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An empirical evaluation of spatial value transfer methods for identifying cultural ecosystem services

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ABSTRACT

A significant barrier to the assessment of ecosystem services is a lack of primary data, especially for cultural ecosystem services. Spatial value transfer, also known as benefits transfer, is a method to identify the probable locations of ecosystem services based on empirical spatial associations found in other geographic locations. To date, there has been no systematic evaluation of spatial value transfer methods for cultural ecosystem services identified through participatory mapping methods. This research paper addresses this knowledge gap by examining key variables that influence value transfer for cultural ecosystem services: (1) the geographic setting, (2) the type of ecosystem services, and (3) the land cover data selected for value-transfer. Spatial data from public participation GIS (PPGIS) processes in two regions in Norway were used to evaluate spatial value transfer where the actual mapped distribution of cultural ecosystem values were compared to maps generated using value transfer coefficients. Six cultural ecosystem values were evaluated using two different land cover classification systems GlobCover (300 m resolution) and CORINE (100 m resolution). Value transfer maps based on the distribution of mapped ecosystem values produced strongly correlated results to primary data in both regions. Value transfer for cultural ecosystems appear valid under conditions where the primary data and value transfer regions have similar physical landscapes, the social and cultural values of the human populations are similar, and the primary data sample sizes are large and unbiased. We suggest the use of non-economic value transfer coefficients derived from participatory mapping as the current best approach for estimating the importance and spatial distribution of cultural ecosystem services.

1. Introduction

A logical consequence of the Millennium Ecosystem Assessment (2005) has been increased effort to identify and map the distribution of ecosystem services globally, but ecosystem services are resource-intensive to identify, inventory, and map. In the absence of primary data in most places, a common method has been the use of proxies based on "benefits transfer" Plummer (2009), also known as "spatial value transfer" (Troy and Wilson, 2006). These methods involve estimating ecosystem benefits from a small region and applying them over a larger area, or stated more generally, the transfer of primary data to areas where no data exist. A common approach is to estimate ecosystem services from land cover data and then apply economic valuation as transfer coefficients (e.g., Sutton and Costanza, 2002; Troy and Wilson, 2006; Turner et al., 2007; Petrosillo et al., 2009).

Cultural ecosystem services (CES) are a subset of ecosystem services that provide non-material benefits such as spiritual enrichment, cognitive development, reflection, recreation, and esthetic experiences (MEA, 2005). Identifying the spatial distribution of CES presents special challenges because they are not adequately defined or integrated within the ecosystem services framework (Chan et al., 2012; Daniel et al., 2012), are usually intangible and incommensurate with economic valuation methods (Chan et al., 2012; Hernández-Morcillo et al., 2013), may be "bundled" with other ecosystem services (Raudsepp-Hearne et al., 2010), and involve complex psychological dimensions in the valuation process (Kumar and Kumar, 2008). Due to these methodological challenges, cultural ecosystem services are rarely fully considered in ecosystem services assessments (Plieninger et al., 2013).

Most CES are not directly observable in the physical landscape and require (1) proxy or indicator measures derived from observed or inferred human behavior, or (2) direct human inquiry about the

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benefits received. Proxies may be used to identify the location of CES, for example, the number of tourist attractions as a proxy for tourism benefits or the number of observations of rare species as a proxy for nature appreciation benefits (Raudsepp-Hearne et al., 2010). However, the validity of proxies, especially for CES, is often questionable (see Eigenbrod et al., 2010a). Research to collect primary data on CES has increasingly used participatory mapping methods, variously called public participation GIS (PPGIS), participatory GIS (PGIS), and volunteered geographic information (VGI) (see Brown and Fagerholm, 2015; Brown and Kyttä, 2014, for a review of applications). The mapping of place-based values using PPGIS/PGIS/VGI methods appears valid for identifying CES under the assumption that the values elicited identify locations that directly or indirectly contribute to human well-being. The terms ecosystem "service" and "value" are often conflated in the literature as the terms are closely related. Ecosystem services are the benefits people obtain from ecosystems while ecosystem values are measures of how important ecosystem services are to people. An assumption of participatory mapping is that when a place is identified as valuable by a participant, it is providing a benefit or service. The mapping of ecosystem values identify *relationship* values (Brown and Weber, 2012) that bridge *held* values (what is important to the person mapping) and *assigned* values (the physical place features that contribute to the value).

Participatory mapping methods are a desirable method for identifying CES given their flexibility and adaptability to a wide range of physical and social settings. Specifically, participatory mapping can be designed to identify a full range of CES from landscape esthetics to "sense of place", can use digital or non-digital mapping technologies, can use qualitative or quantitative methods, and can target different sampling groups ranging from randomly selected households, to stakeholder groups, to crowd-sourced volunteers. But this methodological pluralism also means that "best practice has yet to coalesce" in the mapping of ecosystem services (Brown and Fagerholm, 2015, p. 119) resulting in continuing trials and case studies that map CES. Given the effort required to collect primary CES data, there is benefit if the participatory mapping of CES can be meaningfully spatially transferred to other places where primary data does not exist.

The spatial value transfer of CES involves describing the spatial associations between CES and the physical landscape in one area and then applying these associations to other areas or regions. One of the challenges to spatial value transfer is the heterogeneity in global physical environments and diversity in human cultures. For example, the cultural ecosystem service of recreation may be found in a wide range of physical environments, from mountains to lakes to urban parks, while preferences for specific types of recreation activities are typically embedded in cultural norms. Significant spatial associations between CES and land cover have been identified in multiple empirical studies (e.g., Brown, 2013; Brown et al., 2012; Brown and Brabyn, 2012a,b) but the associations vary by place and cultural setting. The distribution of CES may also be influenced by land tenure and protected area status (Brown et al., 2015b; Hausner et al., 2015).

Generalization errors are the major threat to the validity of spatial transfer methods. As described by Plummer (2009), generalization error can be subdivided into three components of *uniformity*, *sampling*, and *regionalization*. Uniformity error occurs when ecosystem values are not constant (uniform) for a particular physical environment such as land cover, sampling error results from too few study areas being used to develop transfer indices or coefficients, and regionalization error occurs when the study area is not representative of the area being transfer mapped. Results from benefit transfer of primary recreation data in England using 10 km × 10 km grid cells and land cover proxies show that generalization errors are "sufficiently large to undermine decisions that might be based on such extrapolated maps" (Eigenbrod et al., 2010b, p. 2487). They found that variation in ecosystem services within the land cover classes (uniformity error) resulted in a poor fit to primary data, while sampling effects and area extrapolation also contributed to reductions in fit with primary data. The high degree of uniformity error was not surprising given that recreation value tends to be spatially clustered, even within a given land use cover class.

The generalization errors depend on the scale and the quality of land use-land cover maps used for benefit transfer. Multiple studies indicate that benefit transfer results are sensitive to both the choice of land cover data, especially for value transfer of biophysical ecosystem services, and the value-transfer population in the case of cultural ecosystem services such as recreation. Foody (2015) found ecosystem service values based on six land cover classes in the U.S. changed almost two-fold when adjusted for misclassification bias, while Konarska et al. (2002) showed the estimated economic value of ecosystem services could increase by a factor of three when using land cover classification derived from 30 m spatial resolution imagery instead of 1 km resolution imagery. Grêt-Regamey et al. (2014) found that the use of too coarse resolutions (250–300 m) underestimate the presence of spatially aggregated ecosystem services compared to finer resolutions (25–30 m). Similarly, Whitham et al. (2015) used six different methods to assess ecosystem service values in a protected area in China and showed that locally based, and more time and skill-intensive economic valuation approaches produced different results from global assessments developed by Costanza et al. (1997). These generalization errors have been assessed for biophysical indicators of ecosystem services and appear applicable to value transfer processes that assess CES.

No studies have previously evaluated the validity of spatially transferring multiple CES from one location to the other using participatory mapping. In the value transfer study most closely related to this study, Brown et al. (2015a) used participatory mapped data that identified places as important for recreation (primary data) in two separate study regions in Norway. In the analysis, the primary spatial data collected in one region was value-transferred to the second region based on the proportion of recreation values found in each land cover class. The value-transfer map was compared to the map generated from primary recreation data. The correlation coefficient between the primary data map and the value transfer map was 0.98 indicating a good fit across regions. However, the Brown et al. (2015a) value-transfer study did not explore the full potential of participatory mapping whose strength lies in the potential to assess multiple CES values while identifying their relative importance. With the value transfer of CES, one might hypothesize that participatory maps generated from local or regional populations would produce large generalization errors in the value-transfer process. And similar to findings from previous value transfer studies of biophysical services, the transfer of CES may be highly sensitive to the type and resolution of land cover data used to implement the value transfer. This study expands on Brown et al. (2015a) by providing a more comprehensive, empirical evaluation of value-transfer for multiple CES and by using two land cover classification systems with different spatial resolutions.

1.1. Research aims and objectives

The purpose of this study is to empirically evaluate value transfer for CES by examining key variables that can potentially influence value-transfer outcomes for CES, including the human population and region sampled, the choice of land cover data, and the type and quantity of primary CES data collected. Thus, the specific research questions to be examined in this study are as follows: