportunities in linking GIS and value transfer

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ABSTRACT

In this paper, a decision framework designed for spatially explicit value transfer was used to estimate ecosystem service flow values and to map results for three case studies representing a diversity of spatial scales and locations: 1) Massachusetts; 2) Maury Island, Washington; and 3) three counties in California. In each case, a unique typology of land cover and aquatic resources was developed and relevant economic valuation studies were queried in order to assign estimates of ecosystem service values to each category in the typology. The result was a set of unique standardized ecosystem service value coefficients broken down by land cover class and service type for each case study. GIS analysis was then used to map the spatial distribution of each cover class at each study site. Economic values were summarized and mapped by tributary basin for Massachusetts and California and by property parcel for Maury Island. For Maury Island, changes in ecosystem service value flows were estimated under two alternative development scenarios. Drawing on lessons learned during the implementation of the case studies, the authors present some of the practical challenges that accompany spatially explicit ecosystem service value transfer. They also discuss how variability in the site characteristics and data availability for each project limits the ability to generalize a single comprehensive methodology.

1. Introduction

> Ecosystem services are the benefits people obtain either directly or indirectly from ecological systems (Millennium Ecosystem Assessment, 2003, page *v*.)

The process of identifying and quantifying ecosystem services is increasingly recognized as a valuable tool for the efficient allocation of environmental resources (Heal et al., 2005; Millennium Ecosystem Assessment, 2003). By estimating and accounting for the economic value of ecosystem services, social costs or benefits that otherwise would remain hidden can potentially be revealed and vital information that might otherwise remain outside of the economic decision making calculus at local, national, and international scales can be internalized (Millennium Ecosystem Assessment, 2005). However, achieving such an objective requires considerably better understanding of ecosystem services and the landscapes that provide them.

In this paper, we present a framework for the spatial analysis of ecosystem service values (ESVs), illustrated through three case studies. Thanks to the increased ease of using Geographic Information Systems (GIS) and the public availability of high quality land cover data sets, bio-geographic entities such as forests, wetlands and beaches can now more easily be attributed with the ecosystem services they deliver on the ground (Bateman et al., 1999; Eade and Moran, 1996; Kreuter et

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al., 2001; Wilson et al., 2004). This approach compliments the other transfer techniques discussed in this Special Issue of *Ecological Economics*.

The ability to integrate biophysical and ecosystem service valuation data is a relatively new phenomenon (Kreuter et al., 2001; Wilson and Troy, 2005). Rather than argue for a single unified methodological approach that can apply to all possible circumstances, our goal is to outline a set of decision rules that have served as the basis of our efforts in three case studies.

This paper first briefly reviews previous efforts to classify and place economic values on ecosystem services associated with natural and semi-natural landscapes in a spatially explicit manner. Second, it describes our decision making framework for conducting spatially explicit value transfer by linking analyses of non-market economic valuation data and biophysical data. Third, it describes how this framework was applied to three case studies. Fourth, it discusses limitations, including the potential variability of each implementation. The paper concludes with observations on current trends and expected future directions in spatially explicit ecosystem value transfer.

2. Spatially explicit value transfer

Value transfer involves the adaptation of existing valuation information to new policy contexts where valuation data is absent or limited.[1] For ESVs this involves searching the literature for valuation studies on ecosystem services associated with ecological resource types present at the policy site. Value estimates are then transferred from the original study site to the policy site (Desvousges et al., 1998; Loomis, 1992). Value transfer has become an increasingly practical way to inform decisions when primary data collection is not feasible due to budget and time constraints, or when expected payoffs to original research are small (Environmental Protection Agency, 2000). As such, the transfer method is now seen as an important tool for environmental policy makers since it can be used to relatively quickly estimate the economic values associated with a particular landscape for less time and expense than a new primary study (see Iovanna and Griffiths, 2006-this issue).

Although the transfer method is increasingly being used to inform policy decisions by public agencies, the academic debate over the validity of the method continues (see Wilson and Hoehn, 2006-this issue). Primary valuation research will always be a “first-best” strategy for gathering information about the value of ecosystem goods and services. However, when conducting primary research is not feasible, value transfer represents a meaningful “second-best” strategy and starting point for the evaluation of environmental management and policy alternatives. While value transfer is far from perfect, we believe that it is better than the status quo approach of assigning a value of zero to ecosystem services.

[1] Following Desvousges et al. (1998), we adopt the term ‘value transfer’ instead of the more commonly used term ‘benefit transfer’ to reflect the fact that our approach is not restricted to economic benefits, but can also be extended to include the analysis of potential economic costs, as well as welfare functions more generally.

One of the biggest potential pitfalls in value transfer occurs when values are drawn from study sites that are situated in very different contexts than targeted policy sites. For example, to simply assume that the economic value of a freshwater wetland in one ecological region is going to be the same for a freshwater wetland in a wholly different region would be inappropriate. Given this, we anticipate that as the richness, extent, and detail of information about the context of value transfer increases, the accuracy of estimated results will improve. The better we are able to match the biophysical and socio-economic context of the source with the target, the more accurate our estimates will be.

While much attention has focused on the economic theory and practice of environmental value transfer itself, much less attention has been paid to the inherently spatial nature of many environmental values. As Eade and Moran (1996) note:

> The spatial dimension to economic valuation has barely been investigated…The adoption of a spatial approach to economic valuation is desirable in terms of producing more accurate economic valuation figures, for use as a repository for benefits estimates, examining spatial sustainability, and facilitating the introduction of natural capital concepts into environmental decision-making processes (p. 109).

Spatial disaggregation of ecosystem services allows us to visualize the pattern and distribution of ecologically important landscape elements and overlay them with other relevant themes (Bateman et al., 1999; Eade and Moran, 1996). A common principle in geography is that spatially aggregated measures of geographic phenomena tend to obscure local patterns of heterogeneity (Fotheringham et al., 2000; Openshaw et al., 1987). Analogously, aggregate measures of non-market values, while useful, can also obscure the heterogeneous nature of the underlying resources that provide those services. For example, an aggregate measure of ecosystem services at the global level may indicate significant amounts of a land cover type associated with nutrient cycling and waste treatment, such as estuaries (Costanza et al., 1997). Yet, this global measure does not tell us whether the estuaries are distributed evenly throughout the study region or are all clustered in one region-conditions that have very different implications for land use management.

To date, the number of published analyses using a spatial value transfer framework is limited. Among those studies is one by Kreuter et al. (2001), who attempted to quantify the impact of urban sprawl on the delivery of ecosystem services using LANDSAT imagery and global ecosystem service value coefficients derived from Costanza et al. (1997). The authors used satellite imagery and remote sensing software to determine the area of six land use classes in each of three watersheds in Bexar County, Texas. These estimates were then incorporated into an economic valuation model that used biome-level, global approximations of ecosystem service values (Costanza et al., 1997). Based on this analysis, the authors determined that there was a 65% decrease of rangeland and 29% increase in the area of urbanized land use between 1976 and 1991 with a resulting net 4% decline of annual ecosystem service values for that same time period. This relatively small decline was attributed to the effect of a 403% increase in the