A SYSTEMATIC MAP OF ECOSYSTEM SERVICES ASSESSMENTS AROUND EUROPEAN AGROFORESTRY

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Introduction

Agroforestry offers proven strategies as an environmentally benign and ecologically sustainable land management practice to promote ecosystem services (Mosquera-Losada et al. 2009). Although agroforestry surface in Europe is decreasing, it has traditionally been an important element of European landscapes. Currently, agroforestry is practiced at least on an area of 25 million hectares in the European Union, which is equivalent to about 5.7% of the territorial area and 14.2% of the utilized agricultural area (den Herder et al. 2015).
A key environmental benefit of agroforestry is the possibility to diversify agricultural landscapes with trees and to increase overall biodiversity. The ecosystem services concept offers a transformative lens for studying agroforestry (Daily 1997). An ecosystem service assessment allows to capture the multifunctionality of agroforestry, which combines 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 (MA 2006). The versatility of the concept of ecosystem service has attracted much attention from researchers as a way to assess agroforestry.
The current review produces a systematic and comprehensive evaluation of the knowledge field through mapping the conducted studies and applied research approaches for ecosystem services assessment around European agroforestry. The aim of this literature review is to identify and catalogue the knowledge field and provide the first systematic synthesis of ecosystem services research in relation to European agroforestry. The specific questions to address include: (1) What agroforestry systems and ecosystem services have been studied in Europe? (2) What approaches to ecosystem service assessment have been applied in research? (3) How are agroforestry systems, ecosystem services and research approaches interlinked?

Material and methods

We reviewed scientific publications from studies conducted in farmland or forest ecosystems in Europe with various types of agroforestry management. Our review followed established guide-lines for systematic review and systematic mapping (Pullin and Stewart 2006). Electronic academic databases used in the search for relevant items comprised ISI Web of Science, Scopus, CAB Abstracts (Ovid), BIOSIS Citation Index, and Geobase (Ovid).
Publication search combined three search strings in English with the following topics: (1) agroforestry and related definitions describing agroforestry systems, structures and practices, (2) ecosystem services and related definitions such as the equivalent of environmental services, and (3) Europe and specific countries.
The searches yielded a total of 286 references including journal articles, reports, books, book chapters, and conference papers. From these we manually selected those studies which: (1) address one or more agroforestry practices within the European biogeographical regions and (2) provide assessment of biodiversity or one or more ecosystem services. Items were selected through a three step filtering process during which, in the first instance, the inclusion criteria were applied on title. Secondly, items remaining were filtered by abstract and, further, by viewing remaining items at full text content. To characterize the context of agroforestry and ecosystemservice assessment literature, each publication was classified according to publication characteristics, study location and context, and characteristics of agroforestry practice studied (**Figure 1**). Characterization of the studied variables was approached through descriptive statistics. Cluster analysis was applied to identify typical clusters of studies approaching ecosystem services and their assessment in similar ways.

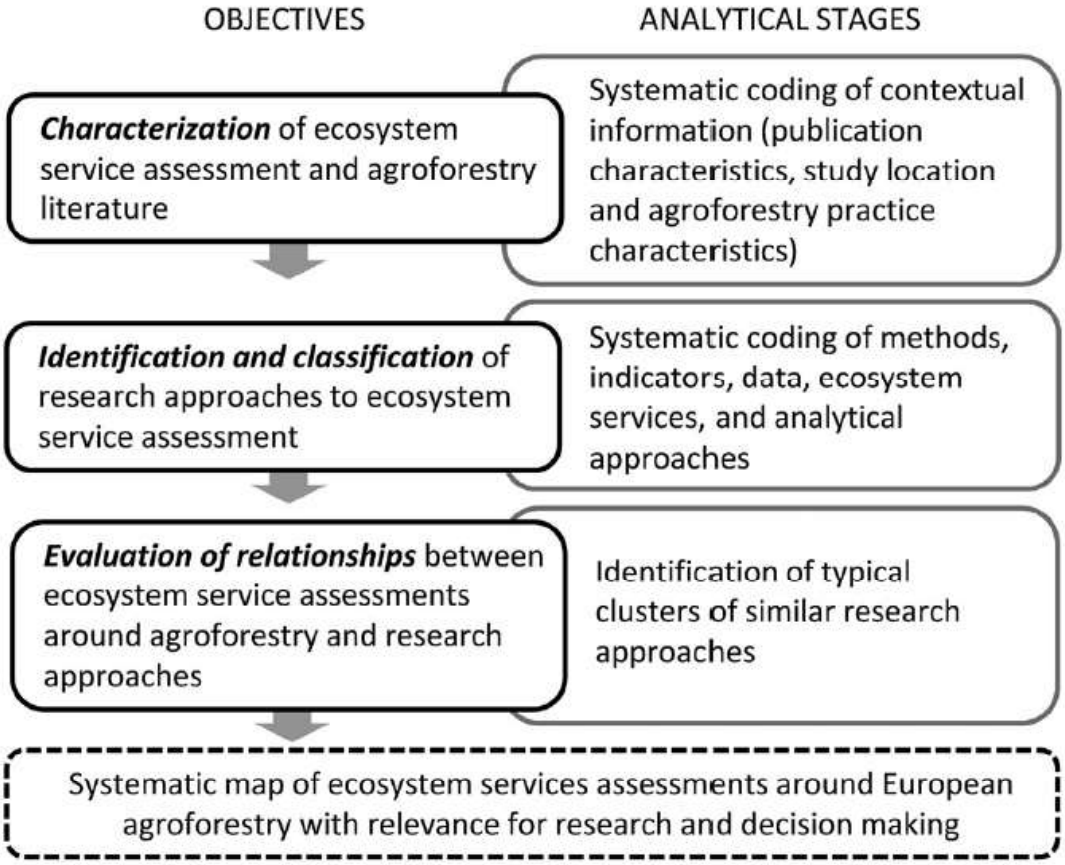

Figure 1: Objectives of the systematic mapping of ecosystem services assessments around European agroforestry with related analytical stages

Results

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 (**Figure 2**). 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 (**Figure 3**).

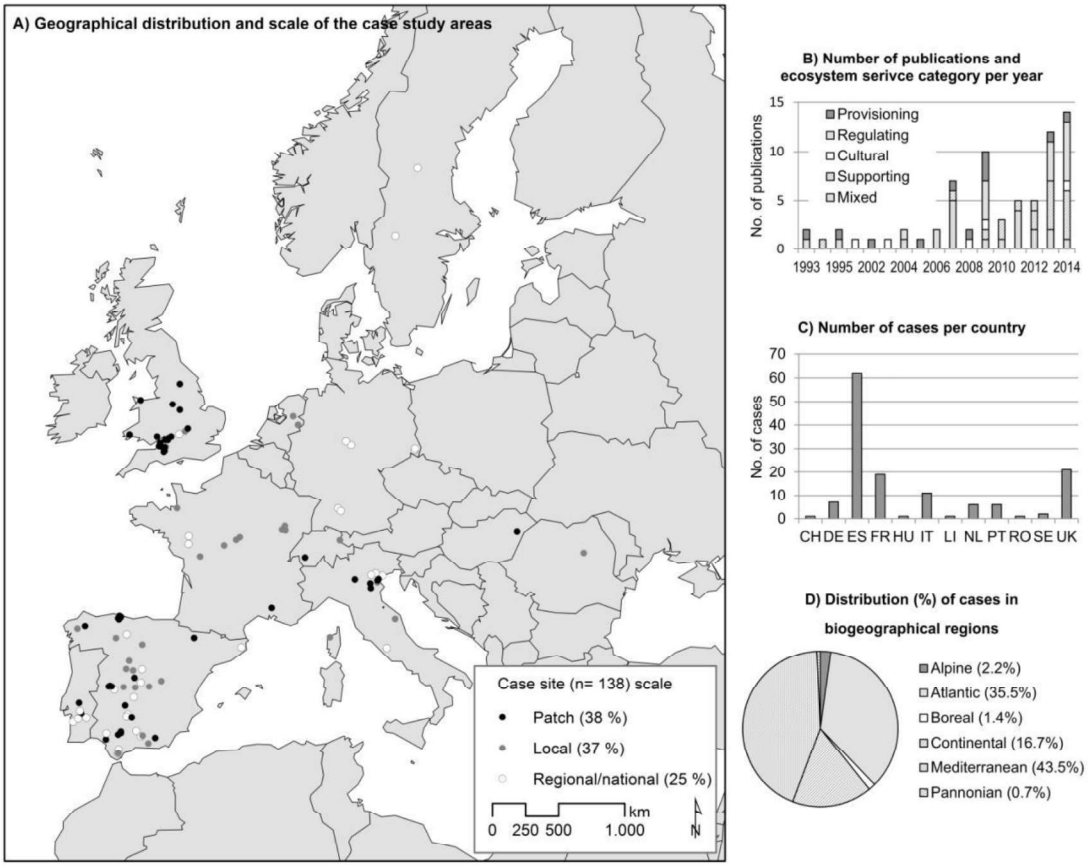

Figure 2: Geographical distribution and the scale of the case study sites (n = 138, 13 sites missing due to lack of data) addressed in the 71 publications: (A) geographical distribution and scale of study areas, (B) number of publications and ecosystem service category per year, (C) number of case study sites per country, and (D) distribution of case in the European biogeographical regions.

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.

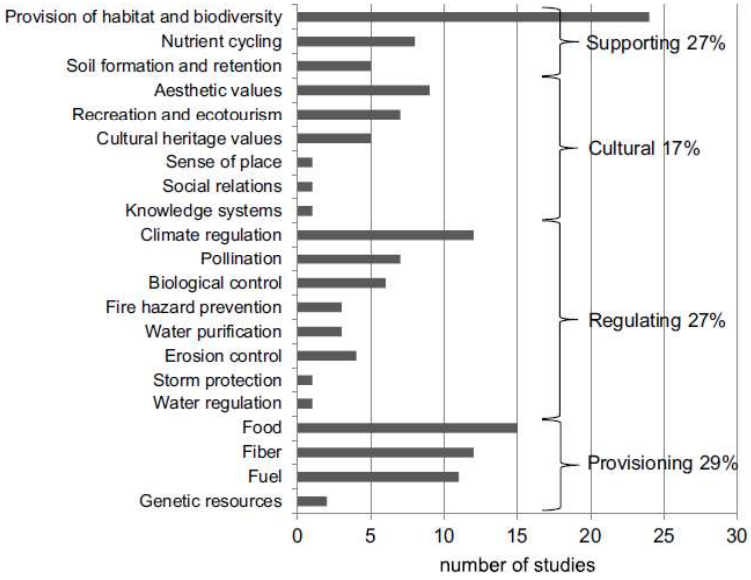

Figure 3: Frequency of the different ecosystem services appearing in the 71 publications and their share (%) in ecosystem service categories.

Discussion

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. For regionsrich in agroforestry (such as Mediterranean Europe) such assessments of biodiversity and ecosystem services may be advanced towards long-term monitoring programs that would allow longitudinal studies.

Stronger consideration of stakeholder participation and introduction of spatially explicit mapping are also important key actions. Identifyingservice trade-offs between land management practices, assessing ecosystem services for particular actor groups, and analyzing bundles of ecosystem services may be one important way towards understanding how different stakeholders have access to and benefit from ecosystem services.

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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