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An assessment of the economic and environmental potential of biomass production in an agricultural region

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Abstract

The establishment of deep-rooted perennial species and their processing for biomass-based products such as renewable energy can have benefits for both local and global scale environmental objectives. In this study, we assess the potential economic viability of biomass production in the South Australian River Murray Corridor and quantify the resultant benefits for local and global scale environmental objectives. We model the spatial distribution of economically viable biomass production in a Geographic Information System and quantify the model sensitivity and uncertainty using Monte Carlo analysis. The total potentially viable area for biomass production under the Most Likely Scenario is 360,728 ha (57.7% of the dryland agricultural area), producing over 3 million tonnes of green biomass per annum, with a total Net Present Value over 100 years of A$ 88 million. The salinity in the River Murray could be reduced by 2.65 EC (μS/cm) over a 100-year timeframe, and over 96,000 ha of land with high wind erosion potential could be stabilised over a much shorter period. With sufficient generating capacity, our Most Likely Scenario suggests that economically viable biomass production could reduce carbon emissions by over 1.7 million tonnes per annum through the production of renewable energy and a reduced reliance on coal-based electricity generation. Our analyses suggest that biomass production is a potentially viable alternative agricultural system that can have substantial local scale environmental benefits with complimentary global scale benefits for climate change mitigation.

Keywords: Biomass production; Economic incentives; Climate change; Landscape scale; Natural resource management; Spatial analysis

Introduction

In many human-dominated regions, development of natural resources has resulted in environmental degradation (Vitousek et al., 1997), and from an anthropocentric perspective, less productive and resilient ecosystems. Development in the South Australian River Murray Corridor (or simply the Corridor) has occurred primarily for agriculture, usually involving both the broad acre clearance of deep-rooted native vegetation and replacement with shallow-rooted, rainfed annual crops and pastures. The effects of this large-scale land clearance commonly results in the degradation of biological, land, and water resources (Williams and Saunders, 2005). Natural resource management (NRM) actions such as the establishment of deep-rooted perennials are required over broad areas to ameliorate degrading processes such as wind erosion and salinity (INRM Group, 2003). Actions involve substantial economic costs but may also provide significant economic and environmental benefits.

Most land tends to be under private ownership in Australia's agricultural regions. Hence, in order to achieve environmental objectives, NRM actions are often required by private landholders. NRM actions often involve a significant establishment cost to landholders and there may also be a long-term loss of revenue from agricultural production (opportunity cost). However, most of the benefits are realised over long time periods and there is usually some uncertainty involved. The benefits to the landholder resulting from NRM actions may be insufficient to compensate for incurred costs (Bryan et al., 2007).

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Rather, benefits tend to accrue predominately off-farm to the wider community although the beneficiaries rarely share the costs of remedial NRM actions. Thus, private landholders are reluctant to undertake investment in NRM actions on the scale required to mitigate the processes of environmental degradation, and public agencies rarely have the funding required to offset these private costs.

Market-based policy instruments such as auctions, cap and trade systems, levies, credit systems, offsets, trusts, and other instruments have been investigated for their ability to encourage on-ground environmental management works by private landholders (Sterner, 2003). In contrast to policy approaches using explicit directives, as a general rule, market-based instruments (MBI) use the price signals of markets and market-like mechanisms to influence the choices made by land managers. Rather than relying on regulations to identify the best course of action, individuals are able to select actions that best meet environmental objectives. The potential advantage of MBI approaches is that through flexible decision making, they can achieve environmental goals at lower cost.

In the context of the South Australian River Murray Corridor, however, an array of factors may potentially impede market-based instruments from encouraging land management actions at a sufficient scale required to achieve environmental objectives (Connor and Bryan, 2005; Ward and Trengove, 2005). Substantial establishment costs incurred by private landholders are likely to be the major impediment (Ward et al., 2005). Market-based instruments most likely to facilitate broad-scale NRM actions are those that yield economic returns to the landholder that sufficiently compensate the establishment and opportunity costs by introducing positive income streams realised within a few years of establishment. Biomass production that integrates with existing agricultural activities offers the potential to provide significant economic returns (Bennell et al., 2004).

Biomass production based on deep-rooted perennial species may also make substantial contributions to environmental objectives (Tolbert and Wright, 1998). In the Corridor study area, large-scale plantings of deep-rooted species for biomass production are expected to have limited biodiversity benefits, but can mitigate processes of salinity and wind erosion. Biodiversity benefits are limited because of the lack of biological diversity typically found in the monoculture plantation and repeated disturbance caused by regular harvesting. Conversely, the deep-rooted perennials can reduce groundwater recharge and consequent saline groundwater intrusion into the River Murray, thereby reducing the potential contribution of dryland areas to river salt load. Establishment of deep-rooted perennials may also eliminate the impact of wind erosion through the soil-binding effect of the roots and the mitigation of wind speed by standing biomass (Cleugh and Bennell, 2002). In addition to local-scale environmental benefits, the production of renewable energy from biomass can have global scale impacts (Schneider and McCarl, 2003; Van Ierland and Lansink, 2003) in the form of climate change mitigation through the reduction in carbon emissions associated with coal-based energy generation (IPCC, 1996; Sands and Leimbach, 2003). We note that other environmental impacts of coal-based electricity generation such as sulphur, nitrogen, and mercury emission can also be avoided through biomass-based generation although we have not included these additional environmental benefits in this analysis.

In this paper, we jointly examine the economic viability and environmental benefits of biomass production in the Corridor study area based on deep-rooted perennial *Eucalyptus* species. The focus of this analysis is the commercial production of biomass for the supply of feedstock to an integrated tree processing plant and subsequent processing into renewable electricity, activated charcoal, and eucalyptus oil. We conduct a detailed, spatially explicit analysis of the economic viability of biomass production in the Corridor study area. Uncertainty is made explicit through sensitivity analyses. The local environmental benefits of biomass production are quantified in terms of wind erosion and salinity mitigation, as are the global-scale benefits for climate change through carbon emission reductions associated with the generation of renewable energy. This analysis enables the integration of both economic and environmental processes that are heterogeneous over the landscape. The high spatial resolution enables the detailed analysis of farm-scale production economics along with the analysis of landscape-scale soil and hydrological processes such as wind erosion and salinisation. In addition, we discuss the policy strategies and institutional design required to encourage the adoption of biomass production at scales that make substantial contributions towards local and global scale environmental objectives.

Assessing the economic and environmental benefits of biomass

Recently, interest in the production of biomass and bioenergy has increased substantially in response to the threat of climate change and the need to reduce carbon emissions (Hoffert et al., 2002; Steininger and Voraberger, 2003; Walsh et al., 2003; Nord-Larsen and Talbot, 2004). In a global analysis of biomass energy futures, Hoogwijk et al. (2005) estimate that biomass has the technical potential to supply energy at 2050 and 2100 equivalent to several times that currently is derived from crude oil. Renewable energy can be generated from a variety of biomass feedstock. These include both residues of agricultural crops such as sugarcane, corn and wheat (Askew and Holmes, 2002; Gallagher et al., 2003), and purpose-grown tree species such as *Salix* spp., *Populus* spp., *Eucalyptus* spp., and *Acacia* spp. (Varela et al., 2001) and herbaceous species (Hallam et al., 2001) such as switchgrass (*Panicum virgatum* L.).