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Enhancing ecosystem services through targeted bioenergy support policies

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ABSTRACT

While policy-makers in the bioenergy sector have paid considerable attention over the past decade to the risks that energy cropping can pose to forests, soils and food security, there has been less focus on how bioenergy policies can be designed to enhance ecosystem services. Some perennial energy crops have demonstrated the potential to provide habitat for biodiversity, improve soil health, enhance water quality, mitigate dryland salinity and sequester carbon. While much uncertainty exists around which forms of energy cropping might deliver these benefits, opportunities exist to preferentially support beneficial energy crops through the adaptation of existing bioenergy policies. This article provides a global review of bioenergy policy instruments that identifies existing and potential mechanisms for promoting the enhancement of ecosystem services. While many existing bioenergy support policies promote fuel supply (a provisioning service) and climate change mitigation (a regulating service), it is less common for bioenergy policies to actively enhance ecosystem services such as habitat provision, soil improvement and water regulation. Further opportunities to promote these ecosystem services exist through structured tax concessions, sub-mandates, banding and renewable energy auctions, but careful consideration needs to be given to trade-offs between services, risks of disservices and the need for complementary non-energy policies.

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1. Introduction

Bioenergy support policies have attracted criticism due to their potential to diminish ecosystem services, for example by incentivizing the clearing of biodiverse tropical forests to make way for oil palm plantations in Southeast Asia (e.g. Boucher et al., 2011; Gao et al., 2011; Gerasimchuk and Koh, 2013). However, energy cropping systems also have the potential to enhance ecosystem services, such as providing habitat for biodiversity, reducing soil erosion, enhancing water quality, mitigating dryland salinity and building soil carbon (Holland et al., 2015; Lowrance and Davis, 2014; Maletta and Lasorella, 2014; Simpson et al., 2009).

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Berndes and Fritsche (2016) argue that many discussions of bioenergy policy tend to assume that any land use change for bioenergy is inherently "bad" and ignore the possibility that sustainable bioenergy production may be preferable to many current land uses that are unsustainable. Bioenergy production is not the only commercial land use activity that has this potential to enhance biodiversity, reduce soil loss and mitigate climate change, with other land uses such as agroforestry also capable of providing similar benefits (Stanturf, 2015). However, the bioenergy sector presents unique opportunities for innovative policy development around ecosystem service enhancement for three main reasons:

1. The diversity of bioenergy support measures that have been adopted around the world and the high degree of policy experimentation that has taken place.

A wide range of policy instruments are used across the world to promote bioenergy, including transport fuel mandates, electric utility quota obligations, feed-in tariffs, subsidies and tax breaks (REN21, 2016). The primary aims behind many of these policies have been climate change mitigation through the replacement of fossil fuels (e.g. EU Renewable Energy Directive) or enhanced energy security (e.g. US Renewable Fuel Standard). However, the knowledge gained through this policy experimentation also has the potential to be applied to the promotion of energy cropping systems that enhance ecosystem services.

2. The relative lack of attention paid to the enhancement of ecosystem services through bioenergy policies and decision-support tools.

The attention paid to the enhancement of ecosystem services by bioenergy policy-makers has been relatively low compared with the attention paid to preventing negative impacts over the past decade (e.g. incorporating sustainability criteria into bioenergy policies under the EU's Renewable Energy Directive). Similarly, the attention paid to enhancement of ecosystem services in the bioenergy sector has been low relative to other sectors. For example, a recent review by Grêt-Regamey et al. (in press) identified multiple decision-support tools to operationalize the ecosystem services concept in sectors such as forestry and spatial planning, but could not find any tools that had been developed specifically for the bioenergy sector.

3. The energy cropping sector is undergoing a period of transformation, particularly in relation to the shift from first-generation to second-generation (or advanced) biofuels.

Key jurisdictions for bioenergy production and consumption, such as the EU and the USA, have been actively promoting a shift away from first-generation biofuel crops such as corn, sugarcane and oilseeds towards cellulosic biofuels that utilize the woody or fibrous parts of plants (Fig. 1). The EU has cited the negative impacts of first-generation crops, such as deforestation, competition with food production and indirect land use change, as a justification for shifting towards cellulosic biofuels (European Parliament and Council of the European Union, 2015). However, cellulosic energy crops can have a range of different impacts on ecosystem services (Holland et al., 2015) and there is a need for more targeted policy development if cellulosic energy crops are to live up to their full potential.

The aim of this article is not to argue for the universal support of all energy crops on the assumption that they will lead to the generalized enhancement of all ecosystem services. Rather, it is to identify policy mechanisms that could be used to promote specific land use activities capable of jointly delivering bioenergy outputs alongside other ecosystem services relating to soils, water, biodiversity or other ecosystem features. This notion of joint delivery of outputs can be framed in terms of "multifunctionality" (OECD, 2001) or "coupling" within complex human and natural systems (Liu et al., 2007). However, while some land use practices may be capable of jointly benefitting a number of ecosystem services simultaneously, in other cases the core provisioning service of the land use (e.g. food, fibre or bioenergy provision) may be linked to a range of "disservices", or declines in ecosystem services (Power, 2010). As such, the following section explores the range of impacts that energy cropping can have on the different dimensions of ecosystem services, both positive and negative, before moving on to a consideration of policy mechanisms.

1.1. How can energy crops enhance or degrade ecosystem services?

Table 1 provides examples of energy cropping systems that have been shown to enhance or degrade specific ecosystem services, following the ecosystem services categorization applied by the Millenium Ecosystem Assessment (2003). These examples are intended to demonstrate the diversity of ways in which energy crops can impact ecosystem services. They are not intended to provide an exhaustive list of all possible impacts or indicate the likelihood of energy crops enhancing or degrading ecosystem services overall. More comprehensive reviews of the links between energy cropping and ecosystem services have been undertaken by Gasparatos et al. (2011), Holland et al. (2015) and Baumber (2016), with each review highlighting that impacts are dependent on the specific context and management practices employed.

While the examples in Table 1 demonstrate how specific energy crops can impact specific ecosystem services, in practice it is common for energy cropping systems to impact multiple ecosystem services simultaneously. For example, deforestation for oil palm expansion does not only impact regulating services by releasing carbon to the atmosphere and altering evapotranspiration rates, but may also impact supporting services through habitat loss and soil erosion (Sheil et al., 2009) and cultural and provisioning services through dispossession of local people and the resulting loss

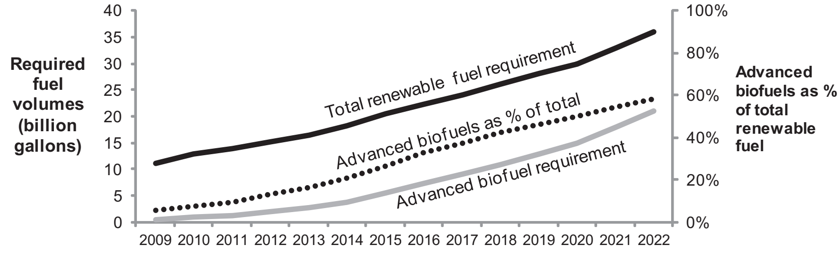

Fig. 1. Increase in advanced biofuel requirement in the US 2009–2022. Data source: Environmental Protection Agency (2010). Advanced biofuels include cellulosic biofuel, biomass-based diesel and other biofuels with >50% GHG savings.