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Analysis

Valuing ecosystem services from wetlands restoration in the Mississippi Alluvial Valley

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ABSTRACT

This study assesses the value of restoring forested wetlands via the U.S. government's Wetlands Reserve Program (WRP) in the Mississippi Alluvial Valley by quantifying and monetizing ecosystem services. The three focal services are greenhouse gas (GHG) mitigation, nitrogen mitigation, and waterfowl recreation. Site- and region-level measurements of these ecosystem services are combined with process models to quantify their production on agricultural land, which serves as the baseline, and on restored wetlands. We adjust and transform these measures into per-hectare, valuation-ready units and monetize them with prices from emerging ecosystem markets and the environmental economics literature. By valuing three of the many ecosystem services produced, we generate lower bound estimates for the total ecosystem value of the wetlands restoration. Social welfare value is found to be between $1435 and $1486/ha/year, with GHG mitigation valued in the range of $171 to $222, nitrogen mitigation at $1248, and waterfowl recreation at $16. Limited to existing markets, the estimate for annual market value is merely $70/ha, but when fully accounting for potential markets, this estimate rises to $1035/ha. The estimated social value surpasses the public expenditure or social cost of wetlands restoration in only 1 year, indicating that the return on public investment is very attractive for the WRP. Moreover, the potential market value is substantially greater than landowner opportunity costs, showing that payments to private landowners to restore wetlands could also be profitable for individual landowners.

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1. Introduction

Ecosystem services, a collective term for the goods and services produced by ecosystems that benefit humankind, have traditionally been undervalued as they often fall outside of conventional markets (NRC, 2005). Without market prices, the incentive to provide them privately has been low relative to competing land uses, such as crops or timber. Reinforcing this notion, the Millennium Ecosystem Assessment reported that about 60% of global ecosystem services are being degraded or used unsustainably (MEA, 2005). Increasingly, society is recognizing the essential link between healthy ecosystems and human welfare and seeks ways to increase the provision of ecosystem services.

In recent decades, U.S. agricultural policy has implemented programs that offer financial incentives to private landowners to spur restoration of natural habitat and its attendant ecosystem services. A younger sibling of the Conservation Reserve Program (CRP), the Wetlands Reserve Program (WRP) focuses specifically on the restoration, protection, and enhancement of wetlands on private land through strategic public payments to landowners as well as increased collaboration between landowners and government agencies. Originally authorized in 1985, the acreage cap for WRP was expanded to 2.275 million acres in the 2002 Farm Security and Rural Investment Bill (USDA–NRCS, 2007).

This study focuses on the restoration of wetland ecosystem services in the Mississippi Alluvial Valley (MAV), the floodplain area below the confluence of the Mississippi and Ohio Rivers and principally located in the states of Arkansas, Mississippi, and Louisiana. These are the top three states in terms of WRP enrollment (USDA–NRCS, 2007). Once containing nearly 10 million hectares (Mha) of bottomland hardwood forest, the MAV had only 2.8 Mha remaining by the 1980s following many decades of hydrological alteration and agricultural expansion (King et al., 2006). The major land use of the region is now agriculture, dominated by cultivation of corn, cotton, rice, and soybeans (USDA–NASS, 2009). This landscape transformation has had profound ecological consequences, such as wildlife habitat loss and fragmentation, loss of flood storage, and water quality degradation due to nonpoint source runoff.

Due to human impact on ecosystems, efforts to maintain and restore ecosystems require an improved understanding of how humans benefit from ecosystems as well as how human behavior can be influenced through conservation payments and other policy tools (Heal, 2000; Kramer, 2007). As a growing body of research examines ecosystem services and their valuation, government agencies are searching for

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ways to incentivize the provision of those services (Ricketts et al., 2004; Barbier, 2007; US EPA, 2002). Economists have been measuring ecosystem service values for years; for example, as part of legal proceedings to assess and assign natural resource damages from oil spills and other environmental accidents (Carson et al., 1994; NRC, 2005). Enthusiasm for ecosystem services, however, expanded to the broader scientific and policy community due in part to two widely influential works published in 1997 by Daily (1997) and Costanza et al. (1997). The Costanza et al. article sought to estimate the economic value of earth's ecosystems in their entirety. Most economists since then have followed the counsel of Toman (1998) to focus on valuing changes in specific ecosystem service flows, as does this paper.

Two recent articles have conducted statistical meta-analyses of wetland valuation studies, using wetland value per unit area as the dependent variable. Updated to 2008 U.S. dollars, the Woodward and Wui (2001) found a mean annual value per hectare of $567 among its constituent studies, whereas Brander et al. (2006) computed a mean of over $4000/ha/year with a median of $215. Out of all the individual wetland services, only bird watching (Woodward and Wui) had a statistically significant and positive effect on the value of wetlands providing that service. Neither study reported GHG mitigation as a service.

Several studies have examined the participation in or benefits resulting from federal programs, such as CRP and WRP. Feather and Hellerstein (1997) evaluated the national benefits of reduced soil erosion for recreation and found that 11% or about $40 million, of those benefits are attributable to the CRP. Ahearn et al. (2006) reported a conservative non-use value of $33 million per year for increases in Central Plains grassland bird populations due to the CRP. Anderson and Parkhurst (2004) considered farmers' decisions to continue commodity crop production or to enroll in the WRP in the delta region of Mississippi and found that land was more likely to go into WRP if it had a lower return crop base and had considerable recreational value.

Given that the effectiveness of the WRP in achieving its restoration goals in the MAV is unknown, this study aims to assess the value to society of actions to restore wetlands there. This objective is accomplished primarily by comparing the economic values of ecosystem services produced on two land use types, cropland and restored wetlands. Constructing values from the bottom up, this study exploits a unique link between field data, process models, and economic valuation. Although the flows of ecosystem services are myriad, we select three focal services: GHG mitigation, nitrogen mitigation, and waterfowl recreation, each representing positive externalities from wetlands at different geographical scales—global, regional, and local, respectively. Furthermore, out of the services measured, these three services are those most likely to see markets developed for them (or to already have a market). By providing empirical measures of service flows and values for an important ecosystem, the findings of this analysis can provide valuable input into public and private decision making on natural resource management, including an assessment of the impact of the WRP.

2. Background

2.1. Study Area

The Mississippi Alluvial Valley (MAV) is the largest floodplain in the U.S., extending from below the confluence of the Mississippi and Ohio Rivers to southern Louisiana (Fig. 1). About three-quarters of the original bottomland hardwood forests have been converted, principally to row crop agriculture, while the remaining quarter is fragmented into over 38,000 discrete patches larger than 2 ha in size (Twedt and Loesch, 1999). The study area encompasses all of the counties that intersect with the MAV, save for those in Louisiana bordering the Gulf of Mexico.

2.2. Benefit Valuation Process

There are three essential steps in the ecosystem service valuation sequence: (1) identify the service, (2) quantify the service flows, and (3) monetize those flows. Disciplines that assess biophysical processes, such as ecology, biogeochemistry, and hydrology, play the central role in moving from identification to quantification, while economics provides the link from service quantification to monetization. The conceptual model of ecosystem service valuation used in this study is explained in Murray et al. (2009). Critical to bridging the biophysical and human aspects of ecosystem services is to transform the service flow data into valuation-ready measures. This transformation may involve integrating field observations with existing process models as well as modeling the service through time. We standardize the service measures into per-hectare values to facilitate comparisons with economic returns from other land uses and the aggregation of benefits at broader scales.

Because valuation needs are more abundant than the time and resources to develop them, benefit transfer methods apply results from previous primary research to new contexts (Rosenberger and Loomis, 2003). An accurate benefit transfer requires that the original study site be comparable to the targeted policy site with respect to the ecosystem service definition, the market context, and the welfare measure employed (Loomis and Rosenberger, 2006) or that the transferred value can be adjusted to reflect important differences between sites (e.g., using a value transfer). Using benefit transfer (Wilson and Hoehn, 2006), we multiply biophysical values for services of interest by shadow prices for the services. These shadow prices are obtained either through market price observations or from estimates of the service's benefits or costs from the environmental economics literature. To better inform public and private conservation decisions, this study also exploits the important dichotomy in economic values between social welfare value and market value. The first represents the economic value to society of the flow of ecosystem services and can be used in social benefit–cost analyses of public policies or programs. Market value embodies what landowners can capture through the market system and can be used to inform the design of landowner incentive programs for ecosystem protection or for the development of new markets for ecosystem services.

Agricultural land use is treated as the baseline activity in this analysis, since it represents the dominant land use in the MAV and thus business-as-usual prior to restoration. Seeking to value the action of restoring forested wetlands on cropland, we capture this economic value by calculating the difference in the values of ecosystem services provided by the two respective land use types.

2.3. Biophysical Measurement of Ecosystem Service Flows

Scientists at the USGS National Wetlands Research Center carried out the data collection for this study as part of the wetlands component of Conservation Effects Assessment Project's (CEAP) National Assessment (Faulkner et al., 2008). Initiated in 2003, CEAP is a multi-agency effort to evaluate the effectiveness of conservation practices used by private landowners participating in selected USDA conservation programs (Duriancik et al., 2008). The wetlands component of the National Assessment measures the effects of conservation practices on ecosystem services provided by wetlands in agricultural landscapes and is being conducted in eleven regions throughout the coterminous U.S. These regional assessments will focus on one or more wetland hydrogeomorphic classes common to agricultural land in that region.

For the CEAP-Wetlands study in the MAV, a stratified random sampling design was used in the Lower White-Cache (AR) and Tensas (LA) river basins where eight replicate sites were selected for each of three treatments: restored to forested wetlands under the WRP, active cropland, and natural forested wetland. These sites are representative

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