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A proposed framework for assessing ecosystem goods and services from planted forests

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ABSTRACT

The planting of forests has been met with both scepticism and support in international forest policy and management fora. Discussions regarding the values of plantations for extrinsic purposes such as timber supply, carbon sequestration, water quality and biodiversity conservation, reveal widely varying opinions across and within different settings. Recent research highlights the role of planted forests in providing multiple ecosystem services to human society. However, there has been little assessment of ecosystems services, partly due to lack of suitable frameworks and evaluation tools. Planted forests generally have low ecosystem services values initially and are more vulnerable to erosion and other impacts of mismanagement than natural forests. Careful monitoring of change in ecosystem services values over time is therefore vital to investors and all stakeholders in plantations. Drawing on lessons derived from ecosystem services assessment for various land use types, here we propose an easy-to-apply framework to assess ecosystem services from planted forests that could be used in various planted forest types around the world. A necessary next step for researchers and practitioners is to test the proposed framework under various settings.

1. Introduction

Planted forests are becoming an increasingly important part of the global forest estate. Commercial timber supplies from natural forests seem to have peaked (Warman, 2014) while supplies from planted forests are increasing (Boucher and Elias, 2014; Warman, 2014) and will have to increase further to meet future global timber supply needs (Payn et al., 2015). In fact, planted forests were estimated in 2010 to cover 278 million ha globally and are expanding, while the area of natural forests continues to decline (Keenan et al., 2015). Planted forests are expected to play a key role in achieving recently adopted, global restoration targets such as the Bonn Challenge (to restore 150 million ha of degraded and deforested land by 2020) and the New York Declaration on Forests as well as the objectives of Article 5 of the Paris Climate Change Agreement. As a whole, planted forests have the potential to provide a wide array of goods, services, ecological functions as well as direct benefits to society and the environment. The Food and Agriculture Organization of the United Nations defines planted forests as those 'composed of trees established through planting or seeding by human intervention' (FAO, 2014). Although there is evidence of conversion of natural-to-planted forests in the tropics and subtropics (e.g., Ainembabazi and Angelsen, 2014; Zamorano-Elgueta et al., 2015), loss of natural forest in these two biomes is primarily driven by agricultural expansion (FAO, 2016).

Forest ecosystem services (ES) include timber and non-timber forest products (provisioning services) and regulating, habitat or supporting services and cultural services (TEEB, 2010). Planted forests, either for productive or protective purposes, also have the potential to mitigate land degradation (e.g. Stanturf et al., 2014). Demand for regulating services such as carbon sequestration and water regulation, and for cultural services such as recreation and spiritual values, are expected to rise because of both increasing global population and rising standards of living (FAO, 2010; Miura et al., 2015). Therefore, the role of planted forests as ES providers has attracted increasing attention (Brockerhoff et al., 2008, 2013; Bauhus et al., 2010; Yao et al., 2014; Vihervaara et al., 2012, Barua et al., 2014). Although the potential to enhance the ecosystem values of planted forests has been recognised for some time (Keenan et al., 1999), Lindenmayer et al. (2015) returned to this topic more recently. Yet there is still a need for developing tools and assessment frameworks to guide informed decision making. Vihervaara et al. (2012) provides important insights into stakeholder perceptions of ES from planted

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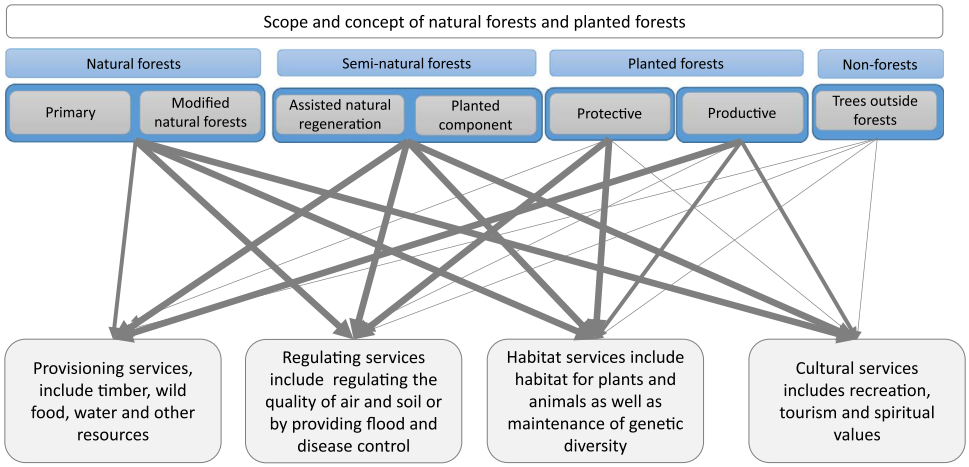

Fig. 1. Natural, semi-natural, planted forest and planted trees outside the forests, and their relative degree of provision of ecosystem services.
The thickness of the arrows indicates relative rate of delivery of ecosystem services (figure adapted from Carle and Holmgren, 2008; Brockerhoff et al., 2013; Ferraz et al., 2013).

forest (but it has been criticized for inadequate research design; Paruelo, 2012). Brockerhoff et al. (2013) review biodiversity-dependent ecosystem services and associated management options. Several other papers outline various aspects of ES associated with planted forests such as climate change adaptation (Ray et al., 2014), water conservation (Van Dijk and Keenan, 2007; Keenan and Van Dijk, 2010 ; Ferraz et al., 2013) and prioritisation of ES for conservation efforts (Moore, 2013). To our knowledge, a robust framework for assessing ES from planted forests is lacking. This paper aims to fill this gap.

Assessment of ES from planted forests can serve many purposes, including: (i) raising clarity and awareness of the relative importance of planted forests to policy makers, investors, environmental NGOs and local communities, (ii) improving the efficient use of limited funds by identifying where planted forests can achieve greatest benefits at lowest cost, (iii) supporting new opportunities to link planted forests with markets for ecosystem services, (iv) providing guidance for decision makers in understanding user preferences and the relative value that people place on ecosystem services, (v) generating information for designing planted forests so as to maximize their contribution to local communities, broader society and the global environment, and (vi) informing land use planning. In the approach outlined here, the values ascribed to various ES is determined by the beneficiaries of the particular ES, which range from local to national and global markets (Baral et al., 2013).

Here we review current approaches for identifying and assessing ES from various types of planted forests and propose a simple and pragmatic framework for assessing ES, applicable to any type of planted forests. To this end, we first review existing typologies of planted forests. Second, we re-visit classification systems and approaches used to assess ES and show their relevance to planted forests. Third, we construct a matrix where different types of planted forests are linked to specific ES. Finally, we propose an approach to assess ES from planted forests that is generalizable to a wide range of settings.

2. Planted forests – typologies and associated ecosystem services

A wide range of objectives, definitions, associated typologies and classifications for planted forests exist in the literature (Sohngen and Sedjo, 1999; Helms, 1998; Ingles et al., 2002; Evans, 2009; Batra and Pirard, 2015). Objectives are mainly based on (i) purpose, such as industrial use, environmental, agroforestry, farm forestry; (ii) species choice, such as monoculture or mixed species, hardwood or softwood, native or exotic species; (iii) management objectives such as production or environmental protection; (iv) rotation length – short (< 10 yrs), medium (10 – 20 yrs), long (> 20 yrs); (v) end use – e.g. timber, non-timber products, pulp, bioenergy; (vi) intensity of management – intensive or extensively managed; (vii) scale of operation – large and contiguous or small and fragmented; (viii) ownership – company, communal, share farming, out growers. A broad classification of natural, semi natural and planted forests is commonly used to reflect the different capacity of various planted forests to supply ecosystem services (Fig. 1). It is important to note that planted forests generally differ from natural forests in species diversity, regeneration characteristics, ecosystem functioning and associated ecosystem services provision – especially in their early stages of establishment. However, in some cases, the number and types of ecosystem services from planted forest may be similar to those of natural forests – especially later in their establishment. A summary list of ecosystem services from planted forests is shown in Table 1.

The magnitude (or value) of ecosystem services provided by various types of planted forests may differ (see De Groot et al., 2010). For example, a plantation estate of exotic monoculture managed on a short rotation basis may ultimately provide high fibre supply but is likely to provide lower regulating and cultural services than a long rotation estate (Pirard et al., 2016) or than a mixed species or native tree plantation (Felton et al., 2016). The human beneficiaries of provisioning, regulating and cultural services can also differ (Fig. 2).

3. Revisiting the concepts – defining and classifying ES

Ecosystem services have been defined and classified in many ways and the ongoing debate about the implications of these classifications for assessment and valuation is well covered in the literature (MEA, 2005; Boyd and Banzhaf, 2007; Costanza, 2008; Fisher et al., 2009; Haines-Young and Potschin, 2009; Patterson and Coelheo, 2009; Baral et al., 2014). For our purposes, we use the definition and classification proposed by The Economics of Ecosystems and Biodiversity (TEEB), which defines ES as, 'the direct and indirect contributions of ecosystems to human well-being' (TEEB, 2010). TEEB classification replaced the 'supporting services' in the Millennium Ecosystem Assessment (MEA) with 'habitat and supporting' services, which helps to prevent double counting in ecosystem services audits. Other influential definitions and classifications frequently cited in environmental literature are listed in Appendix A. We use the TEEB classification as it has been much refined and shown to have great utility since the original classification of the MEA.