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The impact of relative individual ecosystem demand on stacking ecosystem credit markets

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ABSTRACT

A blended actual and hypothetical vertical ecosystem services stacking scenario is developed for a water quality trading (WQT) program in North Carolina. Demand is estimated for total nitrogen reduction and simulated for total phosphorous reduction. Nitrogen and phosphorus are complementary pollutants jointly produced by a single conservation practice, riparian buffers. The supply of reduction is based on the amount of riparian buffers that would be implemented by farmers at a given offering price for WQT credits. Nitrogen reduction is the primary ecosystem service that already has a market in the form of a WQT program. Phosphorus reduction is a hypothetical, secondary ecosystem service that we introduce to evaluate ecosystem stacking. We specifically evaluate stacking in thin markets, where there are few buyers and/or sellers. Our detailed analysis shows that the relative size of demand for different services plays a profound role in the success of stacking when markets are thin; and many if not most ecosystem markets are thin. A secondary service with relatively low demand will either be too small (insufficient) to generate any new credits, or, in a non-competitive market with few sellers, produce no additionality of the secondary service (double dipping). In these two cases, sponsors of the secondary market should not make payments since they will receive no additional benefits above what would have been achieved under conservation practices implemented for the primary ecosystem service. We find that ecosystem stacking is most likely to generate more revenue to producers and to reduce pollution emissions when demand for the secondary service is comparable in magnitude to the primary service. Accurate assessment of relative demand can help policy makers determine where stacking might work, and help purchasers avoid paying for services without results, especially where markets are thin.

1. Introduction

A growing number of studies have examined the benefits of stacking payments for multiple ecosystem services (ESs) (Engel et al., 2008; Wunder & Wertz-Kanounnikoff, 2009; Wendland et al., 2010; Fox et al., 2011; Olander, 2011; Deal et al., 2012; Meijaard et al., 2014; Ingram et al., 2014; Lentz et al., 2014). Conceptually, if landowners could increase revenue by selling more ESs, they might be more likely to participate in conservation programs (CIER & WRI, 2010; Gasper et al., 2012). For example, Lankoski et al. (2015) showed that stacking water quality credits would indeed motivate farmers to provide additional environmental services such as carbon sequestration. Of course, the additionality principle requires that payments from a second market result in more conservation than would have already occurred through payments in the original market. Mounting studies have found that there are situations where one unit of mitigation is sold into multiple markets without actually reducing pollution more than would have been achieved with the single market (White & Penelope, 2013). For example, in North Carolina wetland and stream ecosystem services credits were first sold and then years later, in a separate market, those credits were sold again as water quality improvement credits, without additional improvements in conservation practices (Program Evaluation Division, 2009; Kane, 2009;

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Robertson et al., 2014). Ferraro and Pattanayak (2006) showed that none of the programs that they surveyed for conservation payments were directly monitoring for additionality of new ESs.

Ingram (2012) indicated that there are three broad categories for stacking, including horizontal, vertical, and temporal. Horizontal stacking occurs "when more than one distinct management practice is implemented on non-spatially overlapping areas of a land/sea-scape and the project developer receives a single payment for services generated by each management practice"; vertical stacking happens "when the project developer receives several payments for a single conservation practice on spatially overlapping areas" (pg 5). Temporal stacking is similar to vertical stacking but payments are distributed over time. A survey by the Electric Power Research Institute (EPRI, 2011) showed that 70% of survey respondents believed that stacking increases the financial value of the conservation projects. However, as we show here, stacking may not provide desired ecological outcomes (Venter et al., 2009a,b; Bryan, 2013; Torabi & Bekessy, 2015) or offer incentives because additional payments do not always result in additionality (Ott, 2010; Cooley and Olander, 2011), which we refer as a type of double dipping. In some literature, double dipping is referred to as "selling the same ecosystem service credit multiple times" (Robertson et al., pg 3). However, Woodward (2011) and Lentz et al. (2014) use the term to refer to selling multiple services from a single practice into multiple markets. For purposes here, we adopt the working definition that double dipping is receiving multiple payments for a single conservation action when there is no additional ESs. This working definition fits both descriptions and is consistent with the concept of vertical stacking.

Many studies have observed double dipping in credit stacking programs (Kosoy & Corbera, 2010; Bonn et al., 2014) and several offer extensive discussions about how programs that offer payments for multiple ESs can be designed to address double dipping (e.g., Engel et al., 2008; Wunder et al., 2008; Bennett, 2010; Kenny, 2010; Gillenwater, 2012; Baral et al., 2014). Double dipping under a stacking scheme occurs when a secondary ES market offers no value at the margin to the credit producer. For example, Lentz et al. (2014) found that offering a secondary market for phosphorus and wildlife credits from wetlands did not increase the benefits over what would have occurred with the primary market for nitrogen alone. In an economic experiment, Horan et al. (2004) also showed that economic efficiency is improved when two markets jointly influence decisions about the last unit of pollution controlled. In this study, we examine how market structure affects double dipping. In particular, we look at thin markets where competition is limited (because there are few buyers and/or sellers). We chose water quality trading (WQT) programs for an intensive study because they have been tried in many places, but have struggled to grow and thrive due to a host of implementation hurdles (GAO, 2017; Hoag, et al., 2017). According to GAO (2017), there were 11 programs in the U.S. in 2014 but with very few trades being made. Many studies have looked at why these trading programs are not realizing greater success (e.g., Hoag et al., 2017; Ribaudo and Gottlieb, 2011), which provides a rich background and ready data to sort out the specific contribution of a thin market to double dipping. Finally, our results should be valuable to other types of ecosystem marketing schemes, since many if not most face thin markets.

The Jordan Lake water quality trading program in North Carolina offers a current case study to demonstrate how the benefits of stacking can be corrupted by imperfect competition. Under the rules for trading nutrients in North Carolina, urban developers can buy nutrient offset credits from a governmental offset credit provider. This single provider buys credits then bundles them for development projects that impact streams and wetlands. North Carolina created the Ecosystem Enhancement Program (EEP) to serve as the seller to development projects. In this study, we design a clearinghouse market for the Jordan Lake WQT program, assuming that the EEP performs as the only consolidator (or as an intermediary (Woodward and Kaiser, 2002)). We represent this consolidator as a monopolist who buys available credits from farmers and sells them to urban developers. In this single-seller situation, we show how relative demand for a primary ES compared to demand for lower-valued secondary ESs plays a role in the efficacy of a WQT program.

Nitrogen and phosphorus reduction are selected as ecosystem services. These are joint ecosystem services because their outputs cannot be separately allocated through the conservation practice examined (Romstad et al., 2000; Nilsson, 2004). We compare conservation incentives across relative demand for our estimated actual market for total nitrogen reduction and a hypothetical secondary ecosystem market for phosphorous reduction. One of the reasons we focused on phosphorous in this study is that excessive total phosphorous is a leading contributor to eutrophication in Jordan Lake NC and slated for control in future years (NCDENR, 2013). Eutrophication restricts water use for fisheries, recreation, industry, and drinking because of increased growth of undesirable algae and aquatic weeds. Associated periodic surface blooms of undesirable algae and aquatic weeds occur in drinking water supplies and may pose a serious health hazard to animals and humans. In order to reduce the ecological damages of excess phosphorous, its transport from soils to aquatic ecosystems needs to be reduced (increasing sinks) (Bennett et al., 2001). These sinks will be provided by installing our study's conservation practice, riparian buffer zones.

Our objective is to determine the conditions where in a clearinghouse market structure, stacking provides additional revenue to water quality credit suppliers and where those incentives also result in increased implementation of the desired conservation systems. We demonstrate that three potential conditions will occur: (1) Insufficient Multimarket, where neither party gains from stacking, (2) Double Dipping Multimarket, where stacked payments increase farmers' revenue but do not change their conservation behavior (no additionality), and (3) Functioning Multimarket, where the payments increase revenue and improve conservation adoption (additionality). In this study, we demonstrate when and how relative demand between two ESs can result in double dipping under a non-competitive WQT market. We look only at relative demand and acknowledge that many other factors such as transaction cost (Fang et al., 2005; Van Houtven et al., 2012; Lau, 2013) would have an impact on the efficacy of stacking payments in different market structures.

2. Methods

2.1. Graphical illustration

The desirable outcome in a vertical ecosystem stacking program is to pay for a secondary ecosystem service in a way that provides additional value for a single conservation practice (e.g., riparian stream buffers) in addition to what is already generated by a primary service that is also paid for. This type of credit stacking occurs when a single practice provides complementary services (Woodward, 2011). To demonstrate how double dipping occurs in thin markets, we first build a graphical framework with a conceptual example. The force driving the potential for double dipping is a difference in the demand curves for the ecosystem services, and a thin market on the selling side. For simplicity, we examine two services supplied by many farmers, which are then stacked and sold by a single seller, the EEP, thus creating a market monopoly. A case study is presented later, also graphically, to provide further insights and to demonstrate double dipping in an empirical