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Impact of market conditions on the effectiveness of payments for forest-based carbon sequestration

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ABSTRACT

This research analyzes the effects of market conditions on the performance of incentive payment approaches for forest-based carbon sequestration. We develop supply curves for sequestered carbon using the relationship between deforestation for urbanization and the relative returns from forest products and urban uses under two different market conditions. The empirical results for an 18-county case study show that a hypothetical payment system was effective and the marginal cost of carbon sequestration increased with the target level of carbon sequestration during the 2001–2006 real estate upturn, while the same system was ineffective during the 2006–2011 period that included a real estate downturn. Our study is the first to examine the role of temporal changes in market conditions on the performance of incentive payment approaches. Although a first step, our snapshot, static approach shows the value in thinking of the dynamic role of changing market conditions in evaluating incentive payment systems.

1. Introduction

Deforestation is the second largest anthropogenic source of carbon dioxide and a major cause of climate change (van der Werf et al., 2010). Urbanization is a major contributor to deforestation (Bradford, 2015). For example, developed land total area increased by 44 million acres or 59% in the lower 48 states from 1982 to 2012 while the United States lost an average of about 1 million acres of forest each year between 1990 and 2010 (USDA-NRCS, 2012).

Ecosystems from forests provide multiple non-market benefits, or positive externalities, called ecosystem services. Many ecosystem services are adversely affected by factors such as the loss, modification, or fragmentation of habitat, soil and water degradation, population decline of native species, and loss of forest carbon storage through deforestation and urbanization. Despite the multiple dimensions of ecosystem services associated with forests, many policies focusing on mitigating the loss of ecosystem services still address them individually (e.g., Adetoye et al., 2018; Antle et al., 2003; Cho et al., 2017; Gibbons et al., 2011; Kim and Langpap, 2014). Forest-based carbon sequestration is one service most likely to be reflected in such policies. This particular ecosystem service has received attention recently because of its potential to offset the accumulation of greenhouse gas (GHG) emissions in the atmosphere, a primary contributor to climate change (IPCC, 2013). The potential GHG offset in the United States was estimated at 905 million tons in 2011, an offset capacity of 16.1% of total U.S. carbon emissions (or 13.5% of total greenhouse gas emissions) (USEPA, 2013). Globally, forestland has the capacity to sequester 2.4 ± 0.4 peta-grams of carbon emissions annually, an equivalent to 30% of the global carbon emissions from fossil fuels used in 2008 (Le Quéré et al., 2009; Pan et al., 2011).

Despite the benefits of forest-based carbon sequestration, most private landowners managing forests receive no compensation for contributing to this service. Incentive payments can support forest-based carbon sequestration by internalizing the positive externalities generated by carbon storage in private forests. Carbon sequestration has cost advantages compared to carbon emission mitigation efforts (Sedjo et al., 1995; Stavins, 1999; Richards and Stokes, 2004; van Kooten, 2009; Manley et al., 2005; Mason and Plantinga, 2011; Phan et al., 2014). 250 to 500 million tons of forest-based carbon could be sequestered annually in the United States for several decades at a cost of \$10 to \$150 per ton (Richards and Stokes, 2004). The cost of meeting global or European Union (EU) climate targets could be reduced by up to 40% by introducing carbon sinks, such as forests, into climate programs as a means of mitigating GHG emissions (e.g., Anger and Sathaye, 2008; Bosetti et al., 2011; Michetti and Rosa, 2012; Gren et al., 2012) overall, forest carbon sequestration could contribute to one-third

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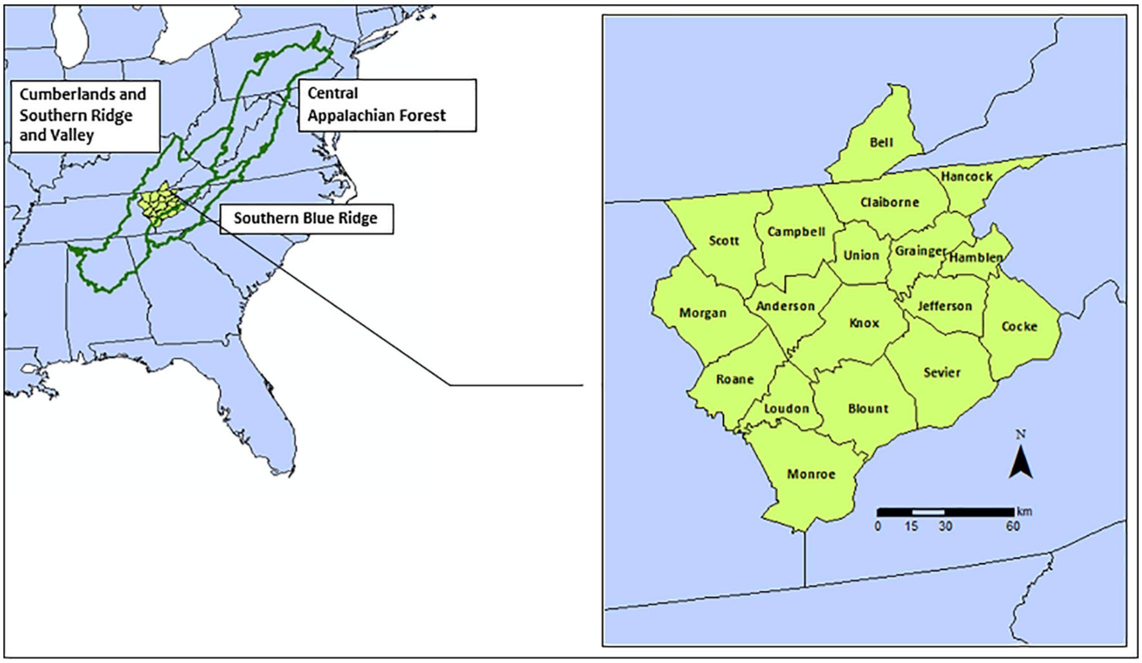

BEAA 88 covering 17 Tennessee counties and 1 Kentucky county

Fig. 1. Overview of study area.

of the total global GHG abatement effort in the first half of the 21st century (Tavoni et al., 2007).

Despite the potential for forest carbon sequestration to act as a tool for climate change mitigation, resources to support incentive payments are limited. For this reason, many studies have focused primary on the efficiency of different incentive payment approaches, paying particular attention to spatial variation of benefits that depend on factors such as soil quality, tree species, and local climate (e.g., Houghton, 2005; Pan et al., 2011) and individual landowners' opportunity costs of providing these benefits (Kim and Langpap, 2014; Lubowski et al., 2006; Mason and Plantinga, 2011). Spatial heterogeneity in the costs of supplying ecological services such as forest carbon sequestration plays a critical role in the effectiveness of incentive payment design (Hanley et al., 2012; Gren and Aklilu, 2016). The more effectively public agencies resolve spatial variation in costs and use this variation to allocate contracts and set payment rates, the more cost-effective payment programs become (Babcock et al., 1997a,b; Antle et al., 2003; Zhao et al., 2003; Mason and Plantinga, 2011; Armsworth et al., 2012; Morelli, 2013; Katayama et al., 2014; Aadland et al., 2015). For example, in the Northern Plains region of the United States, the relative inefficiency of payment per hectare varies spatially and increases with spatial heterogeneity (Antle et al., 2003).

Despite abundant literature on the spatial dimension of incentive payments, the role of market conditions on the performance of incentive payment approaches has been mostly neglected. The lack of such research is surprising, given that changes in market conditions influence the spatial heterogeneity of the opportunity cost of forestland. A landowner's willingness-to-accept (WTA) payment is likely influenced by how market conditions affect the landowner's response to changes in net return, and consequently, affect the performance of payments to encourage forest-based carbon sequestration. Temporal changes in market conditions are critical to program costs and efficiency as the spatial heterogeneity of the opportunity cost of forestland is influenced by temporal market fluctuations. For example, landowners' market confidence and the benefits and costs of retaining forestland are expected to differ during real estate market upturns and downturns. Failing to anticipate these potential differences may undermine the performance of payment programs.

The objective of this study is to examine the effects of market conditions on the performance of incentive payment approaches for forest-based carbon sequestration. To achieve the objective, we develop supply curves for sequestered carbon using the relationship between deforestation for urbanization and the relative returns from forest products and urban uses under two different market conditions, namely the 2001–2006 real estate upturn (referred to as “upturn”) and the 2006–2011 period that includes a real estate downturn (referred to as “downturn”). The supply curves are conceptually based on the minimum WTA payment for supplying forestland and the corresponding quantity of sequestered carbon. A landowner's minimum WTA depends on the competitiveness of the local land market. If the local land market is perfectly competitive, minimum WTA equals the price or opportunity cost of supplying forestland, and the amount of forestland supplied determines the quantity of sequestered carbon at that price. If the land market is not perfectly competitive, the market price will deviate from minimum WTA. The less competitive the local land market is, the larger the deviation will be, because a public agency's maximum willingness to pay (WTP) will deviate from a landowner's minimum WTA payment.[1]

2. Methods

To examine the effect of market conditions, we developed a case study based on one of 179 Bureau of Economic Areas (U.S. Department of Commerce, 2016), which consists of 17 Tennessee counties and 1 Kentucky county (Fig. 1). The supply curves were created using the following procedure (see Fig. 2 for the flow chart of the procedure). First, we developed a conceptual framework for deforestation for urbanization to understand the link between the conversion for forestland to urban use and the change in net return from conversion. We used econometrics to estimate two separate deforestation-for-urbanization models (i.e., “upturn model” for the upturn period and “downturn model” for the downturn period) using a spatial regression approach (see sections 2.1 and 2.2 for details).

[1] The authors appreciate an anonymous referee for bringing this issue to our attention.