



Review

A systematic map of ecosystem services assessments around European agroforestry



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ABSTRACT

Agroforestry offers proven strategies as an environmentally benign and ecologically sustainable land management practice to promote ecosystem services. In this literature review, we systematically consider the agroforestry and ecosystem services literature with the aim to identify and catalogue the knowledge field and provide the first systematic synthesis of ecosystem services research in relation to European agroforestry. We reviewed 71 scientific publications from studies conducted in farmland and forest ecosystems with various types of agroforestry management. Each publication was systematically characterized and classified by agroforestry practice and research approach in order to provide an insight into the current research state in addressing ecosystem services (including methods, indicators, and approaches). Spatial distribution of the case study sites in Europe was also explored. In addition, typical clusters of similar research approaches were identified.

The results show that ecosystem service assessment of European agroforestry is currently focused on the spatially extensive wood pastures in the Mediterranean, Atlantic, and Continental agricultural mosaic landscapes. A specific emphasis has been on regulating, supporting, and provisioning services, such as provision of habitat and biodiversity, food, climate regulation, fibre, and fuel, and the consideration of cultural services has been largely limited to aesthetic value. There is a bias to biophysical and monetary research approaches. The majority of the studies focus on quantitative methods and biophysical field measurements addressing the assessment of only one or two services. Monetary approaches have been applied in less than one fifth of the studies but form a distinctive group.

Our results highlight gaps and biases in the ecosystem service research agenda within agroforestry based on which we conclude that research should aim to diversify from the biophysical and monetary approaches, towards a wider variety of approaches, especially socio-cultural, and a wider coverage of ecosystem services. Stronger consideration of stakeholder participation and introduction of spatially explicit mapping are also important key actions. We make suggestions to advance the promise of ecosystem services provision from European agroforestry in decision making including various actors, stakeholders, and institutions, with strong links to policy processes, such as the EU Biodiversity Strategy and Common Agricultural Policy.

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1. Introduction

The ecosystem services framework has become the most widely adopted integrated framework to study the relations between ecosystems and people. Conceptually it describes how biophysical systems provide a variety of important benefits to human well-being and ultimately it can guide decision-making towards halting or reversing ecosystem degradation (Daily, 1997; Haines-Young and Potschin, 2010; MA, 2005). For this reason the assessment of ecosystem services is important, as it creates the knowledge to understand the supply and demand of ecosystem services, to support awareness raising, and to achieve priority on the political agenda, for example in the European Union (EU) (Cowling et al., 2008; Crossman et al., 2013; Maes et al., 2012).

Assessments of ecosystem functions and their potential provision of services to people have been dominated by natural sciences and economics (Seppelt et al., 2011; Vihervaara et al., 2010). The common approaches to assessment have been identified as biophysical, socio-cultural and monetary (Cowling et al., 2008; de Groot et al., 2010) or alternatively as habitat, system and place-based approaches (Potschin and Haines-Young, 2013). A general tendency in ecosystem service assessments, depicted by the recent literature, is that the measurement of cultural services lags behind the regulating, provisioning, and supporting services categories (Crossman et al., 2013; Martínez-Harms and Balvanera, 2012; Seppelt et al., 2011).

The ecosystem services concept also offers a transformative lens for agroecosystems, the most common anthropogenic ecosystem on the planet (Swinton et al., 2006). While agricultural intensification and expansion are among the most important drivers of ecosystem services degradation (MA, 2005), several multifunctional land-use systems hold the promise to safeguard ecosystem services within commodity production (O'Farrell and Anderson, 2010; Tschardt et al., 2005). Agroforestry, widely adopted in the world's tropical and subtropical regions, is one of such land-use systems that provide multiple ecosystem services, combining the provision of agricultural and forestry products with non-commodity outputs, such as climate, water and soil regulation, and recreational, aesthetic and cultural heritage values (McAdam et al., 2009). The main trait of agroforestry is the deliberate combination of trees/shrubs with agricultural crops or livestock, with people playing a key management role (Mosquera-Losada et al., 2009). The principal forms of agroforestry in Europe include wood pastures, the use of hedgerows, windbreaks, and riparian buffer strips on farmland, intercropped and grazed orchards, grazed forests, forest farming, and more modern silvoarable and silvopastoral systems. Agroforestry has traditionally formed an important element of European landscapes, but many of these systems have disappeared due to economic and social changes (among others, land abandonment and agricultural intensification),

and the remaining ones are highly vulnerable (Nerlich et al., 2013).

An assessment of the current spatial extent of agroforestry by den Herder et al. (2015) shows that agroforestry is most widely practised in southern Europe, especially in Spain, Portugal, Greece, and Italy. Wood pastures cover an extensive area and are distributed around Europe from the Mediterranean oak tree systems to Boreal wood pastures (Plieninger et al., 2015). Most fruit tree systems are found in central and Mediterranean Europe, with mixed olive cultivation in the Mediterranean being the most area-extensive expression of this agroforestry type. Also the traditional temperate fruit orchards are prominent (Herzog, 1998). Currently, agroforestry in the European Union is practiced at least on an area of 25 million hectares, which is equivalent to about 5.7% of the territorial area and 14.2% of the utilized agricultural area (den Herder et al., 2015).

Agroforestry has the potential to advance sustainable rural development in Europe (Primdahl et al., 2013). A key environmental benefit of agroforestry is the possibility to diversify agricultural landscapes with trees and to increase overall biodiversity (Mosquera-Losada et al., 2009; Nerlich et al., 2013). The key agricultural benefits include the opportunity to significantly increase land resource efficiency and productivity compared to the separation of agricultural and tree systems (Cannell et al., 1996; Graves et al., 2007), and to improve animal welfare. Jose (2009) has raised awareness for the ecosystem services that are mediated by global agroforestry not only to farmers and landowners, but also to society at large. The evidence supporting the promotion of agroforestry specifically in Europe has been reviewed by Smith et al. (2013) with the conclusion that temperate agroforestry balances both productivity and environmental protection through multiple ecosystem services. The challenge, however, lies in mainstreaming this land use practice. A meta-analysis on the role of scattered trees occurring throughout farmland matrix and their role as keystone structures maintaining ecosystem services by Rivest et al. (2013) also concluded that management options exist to conserve and restore trees but farmers need to be supported by relevant policies. In addition, Tsonkova et al. (2012) reviewed the ecosystem services provided by a specific type of temperate agroforestry, named alley cropping systems, and identified benefits in terms of increased carbon sequestration, improved soil fertility, enhanced biodiversity and increased overall productivity on marginal lands. Other reviews regarding European agroforestry practices have been published, for example, by Eichhorn et al. (2006) where the focus was on listing and quantifying the existing systems of silvoarable agroforestry and to document the recent changes and by Nerlich et al. (2013) who characterized traditional agroforestry practices and their disappearance from farmland. These recent reviews do not, however, systematically consider the agroforestry and ecosystem services literature in Europe.

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