



Current extent and stratification of agroforestry in the European Union



Michael den Herder^{a,*}, Gerardo Moreno^b, Rosa M. Mosquera-Losada^c, João H.N. Palma^d, Anna Sidiropoulou^e, Jose J. Santiago Freijanes^c, Josep Crous-Duran^d, Joana A. Paulo^d, Margarida Tomé^d, Anastasia Pantera^f, Vasilios P. Papanastasis^e, Kostas Mantzanas^e, Przemko Pachana^a, Andreas Papadopoulos^f, Tobias Plieninger^g, Paul J. Burgess^h

^a European Forest Institute, Yliopistokatu 6, FI-80100 Joensuu, Finland

^b Forestry Research Group, Universidad de Extremadura, Spain

^c Crop Production Department, Escuela Politécnica Superior, Universidad de Santiago de Compostela, 27002 Lugo, Spain

^d Forest Research Centre, School of Agriculture, University of Lisbon, 1349-017 Tapada da Ajuda, Lisbon, Portugal

^e Faculty of Forestry and Natural Environment, Aristotle University of Thessaloniki, 54124 Greece

^f Forestry and Natural Environment Management, TEI Stereas Elladas, 36100 Greece

^g University of Copenhagen, Department of Geosciences and Natural Resource Management, Rolighedsvej 23, 1958 Frederiksberg C, Denmark

^h Cranfield University, Cranfield, Bedfordshire, MK43 0AL, United Kingdom

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ABSTRACT

An accurate and objective estimate on the extent of agroforestry in Europe is critical for the development of supporting policies. For this reason, a more harmonised and uniform Pan-European estimate is needed. The aim of this study was to quantify and map the distribution of agroforestry in the European Union. We classified agroforestry into three main types of agroforestry systems: arable agroforestry, livestock agroforestry and high value tree agroforestry. These three classes are partly overlapping as high value tree agroforestry can be part of either arable or livestock agroforestry. Agroforestry areas were mapped using LUCAS Land Use and Land Cover data (Eurostat, 2015). By identifying certain combinations of primary and secondary land cover and/or land management it was possible to identify agroforestry points and stratify them in the three different systems. According to our estimate using the LUCAS database the total area under agroforestry in the EU 27 is about 15.4 million ha which is equivalent to about 3.6% of the territorial area and 8.8% of the utilised agricultural area. Of our three studied systems, livestock agroforestry covers about 15.1 million ha which is by far the largest area. High value tree agroforestry and arable agroforestry cover 1.1 and 0.3 million ha respectively. Spain (5.6 million ha), France (1.6 million ha), Greece (1.6 million ha), Italy (1.4 million ha), Portugal (1.2 million ha), Romania (0.9 million ha) and Bulgaria (0.9 million ha) have the largest absolute area of agroforestry. However the extent of agroforestry, expressed as a proportion of the utilised agricultural area (UAA), is greatest in countries like Cyprus (40% of UAA), Portugal (32% of UAA) and Greece (31% of UAA). A cluster analysis revealed that a high abundance of agroforestry areas can be found in the south-west quadrant of the Iberian Peninsula, the south of France, Sardinia, south and central Italy, central and north-east Greece, south and central Bulgaria, and central Romania. Since the data were collected and analysed in a uniform manner it is now possible to make comparisons between countries and identify regions in Europe where agroforestry is already widely practiced and areas where there are opportunities for practicing agroforestry on a larger area and introducing novel practices. In addition, with this method it is possible to make more precise estimates on the extent of agroforestry in Europe and changes over time. Because agroforestry covers a considerable part of the agricultural land in the EU, it is crucial that it gets a more prominent and clearer place in EU statistical reporting in order to provide decision makers with more reliable information on the extent and nature of agroforestry. Reliable information, in turn, should help to guide policy development and implementation, and the evaluation of the impact of agricultural and other policies on agroforestry.

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* Corresponding author.

E-mail addresses: michael.denherder@efi.int, michael.denherder01@gmail.com (M. den Herder).

1. Introduction

The European Commission (2013) defines agroforestry as “land use systems in which trees are grown in combination with agriculture on the same land”. Other authors have defined agroforestry as the practice of deliberately integrating woody vegetation (trees or shrubs) with crop and/or animal systems to benefit from the resulting ecological and economic interactions (Burgess et al., 2015 building on MacDicken and Vegara, 1990 and Nair, 1993) and providing agricultural products from the understory (Sommariba 1992; Mosquera-Losada et al., 2016). There are several categories of common agroforestry practices worldwide and also in Europe (Mosquera-Losada et al., 2009, 2016; den Herder et al., 2015a, b); these include wood pastures, hedgerows, windbreaks, riparian buffer strips, intercropped and grazed orchards, grazed forests, forest farming and more novel silvoarable and silvopastoral practices and systems such as alley cropping, alley coppice, and woodland chicken. What all of these practices have in common is that the interactive benefits from combining trees and shrubs with crops and/or livestock offers land owners and managers the opportunity to create an integrated land-use system (Lundgren and Raintree, 1982; Leakey, 1996). In addition, the improvement in public ecosystem services provided by agroforestry systems and practices is widely acknowledged (e.g. Dupraz and Liagre 2008; Jose 2009; Bugalho et al., 2011; Torralba et al., 2016; Mosquera-Losada et al., 2016). Agroforestry systems are often associated with high conservation values and provide a wide variety of goods and ecosystem services (Jose, 2009; Bugalho et al., 2011).

An accurate and objective estimate on the extent and geographical distribution of different agroforestry types in Europe is crucial for the development of supporting policies. Despite agroforestry being almost everywhere, it is difficult to find reliable data on the global extent of agroforestry (Zomer et al., 2009) and the same applies to Europe. The lack of European data, and a narrow definition of agroforestry, has led in the past to the misconception that agroforestry is unimportant in the European context and this in turn has led to agroforestry not being included in policy decisions concerning land use and environmental challenges (Rigueiro-Rodríguez et al., 2009). This problem can best be tackled by providing an objective estimate of the extent of agroforestry in Europe. This is especially important since agroforestry has recently gained momentum not only in research but also in farm and policy circles. The revived interest in agroforestry originates from an increasing amount of evidence of environmental (Palma et al., 2007a, b; Reisner et al., 2007; Rigueiro-Rodríguez et al., 2009; Andrianarisoa et al., 2015; Cardinael et al., 2015), social and economic benefits (Graves et al., 2007; Glover et al., 2013; Mercer et al., 2014; Ranca et al., 2014) of this land use system. However, many of these systems are declining, showing high vulnerability to changes in disturbance regimes such as fire and drought (Acácio et al., 2009; Guiomar et al., 2015; Paulo et al., 2016) and to pests and diseases (Hansen, 2015; Tiberi et al., 2016). Gibbons et al. (2008) showed that the progressive loss of trees in agrarian landscapes has been a global pattern. Nevertheless, agroforestry practices can improve sustainability of farming systems and can, for example, mitigate emissions from the agricultural sector (Paolotti et al., 2016). Therefore, forthcoming EU commitments as expressed in the second amendment of Kyoto Protocol and commitments at the UN Climate Change Conference at Paris in 2015 include agroforestry practices within the Land Use Land Use Change and Forestry (LULUCF) carbon accounting framework (Mosquera-Losada et al., 2016). One important focus in contemporary agroforestry research is envisaging how adaptive management of agroforestry systems can contribute to climate change mitigation (Palma et al., 2015).

Databases providing an estimate on the extent of agroforestry in Europe are already available. The Corine land cover classification

(European Environment Agency, 1995) contains land cover data for Europe and includes the land cover class “agroforestry”. According to the Corine database, agroforestry covers about 3.3 million hectares in Europe, mainly in Spain, Portugal and Italy with some smaller areas in France and Austria. However, previous studies, often based on a literature review, have documented greater areas of agroforestry practices in Europe (Herzog, 1998; Eichhorn et al., 2006; Bergmeier et al., 2010; Plieninger et al., 2015) and it is clear that the Corine database is presently underestimating the agroforestry area. Agroforestry was recorded by CORINE only for regions where it is the prevailing land use. A recent literature study, summarising the currently available data sources estimated that agroforestry in Europe is practiced at least on an area of 10.6 million hectares equivalent to 6.5% of the utilised agricultural area in Europe (den Herder et al., 2015a,b). Wood pastures cover the largest area and are distributed around Europe in all climatic zones ranging from the Mediterranean to boreal zones (Rigueiro-Rodríguez et al., 2009; Bergmeier et al., 2010; Plieninger et al., 2015). Oak tree systems in the Mediterranean and reindeer husbandry in northernmost Fennoscandia are particularly area-extensive (Jernsletten and Klokov, 2002; Eichhorn et al., 2006; Mosquera-Losada et al., 2009). Other systems include grazing or intercropping of fruit tree systems in the continental (Herzog, 1998) and Mediterranean regions of Europe, with large areas of olive agroforestry in the Mediterranean region (Eichhorn et al., 2006).

Zomer et al. (2009) made a first attempt to quantify the extent of agroforestry at the global scale. One surprising result was the unexpectedly large extent of agroforestry worldwide. Globally, approximately 46% of all agricultural land had at least 10% tree cover. For Europe, the corresponding figure amounted to 40% of all agricultural land (Zomer et al., 2009). A key conclusion was that agroforestry is a significant feature of agriculture in all regions around the world. In the 2014 update on the global extent of agroforestry, Zomer et al. (2014) reported that approximately 48% (i.e. about 113.5 million ha) of all agricultural land in Europe had at least 10% tree cover. Thus, estimates on the extent of agroforestry depend a lot on the definition of agroforestry, the scale, the spatial resolution of the available data and the type of analysis.

Agroforestry can be classified in different ways, for example on the basis of components, products, agro-ecological zones, and socio-economic groupings (Nair, 1993; Sinclair, 1999; Mosquera-Losada et al., 2009; McAdam et al., 2009). For any attempt to map agroforestry, first clear boundaries are needed to frame what is and what is not agroforestry. In this assessment, agroforestry systems linked to farm and landscape have been stratified according to the main farming focus (annual crop, permanent woody crops and livestock) and components (forest and fruit trees, herbaceous crops and/or livestock). Accordingly, we classified agroforestry into three main categories: arable agroforestry, livestock agroforestry and high value tree agroforestry, all of them with subsequent subcategories (Burgess et al., 2015). The aim was to provide a systematic estimate on the current extent and geographic distribution of these types of agroforestry in the European Union at country level, based on existing Pan-European statistical land use and land cover data (Eurostat, 2015). We then defined certain regions of high likelihood to find agroforestry systems that correspond to regions where extensive traditional agroforestry systems are still extant.

2. Material and methods

Agroforestry areas in the EU were mapped using LUCAS data (Land Use and Land Cover survey; Eurostat, 2015). Hereafter, the results were compared with values available in the literature.

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