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Analysis

Floodplain conservation as a flood mitigation strategy: Examining costs and benefits

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ABSTRACT

There is growing interest in floodplain conservation as a flood damage reduction strategy, particularly given the co-benefits that protected lands provide. We evaluate one such investment—a greenway along the Meramec River in St. Louis County, Missouri. We estimate the opportunity costs, the avoided flood damages, and the capitalization of proximity to protected lands into nearby home prices. To estimate avoided flood damages, we undertake a parcel-level analysis using the Hazus-MH flood model, a GIS-based model developed for FEMA that couples a hydrology and hydraulics model with a damage model relating flood depths to property damage. We examine the distribution of damages across parcels, demonstrating that careful spatial targeting can increase the net benefits of floodplain conservation. In addition, we estimate a hedonic model and find that the increased property values for homes near protected lands are more than three times larger than the avoided flood damages, stressing the continued importance of more traditional conservation values. The proximity benefits alone exceed the opportunity costs; the avoided flood damages further strengthen the economic case for floodplain conservation.

1. Introduction

Several severe flooding events over the last few years have brought increased attention to the damages caused by natural disasters. Worldwide, flooding is not only the most costly natural disaster, but has also affected the most people (Miller et al., 2008; Stromberg, 2007). In the United States over the twentieth century, out of all natural disasters, flood events were responsible for the highest number of fatalities and the most property damage (Perry, 2000). And the economic costs of flooding have been increasing over the last several decades, largely due to more people and property locating in hazardous areas (Pielke and Downton, 2000). In addition, many climate models predict an increase in heavy precipitation as the climate warms, which may increase the risk of flooding in certain locations (e.g. Kollat et al., 2012; Wuebbles et al., 2009).

Communities have shown increasing interest in removing structures from flood-prone areas as a flood damage reduction strategy. Two decades ago, after the devastating 1993 flood on the Missouri and Mississippi Rivers, the state of Missouri and local governments invested in floodplain land acquisition using Federal Emergency Management Agency (FEMA) grant funds and Community Development Block Grants. The state acquired over 4000 properties (Missouri State Emergency Management Agency, 2000). Some communities are preempting development in the first place using local funds. Milwaukee is one example; its Greenseams program acquires undeveloped streamside properties and retains them as open space. Similar programs have been adopted internationally, as well, such as the Room for the River program in the Netherlands.[2] Such investments may be driven in part by the high costs of structural flood control, as well as a growing awareness of green approaches. Perhaps more importantly, however, conserved riparian areas generate a range of ecosystem services, in addition to the hazard mitigation benefits they provide. Protected forests, grasslands, and wetlands along rivers and streams can improve water quality, provide habitat to many species, and offer a wide range of recreational opportunities.

There remains, however, large uncertainty concerning the benefits and costs of floodplain conservation, hindering greater investment. There is an opportunity cost associated with keeping lands out of development, which may be large, since many of these areas are desirable places to live. The precise benefits in terms of total avoided flood damages, not to mention the many other nonmarket benefits, are difficult to measure. Whether, on net, the investment pays off for a community depends on local conditions—the hydrology and hydraulics of streams and rivers, topography, land values and uses, residents' preferences, and a host of other factors.

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[2] See the program website for more information: http://www.ruimtevoorderivier.nl/meta-navigatie/english/room-for-the-river-programme/.

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In this study, we look retrospectively at a floodplain conservation effort and evaluate the avoided flood damages, opportunity costs, and some of the nonmarket benefits. Our case study is southern St. Louis County, Missouri. The county lies in a triangle formed by three rivers—the Missouri, Mississippi, and Meramec—and has been dealing with flooding throughout its history. In contrast to the Missouri and Mississippi Rivers, which are lined with levees, the Meramec remains in a relatively natural state. We focus our analysis on the Meramec Greenway, a collection of lands along 108 miles of the Meramec River from its confluence with the Mississippi River back into the Ozark Uplands. In St. Louis County, as of 2013, roughly 9000 acres have been preserved to date as state and local parks, as well as some nonprofit conservation lands. This is roughly 15% of the 500-year floodplain of the Meramec and its tributaries in the County. Assessing the impacts of this investment is important for the region as conservation activities continue, not just in the Meramec Greenway, but also for the more extensive River Ring, a planned network of more than 45 greenways, and over 600 miles of trails along all of the rivers in the area, including the Meramec (Great Rivers Greenway, 2011; Meramec River Recreation Association, 2004).

In order to assess the flood damage reduction benefits of the Greenway, we compare flood damages under current conditions with a counterfactual, "developed floodplain" scenario in which the Greenway protected lands are developed instead. The difference between the flood damages in the two scenarios is a measure of the avoided flood damages from the conservation that has occurred to date. We estimate these avoided flood damages using the Hazus-MH model, a GIS-based model developed by FEMA to estimate the damages from several different natural hazards, including riverine flooding.[3] We undertake a parcel-level analysis, improving estimation over the default Hazus approach of aggregating data to census blocks.

We estimate the average annual avoided flood damages of the Greenway at $7.7 million. We estimate the annual opportunity cost of these protected lands at roughly $17.2 million. Avoided flood damages and opportunity costs are never distributed uniformly across a landscape. Our results show that while the bulk of parcels have modest average annual flood damages, a few parcels incur quite substantial damages. Thus the costs of this flood mitigation strategy could have been lowered with a more careful targeting of the parcels for protection.

Flood mitigation, however, was not the sole purpose of the protection of lands along the Meramec River. Another important benefit has been the recreational and aesthetic value provided by the conserved lands. Using property sales data between 2008 and 2012 for the neighborhoods surrounding the Greenway, we estimate a hedonic property value model to obtain locally specific estimates of the capitalization of the Greenway into housing values. We find that for every 1000 ft that a property is closer to a park or protected area, the sales price increases by almost 1%—$2156 for a median-priced home in our sample. Based on these econometric results, we calculate an order-of-magnitude estimate of these annual benefits of the Greenway in St. Louis County of roughly $24 million. These benefits are over three times the estimated avoided flood damages and exceed the opportunity costs.

With growing interest in floodplain conservation, it is important to evaluate the potential returns from such investments. Local governments are in need of economic analysis at a fine spatial scale to help justify expenditures, and our analysis can be a guide for how to estimate both costs and benefits. Two important findings come out of this research. First, land conservation comes at a cost in terms of the forgone opportunities on the land, and those costs may be only partially offset by the avoided flood damages. Moreover, careful spatial targeting is important for improving cost-effectiveness, as has been found in many other settings (Ando et al., 1998; Ferraro, 2003; Kousky et al., 2013). Second, the more traditional benefits provided by conserved land, such as recreational opportunities and aesthetics, can be substantial and should not be neglected. This latter finding highlights the importance of the multiple benefits obtained from protecting natural lands and stresses the need for a full consideration of these when developing protection strategies.

The paper proceeds as follows. The next section of the paper provides background on our study area. Section 3 discusses both the data and methods used for the Hazus modeling. Section 4 presents the results of the Hazus-MH analysis and our estimation of opportunity costs. Section 5 presents the methods and findings of the hedonic property model, comparing them with our other estimates. Section 6 concludes.

2. Background on Study Area

Being framed by three rivers, St. Louis County has repeatedly suffered flood events. Presidential disaster declarations were issued in the county in 2011, 2008, 2007, 2003, 1998, and 1993. Whereas the 1993 and 2011 floods were on the major rivers, substantial flash flooding along creeks in 2008 caused more than $2.2 million in damages to public infrastructure and created sewer backup problems on 1200 to 1400 properties, even though it was estimated to be only a 15-year storm event (Wilson, 2008). Flooding on the Meramec led to road closures as recently as June 2013.

The Meramec River joins the Mississippi at the southern edge of St. Louis County. Much of the Missouri and Mississippi Rivers in the county are lined with levees. The Meramec River, on the other hand, is largely devoid of any structural protection.[4] Flooding along the Meramec can occur when large floods on the Mississippi back up or when heavy spring and summer precipitation leads to seasonal flooding; in areas along the river with steep slopes and thin soil cover, flash flooding is common. In 2000, for example, flash flooding along the Meramec River damaged structures, roads, and bridges and led to two deaths (Winston and Criss, 2003).

The Meramec Greenway runs from its confluence with the Mississippi back 108 miles into the Ozark Uplands. It was initially created in 1975 and encompasses the lands around the river in the floodplain, the surrounding bluffs within sight from the river, upland areas deserving special protection, and publicly owned lands connected to the river valley (St. Louis County Department of Planning, 2003). Much of the lands remain in private hands. As of 2013, however, more than 28,000 acres were protected, with just over 9000 of those protected acres located in St. Louis County. The protected lands include state and local parks, private conservation lands, as well as buyouts of frequently flooded properties funded by FEMA in 1982 and 1993.[5] Fig. 1 is a map of the area created with the data described in the next section. It shows in green the currently protected lands in the St. Louis County portion of the Greenway.

Local park agencies and nonprofits in the region continue to plan for future acquisitions in the Greenway. The county adopted a Concept Plan for the Greenway in 2003 with multiple stated goals, including flood damage reduction, water quality improvements, and expanded recreational opportunities (St. Louis County Department of Planning, 2003). The Meramec Greenway is also one component of the larger River Ring project envisioned for the region. The River Ring will include a near circle of natural lands along the Cuivre River to the north, the Mississippi River to the East and the Meramec River to the south, as well as a greenway along the Missouri River and several smaller rivers and streams in St. Louis and surrounding counties (Great Rivers Greenway, 2011; Meramec River Recreation Association, 2004).

[3] Documentation and software available at: http://www.fema.gov/hazus.

[4] In our study area, there is one small levee, the Valley Park Levee, which would likely provide protection up to the 50-year event for a small subset of properties in our sample. There are only three protected parks in the protected area and they are each one acre or smaller; adjusting for these properties has a negligible influence on results.

[5] FEMA has several grant programs for state and local governments that can be used to acquire flood-prone properties and convert them to open space. Some grants are tied to the National Flood Insurance Program. The Hazard Mitigation Grant Program, funded after a presidentially declared disaster, will also give funds for this purpose.