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Review

Incentives, land use, and ecosystem services: Synthesizing complex linkages

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ABSTRACT

Incentive schemes are increasingly used to motivate the supply of ecosystem services from agro-ecosystems through changes in land use and management. Here, I synthesize the complex effects of incentives on ecosystem services through their influence on land use and management. Linkages between incentives and land use change, and between land use change and ecosystem services can be one-to-many, many-to-one, and many-to-many. Change in land use and management can affect multiple ecosystem services, with both co-benefits and trade-offs. Incentives can motivate multiple changes in land use and management and multiple incentives often interact with both synergies and tensions in their effect upon ecosystem services. These vary over both space and time, and can be non-linear. Depending on incentive design, changes in ecosystem service supply can also have a feedback effect on incentive prices. I suggest that continued quantitative development is required to further explore these linkages: in the influence of incentives on land use change; in the impact of land use change on ecosystem services, and; in ecosystem service supply feedbacks on incentive prices. Quantifying and understanding these linkages is essential to progress more comprehensive analyses of the impact of incentives on ecosystem services, and the design of incentives capable of realizing synergies and avoiding tensions.

1. Introduction

Services from agro-ecosystems include a range of provisioning (e.g., food, fresh water, and bioenergy), regulating (e.g., climate, erosion, and pests), supporting (e.g., biogeochemical cycling, biodiversity/habitat), and cultural (e.g., recreation and education) services (Power, 2010; Swinton et al., 2007). Agricultural land use has degraded the soil, water, and biological assets in agro-ecosystems to such an extent that the restoration of natural capital and rehabilitation of ecosystem services through changes in land use and management is now a global priority (Ehrlich et al., 2012; Foley et al., 2011; Millennium Ecosystem Assessment, 2005). A primary reason for this degradation is the failure of agricultural commodity markets to internalize environmental costs associated with land use and management decisions (Lant et al., 2008). New market-based policy instruments – particularly financial incentives such as payments for ecosystem services – have emerged to redress these market failures (Farley and Costanza, 2010). Whilst market-based incentives remain one of the great hopes for the restoration of ecosystem services (Daily et al., 2009; Pascual and Perrings, 2007), the potential for inefficiencies and negative outcomes has also been recognized (Frame, 2011; Kinzig et al., 2011).

In agro-ecosystems, incentives influence ecosystem services through motivating changes in land use and management (Fig. 1). This chain of influence is complex because

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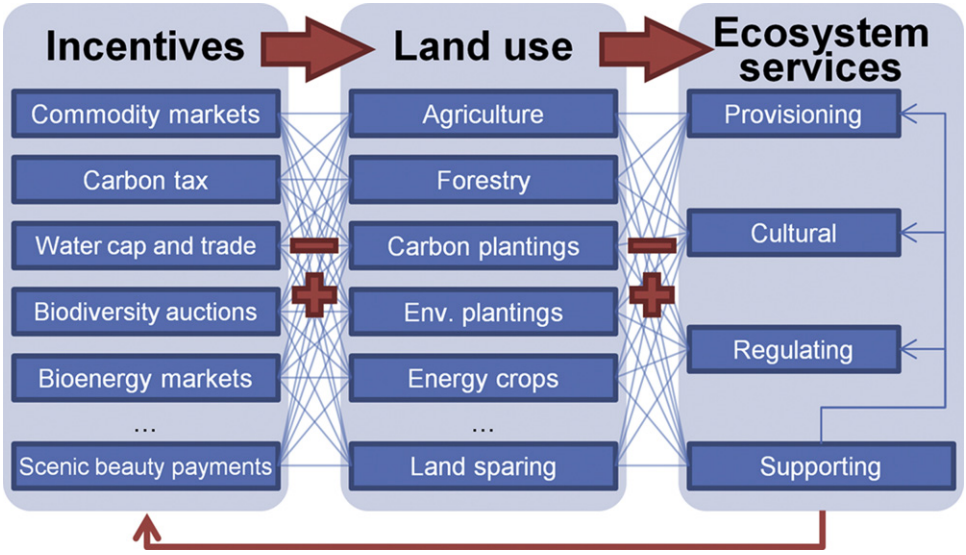

Fig. 1 – A simple conceptual representation of the linkages between incentives, land use, and ecosystem services. Financial incentives can have synergies (positive) and tensions (negative) in changing land use and management – which in turn have a range of co-benefits (positive) and trade-offs (negative) across multiple ecosystem services. Relationships between incentives and land use, and between land use and ecosystem services, vary across space and time and can be non-linear. These relationships can also be many-to-one, one-to-many, and many-to-many. The bottom link represents the potential dynamic effect of changes in supply of ecosystem services on incentive prices.

incentives can cause multiple intended and unintended changes in land use and management, each potentially having co-benefits and trade-offs across multiple ecosystem services (May and Spears, 2012). More often than not, multiple incentives co-exist (Pittock, 2011; Schrobback et al., 2011). These incentives interact, providing price signals for multiple land use and management changes, thereby compounding the effect on ecosystem services (Deal et al., 2012). Hence, the linkages between incentives and land use, and between land use and ecosystem services can be one-to-many, many-to-one, or many-to-many. These effects are typically heterogeneous across both space and time, and can be non-linear (Holland et al., 2011; Laterra et al., 2012). Changes in the supply of ecosystem services may also have a dynamic feedback effect on incentive prices, depending on instrument design. Understanding these effects can lead to substantial gains in the efficiency of policy and management in agro-ecosystems (White et al., 2012) and avoid negative outcomes (Bryan and Crossman, submitted for publication). Whilst many recent studies have addressed individual components, none have attempted the integrated assessment of incentive interactions on land use and ecosystem services inclusive of all of the linkages depicted in Fig. 1.

Here, I explore, clarify, and synthesize current understanding of the complex and multifarious influence of market-based incentives on land use and ecosystem services. I also discuss the requirements for quantifying these interactions and suggest directions for future work to support this important task. Awareness of these linkages is necessary to realize the benefits and avoid adverse outcomes for ecosystem services from changes in land use and management motivated by market-based incentives.

2. Incentives for ecosystem services

Ecosystem services contribute to human well-being through a range of direct-use (e.g., food and recreation), indirect-use (e.g., insurance and option), and non-use (e.g., existence, intrinsic and bequest) values (Pascual and Perrings, 2007). Whether or not the value of ecosystem services is reflected in markets depends on the *rivalness* of the good/service consumption (whether their use precludes use by others) and its *excludability* (whether access can be restricted to those who pay) (Kemkes et al., 2010). Some *market goods*, such as agricultural crops and livestock, are rival and excludable, and are routinely valued and traded in markets (Farley, 2008). *Public goods* (e.g., biodiversity), on the other hand, are non-rival and non-excludable; *common pool resources* (e.g., fisheries) are rival and non-excludable, and; *club goods* (e.g., toll access to a nature park) are non-rival and excludable (Kemkes et al., 2010). Markets for public goods and common pool resources rarely emerge naturally and, as farmers do not receive a price signal for these non-market ecosystem services, they under-produce them (Ribaudo et al., 2010).

Market-based incentives aim to correct this market failure and manage the supply of public good and common-pool type ecosystem services (Farley and Costanza, 2010). To be effective, incentives need to be supported by a carefully designed regulatory framework (e.g., safe minimum standards, quantifiable units of service provision, clearly defined property rights, monitoring requirements, and contractual arrangements) (Kroeger and Casey, 2007). Properly supported by regulation, financial incentives can be used to motivate the