TESE DE DOUTORAMENTO

The Comon Agricultural Policy (CAP) and agroforestry systems in the European Union

José Javier Santiago Freijanes

ESCOLA DE DOUTORAMENTO INTERNACIONAL

PROGRAMA DE DOUTORAMENTO EN HISTORIA, XEOGRAFÍA E HISTORIA DA ARTE

SANTIAGO DE COMPOSTELA / LUGO

2020

DECLARACIÓN DO AUTOR/A DA TESE

La Política Agrícola Común (PAC)
y los sistemas agrofestales en la Unión Europea

D./Dna. José Javier Santiago Freijanes.

Presento a miña tese, seguindo o procedemento axeitado ao Regulamento, e declaro que:

1) A tese abarca os resultados da elaboración do meu traballo.
2) De selo caso, na tese faise referencia ás colaboracións que tivo este traballo.
3) A tese é a versión definitiva presentada para a súa defensa e coincide coa versión enviada en formato electrónico.
4) Confirmo que a tese non incorre en ningún tipo de plaxio doutros autores nin de traballos presentados por min para a obtención doutros títulos.

En Lugo, maio de 2020

Asdo José Javier Santiago Freijanes

AUTORIZACIÓN DO DIRECTOR / TITOR DA TESE

La Política Agrícola Común (PAC) y los sistemas agrofestales en la Unión Europea

D. José Antonio Aldrey Vázquez
D. Antonio Rigueiro Rodríguez

INFORMAN:

Que a presente tese, correspóndese co traballo realizado por D. José Javier Santiago Freijanes, baixo a nosa dirección, e autorizamos a súa presentación, considerando que reúne os requisitos esixidos no Regulamento de Estudos de Doutoramento da USC, e que como director desta non incorre nas causas de abstención establecidas na Lei 40/2015.

De acordo co artigo 41 do Regulamento de Estudos de Doutoramento, declara tamén que a presente tese de doutoramento é idónea para ser defendida en base á modalidade de COMPENDIO DE PUBLICACIÓNS, nos que a participación do/a doutorando/a foi decisiva para a súa elaboración.

A utilización destes artigos nesta memoria, está en coñecemento dos coautores, tanto doutores como non doutores. Ademais, estes últimos teñen coñecemento de que ningún dos traballos aquí reunidos poderá ser presentado en ningunha outra tese de doutoramento.

En Santiago de maio de 2020

Asdo. D. José Antonio Aldrey Vázquez

En Lugo, maio de 2020

Asdo. D. Antonio Rigueiro Rodríguez

Memoria realizada na Escola de Doutoramento Internacional (EDIUS) dentro do Programa de Doutoramento en Historia, Xeografía e Historia da Arte e como parte dos proxectos AGFORWARD e AFINET (financiados pola UE cos contratos N°613520 do 7º programa marco e 727872 do H2020, respectivamente), baixo a dirección dos profesores Dr. José Antonio Aldrey Vázquez e o Dr. Antonio Rigueiro Rodríguez, para obter o Grao de Doutor pola Universidade de Santiago de Compostela.

A ELENA E CARMEN

Contan que había un libro cuxa dedicatoria dicía "Aos meus queridos fillos cuxa contribución evitou que este libro teña saído antes". Eu non podo dicir o mesmo. Grazas.

AGRADECEMENTOS

Antes que nada querería agradecer a atención, dedicación, os bos consellos e a confianza dos directores: Antonio, que me introduciu no mundo da agroforestería e José Antonio, que me axudou a ubicarme dentro da Xeografía.

Cando un está a punto de presentar un traballo como é a tese de doutoramento nunha idade máis próxima á xubilación que á licenciatura non pode evitar botar a vista atrás e ver pasar a vida como contan que sucede en situacións de perigo extremo.

A miña vida non tería sido a que foi sen o amor, coidado, referencia e guía de mamá e papá, de Moncho e Carmela. Moitas grazas. Tamén foron moi importantes os meus irmaos Ramón e Julio e Irmás Mariapaz, Marta e Maricarmen, e as sobriñas Julia, Ainhoa e María e os sobriños Martín e Xián e os meus cuñados e cuñadas, tíos e primos e Elena. Grazas a todos.

Elena e Carmen non son apenas a proxección do futuro, tamén teñen contribuído a modelarme e facerme menos impulsivo. Moitas grazas.

A miña vida foi unha peregrinaxe por moi diversos lugares desde o meu Ourense natal ao Lugo onde moro, un itinerario que pasa por Lalín, Tenerife, A Coruña, os estudos en Compostela e Sheffield e con eses lugares unha boa lista de nomes como Ricardo, Manuel, Diana, Ana, Enrique, Beti, Juan, Carlos, Ramón, Marta, Isabel, Roberto, Xabier... e moitos máis. Grazas a vós tamén.

Grazas a todos os que traballaron comigo no laboratorio de Silvopastoreo, especialmente a Divi, a Pablo e a Tere. E aos profesores como Juan Luis, Pilar ou Rosa. E tamén a todos os alumnos que fixeron os traballos de Fin de Carreira ou de Grao, aos que nos visitaron cos Erasmus, e tamén aos que fixeron as teses de doutoramento como Lourdes, Esther, Mercedes, Rocío e Nuria e aos que seguen, Vanesa, Pancho e Dario, porque ser testemuña da súa aprendizaxe contribuíu moito á miña.

E grazas a todas as persoas de empresas e asociacións colaboradoras coas que tratei: a Alberto e todos os de AGROAMB, á

xente de GESTAGUA e CEAMSA, aos presidentes e secretarios de comunidades de Montes (como as de Carballo, Mouriscados ou a de Toca) aos membros de cooperativas de produtores e de outras asociacións coas que traballamos polo desenvolvemento rural.

Tamén quería dar a grazas aos profesores do Departamento de Xeografía cos que tiven a sorte de facer o terceiro ciclo. Comezando polo primeiro tutor, Ramom Chantada, xunto con Miguel Pazos, López Andión e Carlos Ferrás.

Moitas grazas aos investigadores de outras institucións como Eloi, Javier, José Luis, Ana, Gerardo, Alison, Michael ou Anastasia que tamén contribuíron na miña aprendizaxe, non só técnica mais tamén persoal.

E por suposto, Moitas grazas á persoa que me motiva e axuda, que me coida e que tanto ten que ver con esta tese. Moitas grazas Rosa.

ABSTRACT

Resumo

Esta tese de doutorado estuda sistemas agroforestais (SAF) a unión deliberada de vexetación leñosa a culturas anuais e / ou pasteiros. Primeiro, avalía as principais políticas globais que indican que se deben promover os SAF e, en seguida, aborda a caracterización de diferentes prácticas agroforestais en nivel europeo, tanto en xeral canto na caracterización do uso de estruturas leñosas lineares. Finalmente, a tese se concentra no estudo ao través de mapas de como os principais regulamentos de desenvolvemento rural promoven SAF na Europa.

A importancia dos sistemas agroforestais no manexo do territorio pode ser analisada de un punto de vista produtivo, avaliando as contribución da vexetación leñosa na fertilización. A vexetación leñosa tamén axuda a temperar o microclima do seu hábitat e protexe o solo da erosión. Do punto de vista ambiental, os SAF melloran o uso da radiación solar e aumentan a materia orgánica no solo, resultando en maior biodiversidade e comodidade da paisaxe. Este último interactúa con a importancia social da SAF, sendo fonte de mobilización do turismo rural, por outro lado, a diversidade de produtos obtidos e a menor dependencia de insumos externos (fertilizantes e pensos) contribúen para a fixación da poboación na rexión. o medio rural.

Os SAF tén unha extensión maior en áreas tropicais do que en áreas temperadas. A intensificación da agricultura ao longo do século pasado levou a unha redución drástica. A súa promoción política é dificultada pela falta de coñecemento da súa extensión real. A nivel europeo, temos dúas fontes de dados, a Corine Land Cover, que posúe unha extensión claramente infravalorada, concentrada no sur da Europa e especialmente na Península Ibérica e LUCAS, exclusivamente da Unión Europea, que fornece dúas coberturas e dous usos, xuntamente con outros dados, para cada punto visitado.

Palabras chave

Clima; Ecointensificar; Política Agraria Común (PAC); Sistemas agroforestais; Uso da terra

Resumen

Esta tesis doctoral estudia los sistemas agroforestales (SAF) unión deliberada de vegetación leñosa con cultivos anuales y/o pastos. En primer lugar, evalúa las principales políticas globales que señalan que los SAF deben fomentarse y después aborda la caracterización de diferentes prácticas agroforestales a escala europea tanto en general como en la caracterización del uso de las estructuras leñosas lineales. Finalmente, la tesis se centra en el estudio mediante mapas de cómo los principales Reglamentos de Desarrollo Rural promueven los SAF en Europa.

La importancia de los sistemas agroforestales en la gestión del territorio se puede analizar desde el punto de vista productivo valorando las contribuciones de la vegetación leñosa en la fertilización. La vegetación leñosa también contribuye a suavizar el microclima de su hábitat, y protege el suelo de la erosión. Desde el punto de vista ambiental los SAF mejoran el uso de la radiación solar y aumentan la materia orgánica en el suelo, redundando en una mayor biodiversidad y en la amenidad del paisaje. Esta última interactúa con la importancia social de los SAF, al ser fuente de movilización del turismo rural, por otro lado, la diversidad de productos obtenidos y la menor dependencia de insumos externos (fertilizantes y piensos) contribuye a la fijación de la población en el medio rural.

Los SAF tienen una extensión superior en las zonas tropicales que en las templadas. La intensificación de la agricultura durante el siglo pasado produjo su drástica reducción. Su promoción política está dificultada por la falta de conocimiento de su extensión real. A nivel europeo tenemos dos fuentes de datos el Corine Land Cover que presenta una extensión claramente muy minusvalorada, concentrada en el sur de Europa y especialmente en la península ibérica y LUCAS, exclusivamente de la Unión Europea que aporta dos coberturas y dos usos, junto otros datos, por cada punto visitado.

Palabras Clave

Clima; Ecointensificar; Política Agraria Común (PAC); Sistemas agroforestales; Uso de la tierra

Abstract

This doctoral thesis studies agroforestry systems (SAF), a deliberate join of woody vegetation with annual and/or grassy crops. First, it assesses the main global policies that indicate that SAFs should be promoted and then addresses the characterization of different agroforestry practices at European level both in general and in the characterization of the use of linear woody structures. Finally, the thesis focuses on the study through maps of how the main Rural Development Regulations promote SAFs in Europe.

The importance of agroforestry systems in the management of the territory can be analysed from a productive point of view by assessing the contributions of woody vegetation in fertilization. Woody vegetation also helps to temper the microclimate of its habitat and protects the soil from erosion. From an environmental point of view, SAFs improve the use of solar radiation and increase organic matter in the soil, resulting in greater biodiversity and the amenity of the landscape. The latter interacts with the social importance of the SAF, being a source of mobilization of rural tourism, on the other hand, the diversity of products obtained and the reduced dependence on external inputs (fertilizers and feed) contributes to the fixation of the population in the rural environment.

SAFs have a higher extent in tropical areas than in temperate areas. The intensification of agriculture over the past century led to its drastic reduction. His political promotion is hampered by a lack of knowledge of its actual extent. At European level we have two data sources, the Corine Land Cover, which has a clearly undervalued extension, concentrated in southern Europe and especially in the Iberian Peninsula and LUCAS, exclusively from the European Union which provides two coverages and two uses, together with other data, for each point visited.

Keywords

Climate; Eco-intensify; Common Agrarian Policy (CAP); Agroforestry Systems; Land Use

CONTENTS

INTRODUCTION

1 Agroforestry systems

1.1 Definition

Agroforestry (AF) is defined as the deliberate integration of a woody component with agricultural production in the understory in the same unit of land, being one of the most worldwide powerful tools to mitigate and adapt agricultural and forestry systems to climate change and comply directly or indirectly with the Sustainable Development Goals indicated by FAO (2013) (Figure 1).

Figure 1. Sustainable Development Goals (United Nations 2018).

Although there is a generalized recognition that agroforestry practices are types of sustainable land management that must be promoted at the political level (FAO, 2013), the main problem for the promotion of AFS is their identification at a territorial scale, because they are a type of use in different types of land cover.

CAP objectives	Agroforestry Contribution
Contribution to climate change mitigation and adaptation, and sustainable energy development.	Agroforestry is a powerful tool for mitigating and adapting farms to climate change while providing biomass as renewable energy source.
Promotion sustainable development and efficient use of natural resources such as water soil and air.	Agroforestry increases the biomass production per unit of land due to the better use of radiation and the increase of nutrient recycling through the uptake, of the excess of nutrients applied with fertilizers, from the below to the upper strata of the soil, improving water quality and soil health.
Contribution to biodiversity protection, promoting ecosystem services and preserving habitats and landscape.	Agroforestry is able to protect and increase biodiversity thanks to the heterogeneity it creates, but it also promotes provision, ecological and cultural ecosystem services thanks, for example, to the use of indigenous breeds and the corridors it generates among habitats and landscapes.
Promotion of the farm economic viability and resilience and food security.	Optimizing the use of farm resources and promoting multiple product delivery increasing the profitability of farms and promoting food security.
Promotion of agriculture orientation towards markets, increase competitiveness including a greater focus on research, technology, and digitization.	Digitization promotion linked to research promoted by farmers through innovation to implement AFS, which encourages the competitiveness of farms through the provision of multiple products from the same territorial unit associated with new market opportunities at the local level.
Improvement farmers' position in the value chain.	Increasing farm-provided products allows farmers to have a better position along the value chain and be more resilient to market and climate changes.
Attracting young farmers and facilitating business development in rural areas	AFS are complex requiring highly educated young people able to have business opportunity and develop rural areas.

Table 1. Agroforestry Contribution to the objectives of the CAP

From a policy and European point of view, the main uses of AF practices must be linked to the territorial units receiving Common

Agricultural Policy (CAP) payments: arable, permanent grassland and permanent crops areas as agricultural linked to direct payments in the CAP (Pillar I) and forest areas linked to rural development payments (Pilar II). How agroforestry practices meet the recent objectives of the CAP (Table 1) linked to the Global Sustainability Goals can be seen in Figure 1.

That is why this PhD these is primarily focused on evaluation of the main global policies that indicate that AFS should be promoted (Santiago-Freijanes *et al*. 2018) and then addresses the characterization of different agroforestry practices at European level both in general (Mosquera-Losada *et al*. 2018) and in the characterization of the use of linear woody structures (Santiago-Freijanes, *et al*. 2018). Finally, the thesis focuses on the study through the mapping of how the main Rural Development Regulations promote AFSs in Europe (Santiago-Freijanes *et al*. 2018).

1.2 Practices and systems

There are several categories of agroforestry practices identified around the world and Europe (den Herder *et al*. 2015, 2016; Mosquera-Losada *et al*.,2009, 2016c,), these include silvopasture, silvoarable, riparian buffer strips, homegardens with woody components and forest farming linked to the production of non-wood forest products (Table 2). Many of these practices can be combined into the same farm and may even have their importance at landscape level such as the use of wooded pastures and the trashumance or trastermintance of livestock from lowlands to highlands, with the aim of feeding the livestock during different period of the year. The main characteristic of these systems is the incorporation of a woody component on those farms exclusively agricultural or the agricultural use of areas dominated by a forest or fruit (perennial crops) trees or shrubs, either for maintenance or to increase income through the diversification of production. That is why we can talk about agro-silvo-pastoral systems, where woody perennials are

combined with the cultivation of cereals or pastures. Sometimes the woody perennials can be "multipurpose trees" such as oaklands, which allow owners to overcome the lack of forage to feed their herds during the shortage periods such as autumn and which are linked to obtaining high quality products (ex. Acorns in the the dehesa system).

All AF practices are able to provide benefits from the interactive combination of trees and/or shrubs with crops and/or livestock and offer landowners and land managers the opportunity to create an integrated system of use of the territory (Lundgren *et al*. 1983; Leakey, 1996). The characterization of this land use becomes essential to, first, have a level of reference when implementing policies and, secondly, to assess the policy impact to increase AF use at land level financed by the CAP in arable, permanent pastures and permanent crops areas. Table 3 shows how the different agroforestry practices are based on the different types of land use defined for the payment of the CAP by the European Commission.

Agroforestry practice	Description	
Silvopasture		Combining woody with forage and animal production. It comprises forest or woodland grazing and pastoral land with hedgerows, isolated/scattered trees or trees in lines or belts
Homegardens or kitchen gardens		Combining trees/shrubs with vegetable production in periurban and urban areas, also known as part of "trees outside the forest"
Riparian buffer strips		Strips of perennial vegetation (trees/shrubs) natural or planted between croplands/pastures and water sources such as streams, lakes, wetlands, and ponds to protect water quality. They can be recognized as silvoarable) or silvopasture but are signified by its role in preserving water streams
Silvoarable		Widely spaced woody vegetation inter-cropped with annual or perennial crops. Also known as alley cropping. Trees/shrubs can be distributed following an alley cropping, isolated/scattered trees, hedges and line belts design
Forest farming		Forested areas used for harvesting of natural standing speciality crops for medicinal, ornamental or culinary uses.

Table 2. Glossary of terms most linked to AFSs in Europe (Adapted from Nair, 1994; AFTA, 1997; Alavalapati et al. 2001, 2004; Eichhorn et al.,2006; Mosquera-Losada et al. 2009).

Land use and agroforestry practice		Common name	Brief description
AGRICULTURE	Silvopasture	Wood pasture and parkland	Typically areas of widely-spaced trees that are also used for forage and animal production.
		Meadow orchards	This practice includes fruit orchards, shrubs which are grazed or sown with pastures, but also olive groves and vineyards
	Silvoarable	Hedgerows and windbreak systems	Here the woody components are planted to provide shelter, shade, or parcel demarcation to a crop and/or livestock production system
		Alley-cropping systems	Widely spaced woody perennials inter-cropped with annual or perennial crops. It comprises alley cropping, scattered trees and orchards and line belts within the plots. These practices are sometimes found only during the first few years of the plantation
	Riparian buffer strips	Riparian buffer strips	Areas of tree and shrubs allowed to establish croplands/pastures and water sources such as streams, lakes, wetlands, and ponds to protect water quality, can be identified as silvoarable or silvopasture.
FOREST	Silvopasture	Forest grazing	Forested areas with the understory grazed
	Forest farming	Forest farming	Forested areas used for production or harvest of naturally standing speciality crops for medicinal, ornamental or culinary uses
URBAN AND PERIURBAN	Homegardens	Homegardens	Combining trees/shrubs with vegetable production usually associated with peri-urban or urban areas

Table 3. Agroforestry practices linked to the main types of holdings and use of the territory (agriculture, forest or urban/periurban)).

2 Importance of agroforestry systems in the management of the territory

2.1 Productive importance of agroforestry systems

Agroforestry practices are internationally recognized ways of sustainable land management that are also used extensively in developing countries, where the purchase of fertilizers, herbicides and pesticides is very limited. The agricultural management of the territory must be based on knowledge of the environment, its interactions, and its cycles and therefore with a mayor respect for it. A clear example of

this knowledge is the use of leguminous trees or shrubs such as *Leucaena leucocephala* which is able to provide nitrogen to the soil and thus achieve good grass or cereals crops without the need to make nitrogen inputs (Brewbaker, 1987).

The woody component in an agricultural system increases its resilience to climate change and market variations under different edaphoclimatic conditions. In areas where the loss of soil in croplands is a problem, the tree not only prevents water and wind erosion by favouring water infiltration and providing plant cover but generates also soil on its own or is able to be used to produce compost. According to the nutrient cycling, the woody perennials act as real pumps that capture through their roots the nourishing elements that the herbaceous vegetation is not able to use and then "recycle them" from the deeper soil layers to the upper soil layers of the system, through uptake, incorporation into their tissues and subsequently generating residues that are integrated into the upper soil layers. In addition, trees modify the microclimate of agricultural crops in many cases as they provide lower temperatures during drought, increase humidity and even generate dew, making them a tool of enormous utility against climate change in those areas where drought is increasingly severe, but not limiting enough. These aspects are particularly important in areas of strong winds, since the woody component avoids the intense drying effect of them (Takáczs *et al*. 2009; Vidrih *et al*. 2009). On the other hand, AF also provides wood to make fences, supplies firewood, or even new technologically based products (fibres, active compounds) within the framework of the European strategy of bioeconomy and circular economy. As production diversifies, farm resilience is increased in the face of market changes. They also supply food for human being or livestock and generate animal welfare thanks to their shade. That is why the expression "a tree for everything" in the agricultural field makes a lot of sense.

The productive and environmental benefits of AFS in Europe have been documented in the monograph Agroforestry in Europe (Rigueiro-Rodríguez *et al*. 2009a), in addition, in book chapters specifically focused on biodiversity (Rois-Díaz *et al*. 2006; Rigueiro-Rodríguez *et al*. 2010) and carbon sequestration (Mosquera-Losada *et al*. 2011). With AFS, the productivity of the territory is increased, with the exclusively agricultural or forestry systems, since it is enhanced to obtain multiple products from the same territorial unit: wood, pastures, mushrooms, meat, wool, etc. These systems have the advantage, among others, of increasing the land equivalent ratio index (LER) (Graves *et al*.,2010). The LER is an estimate of the area needed to produce the same under an agroforestry scenario as under a design in which tree and crop products are cultivated on independent areas (usually referred to hectares). A LER of 1.2 means that 1 ha of agroforestry land produces the same as 1.2 hectares when tree cultivation is independently cultivated for fruit or wood production and agricultural cultivation as a monocrop. The range of LER in the temperate zone is between 1.2 and 1.8 (Dupraz *et al*.,2008). Proper biodiversity management at the landscape level is also a powerful tool for better at biomass productivity (Gross, 2016).

Productivity and the ecological effects of AF components vary over time. Initially, when the plantation is young, most of the income comes from the understory; however, as time goes on, the woody component becomes increasingly important. This justifies the approach of short medium and long-term studies and strategies, and with different forest ages and species. Moreover management models should consider density, preferential production of wood or crop, the implementation of silvicultural treatments to jointly assesse biomass production, farm-scale profitability and environmental benefits. Due to the diversity of AF components and their interaction with the environment it is extremely important to use mathematical management models that allow to simulate different scenarios it easier for the farm manager

and/or owner to help them to make decisions. In this sense, biophysical and economic models are currently being developed to help AF design on a time scale such as Yield-SAFE.

2.2 Environmental importance of agroforestry systems

AF, thanks to the woody component, provide an improved use of existing resources, both at the air and underground level, linked to the so-called eco-intensification or optimization of resource use. At the aerial level, the increase of photosynthetically active biomass (crop leaves / pastures + leaves of trees) per hectare causes a better use of solar radiation that can increase between 20 and 80% biomass production (Graves *et al*. 2010). This increase in biomass production can be associated with an improvement in the profitability of the farmer if the right species are mixed and income is obtained from all the AF components. At the same time, the fact of being able to increase biomass production increases the source of soil organic matter, the main reservoir of Carbon in terrestrial ecosystems (81%) (Karsenty *et al*. 2003) therefore helping to mitigate climate change.

On the other hand, AF systems are often associated with high values of nature preservation and provide a wide variety of ecosystem goods and services (Dupraz *et al*. 2008; Jose 2009; Bugalho *et al*. 2011; Mosquera-Losada, *et al*. 2016; Torralba *et al*. 2016).

The heterogeneity caused by the presence of the woody component in agricultural lands creates microhabitats that improve alpha biodiversity (richness in the number of species in a uniform area), but also causes changes at landscape level, thus improving beta biodiversity (change of species from one habitat to another) and gamma (richness of species among all habitats in a region). From an ecological point of view, AF improves biodiversity through the creation of heterogeneous areas originated by animals (faeces distribution, selection...) and woodland (shade gradient). In AF practices (silvopastoral and silvoarable), there is also a greater carbon

sequestration than in exclusively agricultural systems because there is a higher volume of soil occupied by the roots in to the deep soil layers and roots that are the principal to the source of soil carbon. This contributes to mitigate greenhouse gas emissions and helps slow down the climate change process (Nair *et al*. 2009; Mosquera-Losada *et al*.,2015a). This increase in carbon sequestration per unit of land, coupled with the reduction of the fire hazard in high-risk areas such as Galicia, contributes significantly to mitigate climate change. The reduction of the risk of fires is due to the consumption by the animal of the shrub and herbaceous strata as feed, reducing the biomass of the plant fuel present in the understory, but also the effect of trampling and dejections promote woody species replacement with herbaceous species in the understory.

At soil level, the difference of the position of the roots of woody and herbaceous plants in depth favours the reuse of nutrients improving their internal recycling and avoiding loss of nutrients, including nitrates, which cause many environmental pollution problems (Rigueiro-Rodríguez *et al*. 2009). The environmental protection carried out by AF is mainly due to the capture by the woody perennials of the excess of nitrogen, phosphorus and other nutrients that the grass does not use (recycling nutrients from the deepest layers of the soil and transport to the most superficial ones), which leads to the improvement of the quality of water and soil.

AF role as a tool to combat climate change can be seen in documents such as the European Climate Change Strategy (EU, 2013a), the European Forest Strategy (EU, 2013b) and the IPCC report (2014) which mention AF as a tool for adapting and reducing greenhouse gas emissions. AF compared to exclusively agricultural systems, implies an increase of more permanent soil carbon reservoir, with the trees having a greater capacity for deep soil exploration, compared to exclusively agricultural or livestock systems, emphasizing the last as important sources of greenhouse gases, especially if

livestock stocking rates are not adjusted (Fernández-Núñez *et al*. 2010; Howlett *et al*. 2011). The latest IPCC documents indicate that carbon sequestration should be seen in conjunction with adaptation and mitigation activities (IPCC, 2014). A review on "AF as a way of management in adaptation to climate change" is included in the book on forests and adaptation to climate change published the MAGRAMA (Mosquera-Losada, Moreno-Marcos, *et al*. 2015) and has been published by the European Commission recently (Mosquera-Losada *et al*. 2017).

2.3 Social importance of agroforestry systems

AF increases the social benefits that derive from a territory. Firstly, because they improve the quality of the landscape due to the heterogeneity they generate, which helps to promote ecotourism in rural areas. On the other hand, being more complex and complete systems, if they are well organized, they allow to generate employment in times when, if there is not diversification of production, jobs would not be generated or generated in a smaller amount. In addition, improving the use of resources reduces the need for inputs linked to fertilization or the use of pesticides or herbicides, producing better quality food and thus contributing to food security (Dawson *et al*. 2013).

3 Promotion of agroforestry systems through politics

AF includes a set of practices of sustainable use of the territory (FAO, 2013; Mosquera-Losada, Moreno-Marcos, *et al*. 2015), usually associated with tropical and developing countries (FAO, 2013). However, and due to all the advantages, that AF can bring to agricultural and forestry systems, they should be systems linked to the use of territory by human beeings in broader territories. This is the case in the field of developing countries, but not in developed countries. The extent of AFS in temperate areas is rather small, as described in Europe (Zomer *et al*. 2009) or in the United States (USDA 2011; 2013). The limited use of agroforestry practices in developed countries is a

consequence of the intensification of agricultural systems in the last century, which also promoted the lack of integration of forest and agricultural land, based on policies that were not appropriate to promote agroforestry practices. Only recently, this type of land use has been recognized in developed countries aiming at to Eco-inten in the context of the production of the land allowing agricultural systems to optimize the use of resources and the delivery of more ecosystem services (Haines Young *et al*. 2012). The United States has established an agroforestry strategy establishing clear agroforestry practices (USDA 2011; 2013) while the European Union has included measure 222 in the 2007-2013 CAP, which has been extended in the current CAP period through the sub-measure 8.2 (Mosquera-Losada and Nair, 2016).

AF has been one of the most common land-use practices worldwide (den Herder *et al*. 2017), as these integrated systems have characterized European rural landscapes until the introduction and adoption in recent decades of modern agricultural practices on a large scale. Previously, woody vegetation was deliberately retained or included in land cultivated or grazed by European farmers, as it traditionally served various purposes in the agricultural economy through its multiple productions and environmental benefits (Nair, 1994; Eichhorn *et al*. 2006; Rigueiro-Rodríguez *et al*. 2009; Mosquera-Losada *et al*. 2016).

The intensive agricultural systems promotion, which in recent decades of the last century spread throughout the developed world is, today, the cause of many environmental problems, as well as the degradation of agricultural ecosystems linked to the loss of some ecological traits, such as the presence of the woody component (Mosquera-Losada *et al*.2009; FAO 2010; 2013). Intensive agricultural systems are mainly based on the use of external inputs into the systems that generally come from out of the farm (e.g. fertilizers such as phosphorus) or are artificially created (nitrogen).). These external inputs cause a huge carbon footprint, because of the energy consumption which is necessary for their industrial synthesis and for

the needed transport from their point of origin to the plots where they are applied. Agricultural and forestry systems are currently intended to provide as many ecosystem services as possible, including those linked to ecosystem provision, regulation and cultural services declared by the Common Nomenclature of Ecosystem Services called CICES (Haines-Young, 2016). The provision of ecosystem services relates to the provision of peer food to growing global population, considering sustainability to enable future human generations to meet their needs (FAO 1989; 2014). In addition, for many years the role of ecological processes in agricultural sustainability (Swift *et al*. 1994), has been studied, and its importance for the future of world agriculture is well recognized (Tscharntke *et al*. 2012). Therefore, cultivation systems should cease to be intensive and become extensive or rather ecointensive, i.e. the use of external inputs must be reduced and the efficient use of available resources should be achieved based on existing biodiversity (Rois-Díaz et al., 2006; Rigueiro-Rodríguez *et al*. 2010; Leakey, 2014; Gross, 2016).

Recently many of these intensive systems are declining, showing a great vulnerability to changes in disturbance regimes, such as fires and droughts (Acácio *et al*. 2009; Guiomar *et al*. 2015; Paulo, Pereira and Tomé, 2017) and pests and diseases (Gibbons *et al*. 2008; Hansen, 2015; Tiberi *et al*. 2016), noting that the progressive loss of trees in agricultural landscapes is being a global negative pattern. All this ensures that agroforestry practices can improve the sustainability of agricultural systems and can, for example, mitigate emissions from the agricultural sector (Paolotti *et al*. 2016). That is why the forthcoming EU commitments expressed in the Second Amendment to the Kyoto Protocol and the commitments at the United Nations Climate Change Conference in Paris in 2015 include agroforestry practices within the framework of carbon land and land use accounting (LULUCF) (Mosquera-Losada *et al*. 2016).

4 Agroforestry systems promote using geography

The conclusions of a recent study under the AFINET project, involving more than 900 farmers from 9 European countries, highlight that the implementation of agroforestry requires four major challenges to be overcome:

Technological: Technological knowledge must be a reality, which on the one hand, indicate which are the best combinations (agricultural crops, grassland, tree or shrub woody species, animal kinds..) in the agroforestry practices establishment framework, and at what point these changes should change considering the alteration of the habitat generated by the development of woody species, trees especially (shadow) and adaptation to specific local conditions.

Economic: Farmers point out that it is very important to develop business plans allowing them to compare the current conventional management models with the agroforestry management model, assess advantages and disadvantages and, above all, improve the possibilities offered by the market through the bioeconomy.

Education and Communication: Participants noted that it is very important that farmers are trained for agroforestry techniques use, but that it is also important for society as a whole to understand that sustainable and environmentally friendly agriculture is created with such systems. The awareness of society in relation to these systems should be based on their presence in the programs at all levels of education, from kinder gardens to university, and the dissemination and communication in relation to them must reach society in general.

Policies: Through the design of appropriate policies that promote the AF use in Europe.

The Spanish academy “Real Academia Española de la Lengua” defines geography as a science dealing with the description of the land, and policy geography, understood as the part of geography that deals with the distribution and organization of the Earth as a dwelling of the humanity, two are the main aspects to which these branches of

knowledge and science can contribute to promote the use of AF in the European territory: Firstly, the physical and up-to-date description of the different AFS in Europe and secondly the evaluation of the different international, European and national policies that promote the use of different primer agroforestry practices in the European territory, aspect fully addressed within the geopolitical discipline (López Trigal, 2015).

4.1 Policy geography

The promotion of agroforestry policy is not easy for several reasons (Rois-Díaz *et al*.,2006; FAO, 2013), such as the lack of knowledge about the combinations of woody and agricultural components adapted to the specific conditions of a particular place, but also due to the inertia of the intensification of most agricultural practices carried out by farmers. This is why different NGOs and international organizations, in which farmers and researchers work together, initiated movements around the world trying to highlight the important role that AF must play as a form of multipurpose system based on ecointensification (i.e. optimizing the use of resources to provide more products). These NGOs are the ICRAF or World Agroforestry Centre (http://www.worldagroforestry.org/), operating mainly in tropical countries, the AFTA (Association for Temperate Agroforestry) (http://www.aftaweb.org/) that associates the countries of North America (Mexico, USA and Canada), or EURAF (European Agroforestry Federation) http://www.eurafagroforestry.eu/), involving 17 European countries. AF is also part of an excellent Tool for less-intensive agricultural systems (EIP-AGRI, 2016), such as ecological agriculture, the agroecology (Leakey 2014) and permaculture (Ferguson *et al*. 2014), or in those who the use of the tree canopy can increase fertility or extend the grazing season for livestock feeding in order to reduce the need external inputs (concentrates), between other aspects. These movements are the origin of the recent National AF strategies trying to promote AF in different countries. This has happened on several continents of the world, and in countries as United States (USDA, 2011, 2013, 2019), India (India government, 2014), Mexico (CONAFOR, 2012) and France (Ministère de l'Agriculture, 2015). These Strategies are based on global policies which, in the case

of Europe, are subsequently integrated into pan-European strategies based on which is built the Common Agricultural Policy (CAP). It is because the European Commission has also included AF as a practice in the CAP, as a main tool to support farmers in the 28 countries of the European Union. Some policy funds are focussed focuses on the agriculture activity itself while other are more focussed on the environment, forestry or the sustainable development. The CAP is the main driver of the agricultural farming in Europe. CAP payments were based in the past to produce more (coupled measures), while today they are mostly associated to land use (decoupled measures).

The CAP is Structured in two Axes Main: the Pillar I linked to direct payments to different types of land use (arable area, permanent grasslands and permanent crops) and the Pillar II currently associated with the 118 Rural development programmes of the CAP, in which the different Regions Europe establish concrete measures to management of the territory linked to practices such as agroforestry, which in many cases are not recognized as such, but there is a clear promotion of them. It is because it is necessary to carry out an evaluation of all the Europeans rural Development Programs (RDP) who have had territorial payment base and that Include 2007-2013 CAP (88 RDP) and current CAP 2014-2020 (118 RDP).

4.2 Agroforestry and geography

The New CAP aims to foster sustainability in Europe. The farming practices payments will be linked to compliance of a series of economic, environment and social objectives to which agroforestry practices can contribute. The knowledge of the current distribution and the evolution of agroforestry practices and policies in the last CAPs is essential to associate the benefits of the agroforestry practices to CAP payments based on results. Therefore, it is needed an objective estimation of geographical scope and distribution of these types of agroforestry practices in Europe, which, at the end, is crucial for the development of policy support and also for the evaluation of their impact. Policies must base their implementation on an analysis DAFO to establish the current situation (area included) and the situation aiming at being achieved. Despite AF is present in the most part of the EU

territory, it is difficult to find reliable data on their global extent (Zomer *et al*. 2009) as also happens in Europe. The estimates on the extension of AF depend a lot on the AF definition, the scale, the spatial resolution of available data and the kind of analysis. Zomer *et al*. (2014) tried to estimate the overall area of Agroforestry and designates that AF occupies approximately 48% of the all agricultural land in Europe (it is say, around 113.5 million ha) considering lands that have at least a 10% of tree cover, but their estimates are vague because the land agricultural use is not clearly established. The lack of European data, together with a restricted definition of agroforestry systems, has led in the past to the mistaken consideration that agroforestry systems are not important in the European context and, in turn, that they are not taken into consideration in political decisions on land use and the environment (Rigueiro-Rodríguez *et al*. 2009).This issue can be better addressed if an estimate of the objective extension agroforestry Europe is provided, which is especially important in the current context, where AF have been recently highlighted as a sustainable practice, not only in research, but also in agricultural and political circles. This grew up interest comes from the increasing tests that highlights the the benefits AF provides from an environmental (Palma, Graves, Bunce, *et al*. 2007; Reisner *et al*. 2007; Palma, Graves, Burgess, *et al*. 2007; Rigueiro-Rodríguez *et al*. 2009; Cardinael *et al*. 2015; Andrianarisoa *et al*. 2016), social and economic (Graves) *et al*. 2007; Glover *et al*. 2013; Mercer *et al*. 2014; Rancane *et al*. 2014). Therefore, this PhD aims at carrying out an analysis of the main sources data (Corine Land Cover and LUCAS) that may allow us quantify the extent of AF in Europe. In this PhD, it is interesting to show two main aspects, firstly the agroforestry use categorization linked to arable land, permanent pasture and permanent crop and secondly the land features identification because their importance in Pillar I conditionality and greening, and in relation with Pillar II rural development regulation within the 2014-2020 CAP but also in the former CAP (2007-2013).

4.3 Corine Land Cover

In Europe, there is a land cover classification system that is the Corine Land Cover (CLC) (EEA, 1985), which includes the class "agroforestry". According to this database (CLC), AF represents about

3.3 million hectares in Europe, mainly located in Spain, Portugal, and Italy, with some much smaller areas in France and Austria. However, previous studies, based on literature review, have documented a greater extension of agroforestry practices in Europe (Herzog, 1998; Eichhorn *et al*. 2006; Bergmeier *et al*. 2010; Plieninger *et al*. 2015) and make clear that the "agroforestry class" of the CLC database underestimates the agroforestry area. AF was recorded by CLC only in regions where AF is the predominant land use.

4.4 LUCAS

Agroforestry systems can be classified in different ways, for example based on components, products, agroecological zones and socio-economic groupings (Nair, 1993; Sinclair, 1999; Mosquera-Losada *et al*. 2009). For any attempt to map agroforestry, clear boundaries are first needed to clearly define the boundaries about what is and what not agroforestry is. In this PhD assessment, the AF linked to agriculture and landscape has been stratified according to the main agricultural component (annual crop, permanent pasture, and livestock) and the woody component (forest trees and fruit trees and permanent crops). Based on this initial classification, den Herder *et al*. (2017) classify agroforestry systems into three main categories: arable agroforestry, livestock agroforestry and high value tree agroforestry, all with subcategories (Burgess *et al*. 2015). The aim was to provide a systematic estimate of the current extent and geographical distribution of these types of agroforestry in the European Union at country level, based on land use statistics and land cover data (EUROSTAT, 2015). However, these authors do not include the woody shrub component, which is recognised by FAO as a key component of agroforestry in the same way than trees in the definition of agroforestry (FAO, 2015a).

Agroforestry practices, defined as the combination of a woody component (forest tree, shrub, fruit tree) with an agricultural use of the understory, are difficult to identify based on geographic identification systems, since most categories are based on land cover, but not on land use. LUCAS (den Herder *et al*. 2017) solves this problem by integrating two covers and two uses in the data collection, along with other aspects such as the presence or absence of evidence of grazing (Land Management field). This allows, for example, the recognition of

agroforestry practices such as the combination of trees (or shrubs) with agricultural crops (both annuals -Silvoarable- and non-annuals, combination of olive trees with vineyards, for example). The LUCAS survey approach facilitates the development of an inventory of agroforestry practices linked to the presence of perennial woody trees combined with an agricultural activity in the undergrowth, which will help policy makers to understand and establish the baseline situation of agroforestry practices (e.g. isolated trees and live hedges) associated with agricultural activities across Europe. This methodology is essential to understand how to set up policies and how to develop appropriate policies, as well as to assess their impacts. Den Herder *et al*. (2017) made the first serious attempt to categorize the scope of agroforestry systems by country in Europe, based on the use of LUCAS (Land Use and Cover Statistical Survey), and considering the previous definition of agroforestry under the CAP 2007-2013 (land use systems where trees are grown in combination with agriculture on the same land), but not the new definition derived from the development of Measure 8.2 of Regulation 1305/2013(EU, 2013c), which defines agroforestry systems as a land use systems and practices where perennial woody plants are deliberately integrated with crops and/or animals on the same plot of land management units.

5 Methodological considerations

As this PhD is done by "publications compendium" we present the concrete methodology followed up in each paper that can be found in each of the four chapters of section 3 (Results) where the current publication is presented. For that reason, we do not include a specific section dedicated to methodology, but we describe here a general overview about what has been done.

This PhD is structured in four big sections, dealing with the main results found when (i) global policies are described, (ii) current extent of agroforestry and (iii) linear agroforestry practices and finally the analysis of the promotion of AF in the previous (2007-2013) and current CAP (2014-2020)

Chapter 1 of the result section of the PhD is a study of the different strategies that international organizations such as the UN, Pan-European institutions as well as the Council of Europe and also the

European Union affecting the development of agroforestry practices and systems in Europe with the specific aim of analysing the definitions of AF, the policy promotion through strategies in order to identify the main reasons behind for AF promotion and provide insights for the future development of European regulations.

In addition, chapters 2 and 3 will be discussing the extent of agroforestry by using data from LUCAS (Eurostat, 2012), together with QGIS and LibreOffice Calc. LUCAS stands for Land Use and Occupancy Survey is carried out in several steps every three years on the territory of the EU (with the exception of the overseas regions and the Macaronesian archipelagos). In a first step, more than one million points are selected throughout Europe, with a regular grid of 2 km on each side. Each point is classified attending to one out of the seven defined LUCAS covers. In a second step, several points are selected, which were 330,000 in 2018 but only 270,000 in the 2012, being the main difference among the two surveys the incorporation of Croatia into the EU. In a third and final step, a team of surveyors go to these last points to take data on uses and coverage, among others, and also to take five photographs of the point (point itself and pictures following the four cardinal points).

The result is a database based on covers (LC1 and LC2) and uses (LU1 and LU2) but also on land management (LAND_MNGT). As it turns out that LC1 refers to the highest cover, we have verified that woody vegetation, whether permanent crops, forest trees or shrubs, in LC1 combined with annual crops or with vineyards in LC2 indicates that a silvoarable practice is carried out. Combined with grasses in LC2 or with evidence of grazing in the field of land management indicates that silvopasture agroforestry practice is taking place. This is also indicated by the coverage in LC1 or LC2 with the code for grasses with trees or shrubs scattered (E10) regardless of the combination they may have.

With regard to “use” database columns, they indicate the presence of homegardens (U113) in both LU1 and LU2.

In addition to the observations made at each point visited, in order to be able to map linear elements associated to linear AF practices, the interviewers carry out a 250 m transect from the point in the east, in

which changes in coverage are noted. To the alphanumeric codes of LC1 and LC2 they add others, exclusively numerical, to refer to linear elements such as herbaceous bands, roads, electrical lines, channels and of course those referring to isolated trees and rows of trees, which are the ones used in the third chapter of the results section of this PhD.

These observations are recorded in a set of 80 columns. At each point we have counted the repetitions of the elements object of our study, which are 10 isolated trees, 11 rows of trees, 12 coniferous hedges, 13 hedges with some evidence of management such as pruning and 14 hedges without evidence of management. In addition to listing the covers, few points throughout Europe (1283 out of 270,000) where analysed by measuring their length linked to the before mentioned transect, which allows us to estimate an average dimension for each of the elements and from this give it a dimension in each NUT linked to each RDP and throughout the EU.

To analyse the riparian strips linked to AF practices, we established them automatically by developing a set of algorithms created to locate the lines of trees that were in contact with the bodies and watercourses, to later count and dimension them in the same way as we mentioned before for the linear AF practices.

On the other hand, we have to note that there are no data available to identify or map the amount of land dedicated to cultivated forests, this fact makes it difficult to assess the impact of policies on these practices.

In summary, the global structure of this PhD is primarily focused on the evaluation of the main global policies that indicate that AF should be promoted (Santiago-Freijanes et al. 2018), secondly on the characterization of different agroforestry practices at European level both in general (Mosquera-Losada et al. 2018) and in the characterization of the use of linear woody structures (Santiago-Freijanes, et al. 2018) as part of AF practices. Finally, the PhD focuses on the study through the mapping of how the main Rural Development Programmes promote AF in Europe (Santiago-Freijanes et al. 2018).

OBJECTIVES

The main objective of this PhD is to provide a categorization and extension of agroforestry practices linked to agricultural and forest land, at regional level, which is the territorial basis used by the RDP in Europe, and to assess how these practices are promoted by the previous (2007-2013) and current (2014-2020) CAP, with a special focus on their potential for mitigation and adaptation to climate change. This general objective focuses on the following specific objectives:

1.- Evaluating the historical framework of global policies affecting agroforestry to better understand the current agroforestry policies.

2.- Assessing the current extent of agroforestry practices in Europe by using GIS, as a base indicator of their importance as, for example, climate change mitigation techniques.

3.- Characterizing the current extent of linear AF practices associated landscape features, including riparian strips across Europe and analyse the RDP measures promoting them in the European territory, within the 2007-2013 and 2014-2020 CAPs.

4.- Evaluating the previous and current degree of implementation of policies related to the introduction of woody vegetation in the European rural areas as a first step to establish agroforestry practices, following the review of policies related to the promotion of woody vegetation in different areas of Europe during the 20th century.

RESULTS: PUBLICATIONS ASSEMBLED IN THIS PHD

This PhD, which has been structured in publication compendium format, includes the following articles already published in journals included in the Journal Citation Report (JCR):

1.- Santiago-Freijanes JJ, Mosquera-Losada MR, Rois-Díaz M, Ferreiro-Domínguez N, Pantera A, Aldrey JA, Rigueiro-Rodríguez A 2018. Global and European policies to foster agricultural sustainability: agroforestry Agroforestry systems. https://link.springer.com/article/10.1007/s10457-018-0215-9

2.- Mosquera-Losada MR, **Santiago-Freijanes JJ**, Rois-Díaz M, Moreno G, den Herder M, Aldrey JA, Ferreiro-Domínguez N, Pantera A, Pisanelli A, Rigueiro-Rodríguez A 2018. Agroforestry in Europe: A land management policy tool to combat climate change. Land use policy 78:603-613.https://www.sciencedirect.com/science/article/abs/pii/S0264837718303752

3.- Santiago-Freijanes JJ, Rigueiro-Rodríguez A, Aldrey JA, Moreno G, den Herder M, Burgess P, Mosquera-Losada MR 2018. Understanding agroforestry practices in Europe through landscape features policy promotion. Agroforestry systems: 92:1105-1115. https://link.springer.com/article/10.1007%2Fs10457-018-0212-z

4.- Santiago-Freijanes JJ, Pisanelli A, Rois-Díaz M, Aldrey-Vázquez JA, Rigueiro-Rodríguez A, Pantera A, Vityi A, Lojka B, Ferreiro-Domínguez N, Mosquera-Losada MR 2018. Agroforestry development in Europe: Policy issues. Land use policy 76, 144- 156. https://www.sciencedirect.com/science/article/abs/pii/S0264837717310670

GENERAL DISCUSSION

The analysis of the main community, pan-European and global regulations reveals a promotion of AF associated with the technical, economic, environmental, social, and political principles set by FAO (2015b):

From a **technical** perspective, agroforestry practices are attributed the capacity to ecologically intensify or Eco-inten agricultural systems through the optimization of the use of resources per unit of land and therefore increase productivity with less inputs (Principle 1) by improving the use of light and nutrients (Mosquera-Losada *et al*. 2009) but also by the conservation and improvement of existing resources per unit of land (Principle 2).

From an **economic** perspective, policies that promote agroforestry practices are also based on the improvement of rural livelihoods (Principle 3), taking into account aspects linked to food security, but also to the marketing channels of the products generated, increasing the resilience of farms to market variations, by promoting the multiple use of the territory and therefore the multiple production of products from the same area, which are currently linked to the current strategies of bioeconomy.

From an **environmental** perspective, agroforestry practices are encouraged by international policies because of their ability to enhance community resilience through improved capacity to respond and adapt agricultural systems to climate change and to promote its mitigation (Principle 4). FAO (2013) points out that agroforestry practices are one of the best tools to combat climate change by included them as a Climate Smart Agriculture Practice.

Among the **social** principles linked to the promotion of agroforestry practices is the promotion of rural equity and welfare (Principle 3) and therefore of individuals, but also of communities, as promoted by AF in the context of rural development improving. Finally, agroforestry practices must be linked to better governance principles, which must be responsible and effective.

The promotion of these principles using agroforestry practices in Europe must consider the historical frame of reference, which in many

cases differentiates Eastern and Western Europe. It is worth commenting on these differences between Western and Eastern European countries, since, on the one hand, their history is differentiated with a strong influence of collective work in agriculture in Eastern countries that did not affect most of Western European countries, and, on the other hand, the late entry of Eastern countries as members of the European Union means that they do not base CAP payments on historical payments and are therefore currently more equitable. In Europe, there has been a clear historical differentiation in the evolution of policies associated with agroforestry practices between the countries of the East and the West, although in both areas there has been a deterioration and reduction in the presence of agroforestry systems. However, the great environmental and productive problems in the countries of the East have led to their reestablishment in the last century (the wooded belts of Hungary are an example) through policies that facilitate their implementation.

Western and Eastern European policies related to the introduction of trees were very different until they were integrated into the common European space and this affects the impact of current and future policies related to land use in different countries. For example, more than 50% of the forests in the Eastern European Union countries are publicly owned, except for Slovenia (29.8%) (European Commission, 2003). In contrast, in Western countries, forest land is mostly privately owned, apart from Germany (53.6 per cent public ownership) and Greece (81.9 per cent). These realities affect the impact of the implementation of the CAP in Western and Eastern European countries since the maintenance of the implementation of forestry or agroforestry measures is not applied on public lands.

Agricultural land in Eastern countries was traditionally managed through silvopastoralism in areas of fruit trees and forests. But collective farming and social reform after 1945 destroyed most of the agroforestry systems. However, agriculture in some areas of the Eastern countries was less resistant to the negative impacts of modernization on land management and faced the problems caused by the strong winds that often hit these regions. This justifies that the emergence of national programs of agroforestry practices such as live hedges to ensure better

productivity of their land was earlier in Eastern Europe than in its western part, as was the case in Hungary, Bulgaria, Slovakia and the Czech Republic (Georgiev G, 1960; Takáczs *et al*. 2009; Krčmářová *et al*. 2017; Kachova *et al*. 2018).

In the western part of Europe, CAP (1962) aimed at food self-sufficiency for the European Union, so most payments were focused on increasing production and not linked to land use, which clearly favoured intensified land use in this part of Europe. As important environmental problems related to biodiversity losses were observed at the level of the plots (losses of woody vegetation and its associated habitats and ecosystem services such as pollination) and the landscape (loss of woody vegetation such as hedges, woodlands or forests), some policy solutions to preserve the environment were provided, such as the establishment of payments linked to Less Favoured Areas (in 1975) and to fallow areas (in 1988), which favoured to some extent the preservation of woody vegetation. Finally, the European Commission especially recognized the lack of long-term sustainability of intensive agricultural practices, often based on monocultures, following international (FAO, UN, Millennium Development Goals, Global Research Alliance, Global Alliance for Climate-Smart Agriculture) and Pan-European policies.

Set-aside was a pioneering scheme introduced by the European Economic Community (EEC) in 1988 (EEC, 1988) with the aim of (i) reducing the surpluses produced in Europe due to the implementation of the CAP and (ii) achieving environmental benefits through the promotion of measures such as the basic payment, in particular landscape features such as live hedges which can be linked to agroforestry practices. These measures allowed the growth of woody vegetation within these fallow plots and were seen as an effective way of improving the soil and increasing biodiversity, especially if set-aside on the land was allowed for a period longer than 5 years, promoting AF on a temporary scale.

Subsequently, Regulation 2078/1992 (EEC, 1992a) sought to promote ecologically beneficial agricultural activities such as the conservation of isolated trees, the establishment of live hedges and the conservation of wild forest areas, which can be linked to agroforestry.

However, the establishment of agroforestry schemes was not specifically encouraged. The lack of an adequate inventory of these elements linked to the political promotion of the woody component led to little real recognition at farm and landscape scale, which is necessary for the promotion of agroforestry systems. Furthermore, the objective of a maximum density of 50 trees per hectare on arable land to be eligible for the direct payment associated with Pillar I of the CAP led to the destruction of many of these important landscape features.

EEC Regulation 2080/92 (EEC, 1992b) provided support to partially finance the costs of afforestation of agricultural land, to maintain such areas, to improve existing forests and to compensate for income losses resulting from the change of use from agricultural to forest land use. The objectives of this Regulation were as follows:

(i) accompany changes in the new rules of market organization, including the diversification of the agricultural activity and the promotion of afforestation as an alternative source of income.

(ii) implement forms of rural management more compatible with environmental balance at the landscape level.

(iii) promote afforestation as an alternative use of agricultural land.

(iv) combat the "greenhouse effect" by the absorption of carbon dioxide by woody vegetation.

(v) promote soil and water conservation.

1)

The measure of afforestation of agricultural land, which can be considered as a first step for the implementation of agroforestry systems on arable land, made a significant contribution to rural development and was claimed to have a beneficial effect on the environment, controlling soil erosion, preventing desertification, conserving biodiversity, regulating the water regime and sequestering carbon. This conservation program was carried out mainly in agricultural areas associated with permanent pasture, and the species planted were mainly hardwoods to achieve quality wood growth and long-term yield.

Measures on Axis 2 of 36 (b) article of the Council Regulation (European Commission) 1698/2005 (EU, 2005) were 221, 222 and 223 which promoted tree planting and sustainable use of forest land, its expansion into agricultural and non-agricultural areas and the combination of extensive systems (agricultural and forestry). These three measures had different rules and the expected impact on biodiversity, climate change, soil preservation, water protection and landscape were also different.

Measures 221 and 223 were differentiated by the type of land on which afforestation or reforestation of agriculture or forestry would take place, and also by the commitment of payments made by administrations under previous CAPs to compensate for the loss of income resulting from the cessation of agricultural activity. However, the maintenance of the activity after planting was not promoted, which meant that improvements such as thinning or pruning were not generally practiced. In the CAP 2014-2020 these two measures are combined under sub-measure 8.1 "Support for afforestation/forest creation".

Measure 222 combined arable land with trees in Western countries, which was considered a way to promote agroforestry practices on agricultural lands, due to the high ecological and social value they have in these already intensified areas and with the aim of producing high quality wood and agricultural products. Agroforestry practices were also improved with measure 8.3 by considering forest grazing as a preventive tool against forest fires. Most beneficiaries established agroforestry practices in pastures and the most used tree species were the broadleaves. In the CAP 2014-2020, agroforestry is promoted with the sub-measure 8.2 (establishment and maintenance of agroforestry systems). If measure 222 (CAP 2007-2013) considered agroforestry as the combination of trees and crops on the same land, now measure 8.2 considers that it is the deliberate integration of woody plants with crops and/or animals on the same plot of land in the management unit, an important change to integrate those agroforestry systems associated to shrublands.

The comparison between the RDPs of the two periods is difficult because the increase in the number of regions in which they apply from

the period 2007-2013 up to 2014-2020. Even though Hamburg is now considered to be fully urban, the incorporation of Croatia and the regionalization of France have resulted in an increase from 88 to 118 RDPs between 2007-2013 and 2014-2020 periods. This change in the number of RDPs is not new; the EU went from 15 states in the CAP in 1995 to 25 in 2004 and 27 in 2007.

With regard to the implementation of agroforestry as part of forestry measures in the period 2007-2020, we noticed that while measures 221 and 223 were widely adopted, measure 222 had a rather limited application throughout the EU. Measure 221 was budgeted in 63 RDPs (out of a total of 88) and measure 223 in 33 RDPs, while measure 222 was only programmed in 11 RDPs (which would be 20 if France would have been already regionalized in the period 2007-2013). However, not all the administrations that programmed the measures implemented them: the 63 regions that programmed measure 221 implemented it, but measure 223 was implemented in only 30 regions instead in the budgeted 33, and measure 222 was implemented in only 5 regions out of the 11 RDP, which budgeted it. The comparison between the two periods depends on whether France is considered as one (RDP 2007-2013) or 30 (RDP 2014-2020) different RDP. Thus measure 8.1 is scheduled in 50 regions, which would be 46 if we considered France as one, while measure 8.2 appears in 33 RDPs, which would be 12 if there were only one French RDP. This means that measures related to afforestation and reforestation decreased (from 63 to 50), while those related to agroforestry increased (from 10 to 12, in the case of a single French region and from 11 to 33 with the regionalization of France), highlighting the importance of agroforestry for France.

However, in the current RDP 2014-2020 a high number of regions have been found to implement sub-measure 8.2, mainly due to the administrative reasons mentioned above, but also due to the inclusion of woody species in general, not only trees, and the maintenance, which probably increased the adoption of agroforestry measure 8.2 in southern Europe, where the existence of agroforestry is really important (den Herder *et al*. 2015).

Politically defined agroforestry practices in Europe include silvopasture, silvoarable, hedgerows and riparian buffer strips, forest farming and homegardens (Mosquera-Losada, *et al*. 2016). Silvopasture practice can be also associated with forest grazing and permanent grasslands, while isolated trees can be linked to silvoarable AF practice. Hedges, including riparian protection strips, can be associated with silvopasture or silvoarable, as was the case with isolated trees and small stands. Most of the agroforestry practices of cultivated forests, riparian strips and small stands and hedges were also promoted by measures 221 and 222, while only Toscana promoted them with measure 223. Forest grazing was not promoted by any of the measures 221, 222 and 223 within the RDP 2007-2013. Sicilia and Marche used measures 221 and 222 to promote forest strips, hedges and isolated trees, the regions that used these measures to promote agroforestry. Finally, mainland France activated measures 221, 222 and 223, but the activities linked to them were not readily available during the period 2007-2013.

The evaluation of the first year of CAP 2014-2020 shows that, out of the 16 administrations that have decided to activate sub-measure 8.2, only five have implemented it in the first year of RDP development (2016). It seems that there will be a clear increase to 33 in 2017.

Silvopasture combined with fruit trees (so-called permanent crops), as well as mountain grazing, were mainly linked to activities 214 and 10.1 in the Rural Development Programmes for the period 2007-2013 and the first year 2014-2020, indicating that the ecosystem services they provide are more relevant for policy makers than the agroforestry activity itself.

Half of the Rural Development programmes that applied the agroforestry measure 8.2 did so on agricultural land, which gives us an idea of the intention to link woody vegetation with agricultural lands, although agroforestry is a land use practice that can be implemented on agricultural or forest land. All the programs are directed to private owners, but they can also be directed to public organizations and municipalities. All rural development programmes provide funds to carry out activities, with the exception of the Valencia region, which allocated the budget to fulfil previous commitments. All programmes

support tree planting, while 75% support tree protection, and very few supported tasks of improvement and maintenance of the forestry component (pruning, clearing, mycorrhization, creation/maintenance of infrastructure, regeneration and diversification or densification). Sixty percent of the Rural Development Programmes declared five years as the period for maintenance payments (the maximum allowed by the European Commission). Seventy percent of the Programmes require a minimum tree density (around 50 trees per hectare), while 75% indicate the maximum tree density allowed (just over 450 trees per hectare).

The range of the minimum tree density is between 30 and 200 trees per hectare, with the minimum values of the range being applied in all the French RDPs, which are more related to silvicultural practices, and the highest in Hungary, Scotland, Wales and Portugal, countries where silvicultural grazing is confirmed as the most important agroforestry practice. Arable crops are generally associated with higher radiation input requirements than grasslands (Pardini *et al*. 2010).

Regarding the maximum allowed tree density, only two regions declare the maximum tree density allowed by the European Commission of 450 trees per hectare (Scotland and Asturias), while only seven Rural Development Programmes (all from France) ensure Pillar I payments (100 trees per hectare) with the tree planting density (90-100 trees per hectare). This means that in France they have to use highly productive species and genetically selected trees to guarantee the final production by cutting high quality trees (Dawson *et al*. 2014), since the low initial density decreases the selection capacity at the time of felling (Mosquera-Losada *et al*. 2006), but the rest of the countries have more trees to select those that will be cut at the end.

With respect to the selected woody species, 11 (34%) RDPs propose combinations of trees and shrubs, creating a multi-species system, since it improves the delivery of ecosystem services, such as pollination, necessary for the successful production of arable and fruit crops (Potts *et al*. 2015). The three types of woody components (forest trees, fruit trees and shrubs) are mainly promoted in France. All of them allow conifers and hardwoods to be planted. Most conifers should be associated with marginal lands, due to their pioneering nature and the lower potential they have to improve soil fertility, so on arable land

indigenous hardwoods should be promoted if more ecosystem services are to be achieved (Howlett *et al*. 2011).

Finally, 53% of the RDP that implement agroforestry link it to Natura 2000 sites, valuing the provision of ecosystem services that AF practices have. Finally, most of the RDP finance 80% of the activities of the agroforestry practices, which is sufficiently attractive to guarantee the participation of the farmer, who in some cases can even justify the co-financing with the payment of the time they spend in carrying out the activities.

At the European level, the importance given to the ecosystem services that can be provided by agroforestry practices is now considerably highlighted. This is indicated by the prominence of woody vegetation in the Strategic Plan for Biodiversity, the European Climate Change Programme, the Bioeconomy Strategy, the European Forestry Strategy, and the Cork 2.0 declaration. However, and despite the recognition of agroforestry practices as forms of sustainable land management in the different policies and strategies, these are not implemented by farmers on a massive scale. This can be explained by the lack of knowledge of the systems and the current degree of implementation of the different forms of agroforestry in Europe. The promotion of agroforestry systems with adequate policies must be based on the knowledge of the existing surface of these practices in order to be able to develop governance mechanisms associated with CAP measures adapted to the different regions and also to be able to evaluate the impact of these mechanisms.

Direct payments to farmers promoted by Pillar I of the CAP consist of a fixed amount for each unit of land that meets certain conditions (Mosquera-Losada, Santiago-Freijanes, Pisanelli, Rois-Díaz, *et al*. 2016), one of which establishes a limit of non-fruit trees, which went from 50 feet per hectare in the previous CAP (2007-2013) to 100 in 2014-2020.

The definition of a forest tree only considers those with a crown diameter of more than four metres, i.e. adults, so it could be interpreted that the plantation may have a higher density than that admitted by Member states, with a view to making a selection of trees before they reach that size. However, the most common practice among the

Member States is not to make direct payments on agroforestry land with densities of more than 100 trees per hectare, regardless of their age, and therefore regardless of whether or not the tree exceeds that 4-metre crown diameter. This, in practice, is a brake on measures 222 and 8.2 where up to 400 trees per hectare are allowed.

Based on the data from the Eurostat land use and coverage survey (LUCAS) we have designed a methodology that allows us to develp the inventory the different types of agroforestry practices, consisting of the combination of the two fields of coverage of these practices, identifying the agroforestry plots with a first layer of woody cover (trees or bushes) and a second layer associated with crops (silvoarable AF practice) or pastures (silvopasture AF practice), which is complemented by the use of the specific field of LUCAS that allows to verify evidence of grazing (den Herder *et al*. 2017). From the methodology used we have been able to verify that in Europe the total area occupied by agroforestry practices is around 19.77 million hectares, including some 2.66 million hectares of grazing associated to woody perennials and 1.8 million hectares of agroforestry homegardens (den Herder *et al*. 2017 and Mosquera-Losada *et al*. 2018). Researchers from Herder *et al*. (2017) reviewed estimates of the extent of agroforestry practices in Europe which indicated the existence of 10.6 million hectares, while our estimate using LUCAS and following the definition of agroforestry from Herder *et al*. (2017) and ours is 15.4 million hectares, not including shrub grazing and homegardens, and 19.77 million hectares. The difference in these figures is partly due to the inclusion of new countries, such as Bulgaria (which contributes 0.9 million hectares) and others much smaller in the case of the use of LUCAS. But these inclusions only explain a small part of the difference. Thus in Spain the estimates using LUCAS account for a difference of 1.7 million hectares, while in France the difference is 1 million, in Romania 0.7 million and in Italy 0.4 million hectares, compared to the literature review (den Herder *et al*. 2017). One reason to explain these differences is the existence in these countries of a large amount of published information of an agroforestry nature focused on widespread traditional practices, such as the dehesas in Spain and the montados in Portugal, while other practices are included in the estimates from the LUCAS. In other cases, the limited

extension of traditional agroforestry practices means that few studies have been carried out and, consequently, the extension has been underestimated. It should be borne in mind that it was not possible to make a uniform calculation based on a single definition for the whole of the EU before the LUCAS database was compiled. All these aspects may justify the differences between the results found in the publications of this PhD and the bibliographic estimates (den Herder *et al*. 2017).

The different definition of agroforestry practices has also contributed to these differences in the estimates of the quantitative data of the area dedicated to agroforestry practices in Europe between the data provided by den Herder *et al*. (2017) and those of this thesis, since den Herder *et al*. (2017) only took into account the integration of trees with crops and/or animals, while we started from the FAO definition, which includes all woody vegetation (i.e. trees and shrubs). We consider that the methodology used in this thesis, which allows determining the coverage of agroforestry practices in Europe, is of great relevance, since the database used has been updated frequently every three years, thus providing a very useful tool for monitoring and evaluating, on the one hand, the impact of the CAP, and on the other hand, for mapping the provision of ecosystem services and detecting vulnerable areas on which to act as a priority.

About 90% of the 19.77 million hectares are linked to the silvopasture practice, traditional in Southern Europe, where livestock (goats, sheep, cows, pigs, in many cases of native species that can be raised in environments with summer drought and that constitute a genetic heritage that must be conserved) is able to feed itself based on the woody vegetation that provides these animals with food during the summer drought period (also reducing the danger of fire and the use of concentrates and associated costs) and also on fruits and herbaceous vegetation associated with the temporary extension of the grazing season thanks to the shade with which the trees reduce the negative effect of the drought during the periods of extreme heat under their canopy (Étienne, 1996; Papanastasis *et al*. 1999; Castro, 2009). Silvopasture associated to permanent crops (mainly fruit trees) has a huge potential, since it only accounts for about 10% of European permanent grasslands, ten times more than what is declared as

silvopasture practice in the USA. However, and despite the absence of limitations for its implementation, agroforestry practices are not widely used in permanent crop areas.

Silvoarable practices (the combination of arable crops with woody species) occupy only 360,000 hectares, representing less than 1% of the EU's arable crop area, more than half of which is under permanent crops (mainly fruit trees). They are more widely distributed in southern European countries, although they have a huge potential in the north as a solution to major problems associated with water quality, biodiversity, and reduced production of ecosystem services. Silvoarable practices associated with permanent crops are only present in 0.1% of their potential area, similar to what occurs in other countries in the temperate environment, such as the United States with less than 1% (USDA, 2013).

These figures indicate a great potential for expansion of agroforestry practices in the EU and other temperate zone countries, which would increase the provision of ecosystem services in vulnerable areas with major environmental challenges, while at the same time contributing to the adaptation of agricultural systems to and mitigation of climate change (Plieninger, 2011). The very low presence of silvoarable practices is probably the result of increased intensification of arable land, land consolidation schemes that increased the size of plots and the use of crop-related machinery. In addition, arable-agricultural crops (e.g. cereals) tend to be more affected by shade than grasslands (Pardini *et al*. 2010), as the latter, generally with more biodiversity, have a greater capacity to adapt to different shade conditions, not to mention that intensification practices related to sowing often select seeds adapted to open spaces, but not to areas with tree-growing shade. Recent studies have revealed that the negative effects, including total loss of grain harvest, associated with increasingly frequent heat stress in areas with cereal crops can be reduced by using agroforestry practices, which is already being promoted in the French agroforestry strategy (Ministère de l'Agriculture, 2015). These practices can also be implemented with the distribution of woody vegetation around the arable land and is less

applied with isolated trees and strips of forest or small stands to avoid the effect of trees on the production of the agricultural crop.

Non-wood forest production (NWFP) or cultivated forests (AGFE, 2018) refers mainly to the production of non-wood products on forest land (mushrooms, small fruits, tree fruits and seeds, medicinal plants, honey, hunting, fishing, social use, quarries). There are no data available to identify or map the area where these products are obtained, although we do have data linked to the economic return that this agroforestry practice implies. Thus, during the Ministerial Conference on the Protection of Forests in Europe, it was concluded that the total value of market services of the NWFP is 723 million euros with 49.8% coming from social services (hunting and fishing licenses, cabin rental, sports), 25.0% from other services (for example, licenses for farms and gravel extraction), 21.2% from biosphere services (i.e. carbon capture), 4.9% allocated to social services and 0.03% from other services (those related to spiritual, cultural and historical functions). The lack of knowledge about the area that uses agroforestry practices in Europe is an obstacle to assess the impact of the different policies that promote them, mainly based on the income that forest lands produce in relation to non-wood products without including the economic, social and cultural dimensions of non-wood forest production or cultivated forests. In fact, the characterization of forest cultivation linked to forest land is essential to adopt the best policies promoting this activity, which would contribute in a relevant way to solve current social problems such as stabilizing the rural population, reducing the risk of fires, increasing the profitability of wood products, etc.

Homegardens located in urban and peri-urban gardens are especially related to self-supply agriculture and local commerce, especially horticultural and fruit activities. LUCAS identifies them as a land use, but their recognition seems to be underestimated because many of these gardens are homegardens and are therefore often associated with residential areas. In Europe, their presence in some Eastern countries is noteworthy, especially the Czech Republic and Slovakia, where this use was favoured by the policies of the second half of the last century. In any case, it does not reach 2% of the territory in any country. They are expected to take on a greater role in initiatives

such as Slow Food KM0 (https://www.km0slowfood.com/?lang=es), climate-smart cities (https://www.climatelinks.org/content/climate-smart-cities) and the Mayors' Global Compact for Climate and Energy.

As shown in the articles published in the framework of this PhD, agroforestry practices in arable zones, permanent pastures and permanent crops represent less than 0.1%, 10% and 0.1% of the potential areas assigned to them, respectively (Santiago-Freijanes, Pisanelli, *et al*, 2018; Santiago-Freijanes, Rigueiro-Rodríguez, *et al*. 2018; Santiago-Freijanes, Mosquera-Losada, *et al*. 2018), which allows us to conclude that the promotion of agroforestry systems in these lands will bring many ecosystem benefits to the current uses of the territory linked to intensive agricultural systems, therefore, increasing the agricultural sustainability in Europe.

Moreover, there are other practices of great relevance in the countries of central and northern Europe that are linked to landscape features, which are much more difficult to inventory due to their punctual (trees) or linear (hedges) nature. Fortunately, LUCAS offers a 250 m transect eastwards from each sampling point in order to locate linear elements, although the number of records is much lower than those of a punctual nature. Landscape features that include live hedges made up of shrubs and trees with different spatial structure have been key in the framework of the Common Agricultural Policy, as they are part of conditionality and greening under Pillar I and are in turn promoted by different measures under Pillar II.

Landscape features, including isolated trees and hedges, are not uniformly defined across Europe in the CAP (Pillar I and RDP), with obvious differences in terms of the length and width of these landscape features and the species composition they display in the different countries implementing the CAP. The lack of an overall definition and the different specific characteristics finally approved in the different countries of the European Union hinder the creation of a register of the different types of landscape features promoted by the CAP, but also, the assessment of the impact of policies promoting landscape features at European level, as well as the development of better policies to extend the use of these landscape features mainly focused on a specific type of isolated trees or hedges. Isolated trees are widely distributed in Europe,

particularly in southern countries, while hedgerows are more associated with northern and north-western Europe. The increased presence of isolated trees in the south of Europe may be linked to the benefits they provide for the adaptation of crops and pastures to climate change, but it may also be due to their fodder contribution to animal feed during summer, autumn and winter. On the other hand, hedgerows are more present in areas where strong winds reduce crop production (Krčmářová *et al*. 2017; Kachova *et al*. 2018) and in those associated with karst areas, such as Eastern Europe. In particular, the United Kingdom already has an important system of policies to protect these living hedges since the end of the last century (DEFRA, 1997), which is reflected in their major contribution to the British landscape. Some RDPs promote hedgerows as riparian protection strips by linking them to watercourses.

Most of the isolated trees are old trees and, like the living hedges, are protected by national and regional rules and regulations. A specific regulation was created by United Kingdom and Ireland in 1997 to promote hedges in order to maintain biodiversity and reduce the negative effects of the strong winds on crop production (DEFRA, 1997). In these countries, live hedges are fully eligible under the CAP direct payments and can be used for green payments. These landscape features are particularly important in countries such as Ireland, where climate variability makes it difficult to meet Pillar I diversification requirements, due to its short growing season. Other countries such as France, the Netherlands or Belgium have been using the agri-environmental measures under Pillar II of the previous (2007-2013) and current (2014-2020) CAP to introduce live hedges in their territory. Activities related to the promotion of landscape features are linked to Cross Compliance, Greening in Pillar I and mainly to agri-environmental measures in Pillar II, which complicate the assessment of the promotion of landscape features through the CAP in a systematic way. The condition for receiving payments in any of the different sections of the CAP is that the same activity cannot be paid twice within the same landscape function. However, all payments from different CAP sections can be complementary. Surveys of CAP administrative authorities state that the creation of an inventory of these landscape

features (i.e. isolated trees meaning tree canopies over 4 m) is too complicated, because that would mean committing to intense control over their maintenance and conservation in the future. Therefore, they prefer to choose other landscape features that are easier to audit.

The impact of the CAP with regard to hedges and isolated trees, as part of cross compliance, greening and agri-environmental measures, is complex, because Community regulations may promote CAP payments under three different headings, making difficult to assess the current impact of the CAP on landscape features of hedges and isolated trees. In addition, some Member States make a poor selection of hedges and isolated trees, due to the difficulties in auditing them. Simpler approaches to monitor these landscape feature should therefore be developed to really improve their protection at field level, to which geography can contribute greatly.

Measure 214 of the 2007-2013 CAP period (currently mainly associated with Sub-measure 10.1 (CAP 2014-2020)) has been the most popular measure for preserving landscape features within the Rural Development Plans (RDPs) of the previous and current CAPs, while Measure 216 (currently linked to Sub-measure 4.4) is generally related to the introduction of landscape features. However, there are other measures used in different regions (and for different reasons) which promote these landscape features in Europe. The promotion of forest belts and small stands, hedges and isolated trees mainly linked to agroforestry practices considers the ecosystem services (water protection, biodiversity) and resilience (adaptation to climate change) they provide, and therefore the benefits of the agroforestry ecosystem are truly recognised. Landscape features that include woody perennials should be associated with agroforestry when they are present in arable and permanent grasslands.

CONCLUSIONS

There is a recognition, both globally and at European scale of the role of agroforestry in producing tangible goods while providing environmental services. However, its promotion is not yet well-targeted in the CAP. A clear identification of those practices is needed to connect with agroforestry development plans and establish a final tree density eligible for Pillar I payments adapted to each region.

Agroforestry systems are a type of sustainable management tool of the territory able to improve productivity per unit of surface thanks to eco-intensification, understood as the improvement or optimization in the use of both air (e.g. light) and soil resources (such as nutrients). This means that, in a world increasingly in need of primary sector products, agroforestry systems are being valued and considered practical to promote to produce more per surface unit and improve biodiversity and water quality, as well as to combat climate change through their ability to mitigate and adapt agricultural systems to it.

About current policies that encourage the use of agroforestry practices we consider that they are not well designed. Firstly, because the farmer needs direct payments in order to sustain their farm at the current standard of living, so if the current policy reduces the possibility of direct payments as is the case today, then AF practices will not be uptaken by the farmers and therefore AF practices are not being adequately encouraged by the CAP. Moreover, agroforestry measure (222) was not correctly designed, since it did not provide payments linked to maintenance or to loss of profit, which are indeed considered by other forestry measures, which were the ones adopted by the farmers.

Agroforestry development should be carried out through the establishment of a single measure that recognizes a use of the territory in various coverages, ensuring direct grants payment contemplating maintenance and loss of profit, such as afforestation measures.

The methodology based on the LUCAS survey is very suitable for estimating the evolution of agroforestry practices at European level, but insufficient to place "forest farming" AF practices.

Agroforestry practices and systems presents a huge potential for implementation in Europe since our studies indicate that on 96.4% of arable land and on 90% of grassland AF practices in Europe are not

currently used and would be perfectly implemented favouring the transition towards more sustainable agricultural systems in Europe.

Although they are found throughout Europe, agroforestry systems are mainly associated with Southern countries. Therefore, efforts should be made to promote the establishment of agroforestry practices in Northern countries and to promote their conservation and maintenance in the South.

Landscape features are widely promoted by different measures in the RDP by the regional and state administrations of Europe. However, the lack of a clear categorization of these elements and their promotion in different parts of the CAP (Pillar I and Pillar II), as well as the lack of data on the expenditure of the different policy actions and promoting measures in these elements make difficult to assess the impact of them in the rural areas. This suggests the need for a European-wide standardized register of member states expenditure on each type of landscape, probably associated with the LPIS.

Agroforestry promotion in the CAP is complex, as it is fostered in 25 different measures designed to promote five agroforestry practices. A simplification of the measures would facilitate the payment-related bureaucracy and its follow-up by the European Commission.

BIBLIOGRAPHY

Acácio, Vanda, Holmgren, Milena, Rego, Francisco, Moreira, Francisco y Mohren, Godefridus M. J. (2009), Are drought and wildfires turning Mediterranean cork oak forests into persistent shrublands? *Agroforestry Systems*, 76(2): 389-400. available at http://link.springer.com/10.1007/s10457-008-9165-y [16 diciembre 2017].

AFTA (1997), *The Status, Opportunities and Needs for Agroforestry in the United States - Google Books* (M. L. Merwin, Ed.).

AGFE (2018), Zonas con productos forestales no madereros | Agfe Agroforestry. available at http://agfeagroforestry.eu/que-es-un-sistema-agroforestal/zonas-con-productos-forestales-no-madereros

Alavalapati, Janaki, Nair, P.K. Ramachandran y Barkin, David (2001), Socioeconomic and Institutional Perspectives of Agroforestry, 71-83, en: Springer, Dordrecht. available at http://link.springer.com/10.1007/978-94-010-0664-4_5 [13 junio 2018].

Alavalapati, Janaki R.R. y Mercer, Evan (Eds.) (2004), *Valuing Agroforestry Systems. Advances in Agroforestry, vol 2*. Dordrecht: Kluwer Academic Publishers. available at http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.464.9716&rep=rep1&type=pdf [13 junio 2018].

Andrianarisoa, Kasaina Sitraka, Dufour, Lydie, Bienaimé, Séverine, Zeller, Bernd y Dupraz, Christian (2016), The introduction of hybrid walnut trees (Juglans nigra × regia cv. NG23) into cropland reduces soil mineral N content in autumn in southern France. *Agroforestry Systems*, 90(2): 193-205. available at http://link.springer.com/10.1007/s10457-015-9845-3 [16 diciembre 2017].

Bergmeier, Erwin, Petermann, Jörg y Schröder, Eckhard (2010), Geobotanical survey of wood-pasture habitats in Europe: diversity, threats and conservation. *Biodiversity and Conservation*, 19(11): 2995-3014. available at http://link.springer.com/10.1007/s10531-010-9872-3 [16 diciembre 2017].

Brewbaker, James L. B (1987), Leucaena a multipurpose tree gunus for tropical agroforestry, 289-323, en: Steppler, H. A. y Nair, P.

K. R. (Eds.), *Agroforestry a decade of development*. Nairobi, Kenya: ICRAF. International Council for Research in Agroforestry. available at http://www.worldagroforestry.org/Units/Library/Books/Book 07/agroforestry a decade of development/html/5_leucaena.htm?n=27 [19 febrero 2019].

Bugalho, Miguel N., Caldeira, Maria C., Pereira, João S., Aronson, James y Pausas, Juli G. (2011), Mediterranean cork oak savannas require human use to sustain biodiversity and ecosystem services. *Frontiers in Ecology and the Environment*, 9(5): 278-286. available at http://doi.wiley.com/10.1890/100084 [16 diciembre 2017].

Burgess, Paul J., Crous-Durán, Josep, den Herder, Michael, Dupraz, Christian, Fagerholm, Nora, Freese, D., Garnett, K., Graves, Anil R., Hermansen, J.E., Liagre, Fabien, Mirck, J., Moreno-Marcos, Gerardo, Mosquera-Losada, María Rosa, Palma, João Henrique Nunes, Pantera, Anastasia, Plieninger, Tobias y Upson, M. (2015), *AGFORWARD Project Periodic Report: January to December 2014*. available at http://www.agforward.eu/index.php/en/news-reader/id-27-february-2015.html [16 diciembre 2017].

Cardinael, Rémi, Mao, Zhun, Prieto, Iván, Stokes, Alexia, Dupraz, Christian, Kim, John H. y Jourdan, Christophe (2015), Competition with winter crops induces deeper rooting of walnut trees in a Mediterranean alley cropping agroforestry system. *Plant and Soil*, 391(1-2): 219-235. available at http://link.springer.com/10.1007/s11104-015-2422-8 [16 diciembre 2017].

Castro, M. (2009), Silvopastoral Systems in Portugal: Current Status and Future Prospects, 111-126, en: *Agroforestry in Europe*. Dordrecht: Springer Netherlands. available at http://link.springer.com/10.1007/978-1-4020-8272-6_6 [14 junio 2019].

CEE (1988), *REGLAMENTO (CEE) N° 1272/88 DE LA COMISIÓN de 29 de abril de 1988 por el que se establecen las normas de aplicación del régimen de ayudas desti nado a fomentar el abandono de tierras arables*. COMISIÓN DE LAS COMUNIDADES EUROPEAS. available at https://eur-lex.europa.eu/legal-

content/ES/TXT/PDF/?uri=CELEX:31988R1272&from=EN [17 junio 2019].

CEE (1992a), *REGLAMENTO (CEE) N° 2078 / 92 DEL CONSEJO de 30 de junio de 1992 sobre métodos de producción agraria compatibles con las exigencias de la protección del medio ambiente y la conservación del espacio natural*. EL CONSEJO DE LAS COMUNIDADES EUROPEAS. available at https://eur-lex.europa.eu/legal-content/ES/TXT/PDF/?uri=CELEX:31992R2078&qid=1560842878865&from=PT [18 junio 2019].

CEE (1992b), *REGLAMENTO (CEE) N° 2080 / 92 DEL CONSEJO de 30 de junio de 1992 por el que se establece un régimen comunitario de ayudas a las medidas forestales en la agricultura*. EL CONSEJO DE LAS COMUNIDADES EUROPEAS. available at https://eur-lex.europa.eu/legal-content/ES/TXT/PDF/?uri=CELEX:31992R2080&qid=1560848204450&from=PT [18 junio 2019].

Comission european (2003), *Sustainable forestry and the European Union — Initiatives of the European Commission*. Luxembourg. available at http://europa.eu.int [14 junio 2019].

CONAFOR (2012), *Estrategia Nacional de Agrosilvicultura (Versión preliminar)*. Zapopan, Jalisco. available at http://www.conafor.gob.mx:8080/documentos/docs/5/4151Estrategia Nacional de Agrosilvicultura.pdf [18 junio 2018].

Dawson, Ian K., Leakey, Roger, Clement, Charles R., Weber, John C., Cornelius, Jonathan P., Roshetko, James M., Vinceti, Barbara, Kalinganire, Antoine, Tchoundjeu, Zac, Masters, Eliot y Jamnadass, Ramni (2014), The management of tree genetic resources and the livelihoods of rural communities in the tropics: Non-timber forest products, smallholder agroforestry practices and tree commodity crops. *Forest Ecology and Management*, 333: 9-21. available at https://www.sciencedirect.com/science/article/pii/S0378112714000231 [4 noviembre 2019].

Dawson, Ian K, Place, Frank, Torquebiau, Emmanuel, Malézieux, Eric, Iiyama, Miyuki, Sileshi, Gudeta W, Kehlenbeck, Katja, Masters, Eliot, Mcmullin, Stepha y Jamnadass, Ramni (2013), *Agroforestry*,

food and nutritional security. Background paper for the International Conference on Forests for Food Security and Nutrition. available at www.worldagroforestrycentre.org [19 febrero 2019].

DEFRA (1997), *Hedgerow Regulation*. available at http://www.legislation.gov.uk/uksi/1997/1160/made

Dupraz, Christian y Liagre, Fabien (2008), *Agroforesterie, des arbres et des cultures*. Editions France-Agricole. available at https://www.researchgate.net/publication/230675935_Agroforesterie_des_arbres_et_des_cultures

EEA (1985), *CORINE Land Cover*. available at https://www.eea.europa.eu/publications/COR0-landcover [17 diciembre 2017].

Eichhorn, M. P., Paris, P., Herzog, Felix, Incoll, L. D., Liagre, Fabien, Mantzanas, Konstantinos, Mayus, M., Moreno-Marcos, Gerardo, Papanastasis, Vasilios P., Pilbeam, D. J., Pisanelli, Andrea y Dupraz, Christian (2006), Silvoarable systems in Europe - Past, present and future prospects. *Agroforestry Systems*, 67(1): 29-50. available at http://link.springer.com/10.1007/s10457-005-1111-7 [13 junio 2018].

EIP-AGRI (2016), *Profitability of permanent grassland*. available at https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eipagri_fg_permanent_grassland_final_report_2016_en.pdf [18 junio 2018].

Étienne, M (1996), *Western European Silvopastoral Systems*. Institut national de la recherche agronomique. available at https://books.google.es/books?id=A_l0QgAACAAJ

EU (2005), *REGLAMENTO (CE) n o 1698/2005 DEL CONSEJO de 20 de septiembre de 2005 relativo a la ayuda al desarrollo rural a través del Fondo Europeo Agrícola de Desarrollo Rural (FEADER*. available at https://eur-lex.europa.eu/legal-content/ES/TXT/PDF/?uri=CELEX:32005R1698&from=ES [4 noviembre 2019].

EUROSTAT (2015), LUCAS - Land use and land cover survey - Statistics Explained. available at http://ec.europa.eu/eurostat/statistics-explained/index.php/LUCAS_-_Land_use_and_land_cover_survey [16 diciembre 2017].

FAO (1989), Sustainable development and natural resources managementle, , en: *Twenty-Fifth Conference, Paper C 89/2 - Sup. 2*. Roma: Food and Agriculture Organization of the United Nations.

FAO (2010), *«Climate-Smart» Agriculture. Policies, Practices and Financing for Food Security, Adaptation and Mitigation*. Roma. available at http://www.fao.org/docrep/013/i1881e/i1881e00.pdf [19 junio 2018].

FAO (2013), *Advancing Agroforestry on the Policy Agenda: A Guide for Decision-Makers* (G. Buttoud, Ed.). Rome: FAO. available at http://www.fao.org/3/a-i3182e.pdf [17 diciembre 2017].

FAO (2014), *Building acommom vision for sustainable food and agriculture. Principles and approaches.* Roma: Food and Agriculture Organization of the United Nations. available at http://www.fao.org/3/a-i3940e.pdf [19 junio 2018].

FAO (2015a), Agroforestry. Definition. available at http://www.fao.org/forestry/agroforestry/80338/en/ [11 junio 2019].

FAO (2015b), *Construyendo una visión común para la agricultura y alimentación sostenibles. Principios y enfoques*. Roma: FAO. available at http://www.fao.org/3/a-i3940s.pdf [12 noviembre 2019].

Ferguson, Rafter y Lovell, Sarah (2014), Permaculture for agroecology: design, movement, practice, and worldview. A review. *Agronomy for Sustainable Development*, 34(2): 251-274. available at https://hal.archives-ouvertes.fr/hal-01234801/document [18 junio 2018].

Fernández-Núñez, Esther, Rigueiro-Rodríguez, Antonio y Mosquera-Losada, María Rosa (2010), Carbon allocation dynamics one decade after afforestation with Pinus radiata D. Don and Betula alba L. under two stand densities in NW Spain. *Ecological Engineering*, 36(7): 876-890. available at https://www.sciencedirect.com/science/article/pii/S0925857410000674 [15 junio 2018].

Georgiev G (1960), *Field-protective forest belts in our country*. Varnar: Hungarian Government.

Gibbons, P., Lindenmayer, D. B., Fischer, J., Manning, A. D., Weinberg, A., Seddon, J., Ryan, P. y Barrett, G. (2008), The Future of Scattered Trees in Agricultural Landscapes. *Conservation Biology*,

22(5): 1309-1319. available at http://doi.wiley.com/10.1111/j.1523-1739.2008.00997.x [16 diciembre 2017].

Glover, Edinam K., Ahmed, Hassan B. y Glover, Mawutor K. (2013), Analysis of Socio-Economic Conditions Influencing Adoption of Agroforestry Practices. *International Journal of Agriculture and Forestry*, 3(4): 178-184. available at http://article.sapub.org/10.5923.j.ijaf.20130304.09.html

GOVERNMENT OF INDIA (2014), *NATIONAL AGROFORESTRY POLICY*. New Delhi. available at http://www.indiaenvironmentportal.org.in/files/file/Agroforestry policy 2014.pdf [18 junio 2018].

Graves, Anil R., Burgess, Paul J., Palma, João Henrique Nunes, Herzog, Felix, Moreno-Marcos, Gerardo, Bertomeu, M., Dupraz, Christian, Liagre, Fabien, Keesman, K.J., van der Werf, W., de Nooy, A. Koeffeman y van den Briel, J. P. (2007), Development and application of bio-economic modelling to compare silvoarable, arable, and forestry systems in three European countries. *Ecological Engineering*, 29(4): 434-449. available at http://www.sciencedirect.com/science/article/pii/S0925857406002333?via%3Dihub [16 diciembre 2017].

Graves, Anil R., Burgess, Paul J., Palma, João Henrique Nunes, Keesman, K.J. J., van der Werf, W., Dupraz, C., van Keulen, H., Herzog, F. y Mayus, M. (2010), Implementation and calibration of the parameter-sparse Yield-SAFE model to predict production and land equivalent ratio in mixed tree and crop systems under two contrasting production situations in Europe. *Ecological Modelling*, 221(13-14): 1744-1756. available at http://dx.doi.org/10.1016/j.ecolmodel.2010.03.008 [8 abril 2016].

Gross, Kevin (2016), Ecology: Biodiversity and productivity entwined. *Nature*, 529(7586): 293-294. available at http://www.nature.com/doifinder/10.1038/nature16867 [18 diciembre 2017].

Guiomar, N., Godinho, S., Fernandes, P.M., Machado, R., Neves, N. y Fernandes, J.P. (2015), Wildfire patterns and landscape changes in Mediterranean oak woodlands. *Science of The Total Environment*, 536: 338-352. available at

https://www.sciencedirect.com/science/article/pii/S0048969715304228?via%3Dihub [16 diciembre 2017].

Haines-Young, Roy (2016), *Report of Results of a Survey to Assess the Use of CICES, 2016. Support to EEA tasks under the EU MAES Process*. available at https://cices.eu/content/uploads/sites/8/2016/07/Report-on-Survey-Results_19072016_Upload.pdf [19 junio 2018].

Haines-Young, Roy y Potschin, Marion (2012), *Common International Classification of Ecosystem Services (CICES)*. available at http://test.matth.eu/content/uploads/sites/8/2012/07/CICES-V43_Revised-Final_Report_29012013.pdf [17 diciembre 2017].

Hansen, Everett M. (2015), Phytophthora Species Emerging as Pathogens of Forest Trees. *Current Forestry Reports*, 1(1): 16-24. available at http://link.springer.com/10.1007/s40725-015-0007-7 [16 diciembre 2017].

den Herder, Michael, Burgess, Paul J., Mosquera-Losada, María Rosa, Herzog, Felix, Hartel, Tibor, Upson, M., Viholainen, I. y Rosati, Adolfo (2015), *Preliminary stratification and quantification of agroforestry in Europe*. available at http://agforward.eu/index.php/en/preliminary-stratification-and-quantification-of-agroforestry-in-europe.html [16 diciembre 2017].

den Herder, Michael, Moreno-Marcos, Gerardo, Mosquera-Losada, María Rosa, Palma, João Henrique Nunes, Sidiropoulou, Anna, Santiago-Freijanes, José Javier, Crous-Durán, Josep, Paulo, Joana Amaral, Tomé, Margarida, Pantera, Anastasia, Papanastasis, Vasilios P., Mantzanas, Konstantinos, Pachana, Przemko, Papadopoulos, Andreas, Plieninger, Tobias y Burgess, Paul J. (2017), Current extent and stratification of agroforestry in the European Union. *Agriculture, Ecosystems & Environment*, 241: 121-132. available at http://linkinghub.elsevier.com/retrieve/pii/S0167880917301159 [23 marzo 2017].

den Herder, Michael, Moreno-Marcos, Gerardo, Mosquera-Losada, María Rosa, Palma, João Henrique Nunes, Sidiropoulou, Anna, Santiago-Freijanes, José Javier, Crous-Durán, Josep, Paulo, Joana Amaral, Tomé, Margarida, Pantera, Anastasia, Papanastasis, Vasilios P., Mantzanas, Konstantinos, Pachana, Przemko, Plieninger, Tobias,

Burgess, Paul J. y Papadopoulos, Andreas (2016), *Current extent and trends of agroforestry in the EU27*. available at https://www.agforward.eu/index.php/en/current-extent-and-trends-of-agroforestry-in-the-eu27.html [16 diciembre 2017].

Herzog, Felix (1998), Streuobst: A traditional agroforestry system as a model for agroforestry development in temperate Europe. *Agroforestry Systems*, 42(1): 61-80.

Howlett, David S., Mosquera-Losada, María Rosa, Nair, P.K. Ramachandran, Nair, Vimala D. y Rigueiro-Rodríguez, Antonio (2011), Soil Carbon Storage in Silvopastoral Systems and a Treeless Pasture in Northwestern Spain. *Journal of Environment Quality*, 40(3): 825. available at https://www.agronomy.org/publications/jeq/abstracts/40/3/825 [15 junio 2018].

IPCC (2014), *CAMBIO CLIMÁTICO 2014. Impactos, adaptación y vulnerabilidad. Resumen para responsables de políticas*. Genève. available at http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/ar5_wgII_spm_es.pdf [15 junio 2018].

Jose, Shibu (2009), Agroforestry for ecosystem services and environmental benefits: an overview. *Agroforestry Systems*, 76(1): 1-10. available at http://link.springer.com/10.1007/s10457-009-9229-7 [16 diciembre 2017].

Kachova, Vania, Hinkov, Georgi, Popov, Emil, Trichkov, Lyubcho y Mosquera-Losada, María Rosa (2018), Agroforestry in Bulgaria: history, presence status and prospects. *Agroforestry Systems*, 92(3): 655-665. available at http://link.springer.com/10.1007/s10457-016-0029-6 [14 junio 2019].

Karsenty, Alain, Blanco, Cécile y Dufour, Thomas (2003), *Instruments related to the United Nations Framework Convention on Climate Change and their potential for sustainable forest management in Africa Forest and climate change*. available at http://www.fao.org/tempref/docrep/fao/011/ac836e/ac836e00.pdf [18 diciembre 2017].

Krčmářová, Jana y Jeleček, Leoš (2017), Czech traditional agroforestry: historic accounts and current status. *Agroforestry Systems*,

91(6): 1087-1100. available at http://link.springer.com/10.1007/s10457-016-9985-0 [14 junio 2019].

Leakey, Roger (1996), Definition of agroforestry revisited. *Agroforestry Today*, 8(1): 5-7. available at http://outputs.worldagroforestry.org/cgi-bin/koha/opac-detail.pl?biblionumber=33590

Leakey, Roger R.B. (2014), The Role of Trees in Agroecology and Sustainable Agriculture in the Tropics. *Annual Review of Phytopathology*, 52(1): 113-133. available at http://www.annualreviews.org/doi/10.1146/annurev-phyto-102313-045838 [18 junio 2018].

López Trigal, Lorenzo (2015), Geografia Política y Geopolítica (aplicada), 271-273, en: López Trigal, L. (Ed.), *Diccionario de Geografía Aplicada y Profesional. Terminología de análisis, planificación y gestión del territorio*. León.

Lundgren, B.O. y Raintree, J.B. (1983), Sustained agroforestry, 37-49, en: Nestel, B. L. (Ed.), *Agricultural Research for Development: Potentials and Challenges in Asia : Jakarta, Indonesia, October 24-29, 1982 : Report of a Conference*. ISNAR, International Service for National Agricultural Research. available at https://books.google.es/books?id=qutFAAAAYAAJ

Mercer, D. Evan, Frey, Gregory E. y Cubbage, Frederick W. (2014), ECONOMICS OF AGROFORESTRY, 188-209, en: Kant, S. y Alavalapati, J. (Eds.), *Handbook of Forest Resource Economics*. Routledge. available at https://www.routledge.com/Handbook-of-Forest-Resource-Economics/Kant-Alavalapati/p/book/9781138573185

Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt (2015), *PLAN DE DÉVELOPPEMENT DE L'AGROFORESTERIE*. available at http://agriculture.gouv.fr/sites/minagri/files/151215-ae-agrofesterie-v2_plan.pdf [19 junio 2018].

Mosquera-Losada, María Rosa, Borek, Robert, Balaguer, Fabien, Mezzarila, Giustino y Ramos-Font, María Eugenia (2017), *Agroforestry as a mitigation and adaptation tool*. Bruselas. available at https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/fg22_mp9_cc_adaptation_mitigation_2017_en.pdf [11 junio 2019].

Mosquera-Losada, María Rosa, Ferreiro-Domínguez, Nuria, Santiago-Freijanes, José Javier, Fernández-Núñez, Esther y Rigueiro-Rodríguez, Antonio (2015), Los sistemas agroforestales como forma de gestión en la adaptación al cambio climático, 581-588, en: Herrero-Méndez, A. y Zavala-Gironés, M. Á. (Eds.), *Los bosques y la biodiversidad frente al cambio climático: Impactos, Vulnerabilidad y Adaptación en España*. Madrid: Ministerio de Agricultura, Alimentación y Medio Ambiente. available at https://www.researchgate.net/publication/286923989%7B_%7DLos%7B_%7Dsistemas%7B_%7Dagroforestales%7B_%7Dcomo%7B_%7Dforma%7B_%7Dde%7B_%7Dgestin%7B_%7Den%7B_%7Dla%7B_%7Dadaptacin%7B_%7Dal%7B_%7Dcambio%7B_%7Dclimtico

Mosquera-Losada, María Rosa, Freese, Dirk y Rigueiro-Rodríguez, Antonio (2011), Carbon Sequestration in European Agroforestry Systems, 43-59, en: Kumar, B. M. y Nair, P. K. R. (Eds.), *Carbon Sequestration Potential of Agroforestry Systems Opportunities and Challenges*. Dordrecht: Springer, Dordrecht. available at http://www.springerlink.com/index/10.1007/978-94-007-1630-8_3 [21 septiembre 2018].

Mosquera-Losada, María Rosa, McAdam, Jim H. y Rigueiro-Rodríguez, Antonio (Eds.) (2006), Declaration for Silvopastoralism, 418, en: *Silvopastoralism and sustainable land management*. Lugo.

Mosquera-Losada, María Rosa, McAdam, Jim H., Romero-Franco, Rosa, Santiago-Freijanes, José Javier y Rigueiro-Rodríguez, Antonio (2009), Definitions and Components of Agroforestry Practices in Europe, 3–19, en: Rigueiro-Rodríguez, A., McAdam, Jimn H., y Mosquera-Losada, M. R. (Eds.), *Agroforestry in Europe: Current Status and Future Prospects*. Dordrecht: Springer Netherlands. available at http://link.springer.com/chapter/10.1007/978-1-4020-8272-6_1 [21 julio 2015].

Mosquera-Losada, María Rosa, Moreno-Marcos, Gerardo, Santiago-Freijanes, José Javier, Ferreiro-Domínguez, Nuria y Rigueiro-Rodríguez, Antonio (2015), Sistemas Agroforestales y PAC. *Revista Ambienta*, 112: 110-124. available at http://www.revistaambienta.es/WebAmbienta/marm/Dinamicas/secciones/articulos/SAF.htm [29 octubre 2015].

Mosquera-Losada, María Rosa y Nair, P.K. Ramachandran (2016), AGROFORESTRY AND GOOD GOVERNANCE: A COMPARISON OF THE AGROFORESTRY POLICY FRAMEWORKS IN THE EU AND THE USA, 406-409, en: *3rd European Agroforestry Conference - Celebrating 20 years of Agroforestry research in Europe*. Montpellier.

Mosquera-Losada, María Rosa, Santiago-Freijanes, José Javier, Pisanelli, Andrea, Lamersdorf, Norbert, Burgess, Paul J., Fernández-Lorenzo, Juan Luis, González-Hernández, María del Pilar, Ferreiro-Domínguez, Nuria y Rigueiro-Rodríguez, Antonio (2016), AGROFORESTRY IN THE CAP : ELIGIBILITY, 432-433, en: *3rd European Agroforestry Conference - Celebrating 20 years of Agroforestry research in Europe*.

Mosquera-Losada, María Rosa, Santiago-Freijanes, José Javier, Pisanelli, Andrea, Moreno-Marcos, Gerardo, den Herder, Michael, Lamersdorf, Norbert, Burgess, Paul J., Fernández-Lorenzo, Juan Luis, González-Hernández, María del Pilar, Ferreiro-Domínguez, Nuria y Rigueiro-Rodríguez, Antonio (2016), AGROFORESTRY IN THE CAP : CROSS-COMPLIANCE OR CONDITIONALITY, 434-436, en: *3rd European Agroforestry Conference - Celebrating 20 years of Agroforestry research in Europe*.

Mosquera-Losada, María Rosa, Santiago-Freijanes, José Javier, Pisanelli, Andrea, Rois-Díaz, Mercedes, Smith, Jo, den Herder, Michael, Moreno-Marcos, Gerardo, Malignier, Nina, Mirazo, J.R., Lamersdorf, Norbert, Ferreiro-Domínguez, Nuria, Balaguer, Fabien, Pantera, Anastasia, Rigueiro-Rodríguez, Antonio, González-Hernández, María del Pilar, Fernández-Lorenzo, Juan Luis, Romero-Franco, Rosa, Chalmin, A., Garcia-de-Jalón, Silvestre, Garnett, K., Graves, Anil R., Burgess, Paul J., Ruiz-Mirazo, Jabier, Lamersdorf, Norbert, Ferreiro-Domínguez, Nuria, Balaguer, Fabien, Pantera, Anastasia, Rigueiro-Rodríguez, Antonio, González-Hernández, María del Pilar, Fernández-Lorenzo, Juan Luis, Romero-Franco, Rosa, Chalmin, A., Garcia-de-Jalón, Silvestre, Garnett, K., Graves, Anil R. y Burgess, Paul J. (2016), *Extent and Success of Current Policy Measures to Promote Agroforestry across Europe*. available at https://www.agforward.eu/index.php/en/extent-and-success-of-

current-policy-measures-to-promote-agroforestry-across-europe.html [21 marzo 2017].

Mosquera-Losada, María Rosa, Santiago-Freijanes, José Javier, Rois-Díaz, Mercedes, Moreno-Marcos, Gerardo, den Herder, Michael, Aldrey-Vázquez, José Antonio, Ferreiro-Domínguez, Nuria, Pantera, Anastasia, Pisanelli, Andrea y Rigueiro-Rodríguez, Antonio (2018), Agroforestry in Europe: a land management policy tool to combat climate change. *Land Use Policy*, 78: 603-613. available at https://www.evise.com/co-author/?dgcid=invite_email_coauthoroutreach02648377#/LUP/submission/LUP_2018_357 [24 julio 2018].

Nair, P.K. Ramachandran (1993), *An introduction to agroforestry*. Kluwer Academic Publishers in cooperation with International Centre for Research in Agroforestry. available at http://www.springer.com/us/book/9780792321347 [16 diciembre 2017].

Nair, P.K. Ramachandran (1994), Agroforestry, 13–25, en: Arntzen, C. J. (Ed.), *Encyclopedia of Agricultural Science. Volume 1*. New York: Academic Press Inc.

Nair, P.K. Ramachandran, Kumar, B. Mohan y Nair, Vimala D. (2009), Agroforestry as a strategy for carbon sequestration. *Journal of Plant Nutrition and Soil Science*, 172(1): 10-23. available at http://doi.wiley.com/10.1002/jpln.200800030 [15 junio 2018].

Palma, João Henrique Nunes, Graves, Anil R., Bunce, R.G.H., Burgess, Paul J., de Filippi, R., Keesman, K.J., van Keulen, H., Liagre, Fabien, Mayus, M., Moreno-Marcos, Gerardo, Reisner, Y. y Herzog, Felix (2007), Modeling environmental benefits of silvoarable agroforestry in Europe. *Agriculture, Ecosystems & Environment*, 119(3-4): 320-334. available at https://www.sciencedirect.com/science/article/pii/S0167880906002945 [16 diciembre 2017].

Palma, João Henrique Nunes, Graves, Anil R., Burgess, Paul J., van der Werf, W. y Herzog, Felix (2007), Integrating environmental and economic performance to assess modern silvoarable agroforestry in Europe. *Ecological Economics*, 63(4): 759-767. available at

https://www.sciencedirect.com/science/article/pii/S0921800907000961?via%3Dihub [16 diciembre 2017].

Palma, João Henrique Nunes, Paulo, Joana Amaral, Faias, Sónia Pacheco, Garcia-Gonzalo, Jordi, Borges, Jose G. y Tomé, Margarida (2015), Adaptive management and debarking schedule optimization of Quercus suber L. stands under climate change: case study in Chamusca, Portugal. *Regional Environmental Change*, 15(8): 1569-1580. available at http://link.springer.com/10.1007/s10113-015-0818-x [16 diciembre 2017].

Paolotti, Luisa, Boggia, Antonio, Castellini, Cesare, Rocchi, Lucia y Rosati, Adolfo (2016), Combining livestock and tree crops to improve sustainability in agriculture: a case study using the Life Cycle Assessment (LCA) approach. *Journal of Cleaner Production*, 131: 351-363. available at https://www.sciencedirect.com/science/article/pii/S0959652616304796?via%3Dihub [16 diciembre 2017].

Papanastasis, Vasilios P., Tsiouvaras, C.N., Dini-Papanastasi, O., Vaitsis, T., Stringi, L., Cereti, C.F., Dupraz, Christian, Armand, D., Meuret, M. y Olea, L. (1999), *Selection and Utilization of Cultivated Fodder Trees and Shrubs in the Mediterranean Region* (Vassilos P. Papanastasis, Ed.). CIHEAM-IAMZ.

Pardini, Andrea, MORI, S., RIGUEIRO-RODRÍGUEZ, Antonio y MOSQUERA-LOSADA, María Rosa (2010), Pastos : revista de la Sociedad Española para el Estudio de los Pastos. *Pastos*, 40(2): 211-223. available at http://polired.upm.es/index.php/pastos/article/view/1824 [14 junio 2019].

Paulo, Joana Amaral, Pereira, Helena y Tomé, Margarida (2017), Analysis of variables influencing tree cork caliper in two consecutive cork extractions using cork growth index modelling. *Agroforestry Systems*, 91(2): 221-237. available at http://link.springer.com/10.1007/s10457-016-9922-2 [16 diciembre 2017].

Plieninger, Tobias (2011), Capitalizing on the Carbon Sequestration Potential of Agroforestry in Germany's Agricultural Landscapes: Realigning the Climate Change Mitigation and Landscape

Conservation Agendas. *Landscape Research*, 36(4): 435-454. available at http://www.tandfonline.com/doi/abs/10.1080/01426397.2011.582943 [14 junio 2019].

Plieninger, Tobias, Hartel, Tibor, Martín-López, Berta, Beaufoy, Guy, Bergmeier, Erwin, Kirby, Keith, Montero, María Jesús, Moreno-Marcos, Gerardo, Oteros-Rozas, Elisa y Van Uytvanck, Jan (2015), Wood-pastures of Europe: Geographic coverage, social–ecological values, conservation management, and policy implications. *Biological Conservation*, 190: 70-79. available at https://www.sciencedirect.com/science/article/pii/S0006320715002098?via%3Dihub [11 junio 2015].

Potts, S., Biesmeijer, K., Bommarco, R., Breeze, T., Carvalheiro, L., Franzén, M., González-Varo, J.P., Holz-schuh, A., Kleijn, D., Klein, A.-M., Kunin, B., Lecocq, T., Lundin, O., Michez, D., Neumann, P., Nieto, A., Penev, L., Ras-mont, P., Ratamäki, O., Riedinger, V., Roberts, S.P.M., Rundlöf, M., Scheper, J., Sørensen, P., Steffan-Dewenter, I., Stoev, P., Vilà, M. y Schweiger, O (2015), *STATUS AND TRENDS OF EUROPEAN POLLINATORS Key Findings from the STEP project*. Sofia: Pensoft. available at www.pensoft.net [4 noviembre 2019].

Rancane, S, Makovskis, K, Lazdiņa, D, Daugaviete, M, Gnjtmane, I y Bjnrziņš, P (2014), Analysis of economical, social and environmental aspects of agroforestry systems of trees and perennial herbaceous plants. *Agronomy Research*, 12(2): 589-602. available at http://agronomy.emu.ee/vol122/2014_2_29_b5.pdf [18 diciembre 2017].

Reisner, Y., de Filippi, R., Herzog, Felix y Palma, João Henrique Nunes (2007), Target regions for silvoarable agroforestry in Europe. *Ecological Engineering*, 29(4): 401-418. available at https://www.sciencedirect.com/science/article/pii/S0925857406002357 [16 diciembre 2017].

Rigueiro-Rodríguez, Antonio, Fernández-Núñez, Esther, González-Hernández, María del Pilar, McAdam, Jim H. y Mosquera-Losada, María Rosa (2009), Agroforestry Systems in Europe: Productive, Ecological and Social Perspectives, 43-65, en: Rigueiro-

Rodríguez, A., McAdam, J. H., y Mosquera-Losada, M. R. (Eds.), *Agroforestry in Europe: Current Status and Future Prospects*. Springer.

Rigueiro-Rodríguez, Antonio, López López, Yolanda, Santiago-Freijanes, José Javier y Mosquera-Losada, María Rosa (2009), Efecto de la fertilización con lodos de depuradora urbana sobre el pasto y el arbolado en un sistema silvopastoral establecido con Quercus rubra, , en: *V Congreso Forestal Español*. SECF/ Junta de Castilla y León. available at http://www.congresoforestal.es/

Rigueiro-Rodríguez, Antonio, McAdam, Jim H. y Mosquera-Losada, María Rosa (Eds.) (2009a), *Agroforestry in Europe. Current Status and Future Prospects. Advances in Agroforestry. Volume 6*. Springer. available at http://library.uniteddiversity.coop/Permaculture/Agroforestry/Agroforestry_in_Europe-Current_Status_and_Future_Prospects.pdf [18 diciembre 2017].

Rigueiro-Rodríguez, Antonio, McAdam, Jim H. y Mosquera-Losada, María Rosa (Eds.) (2009b), *Agroforestry in Europe. Current Status and Future Prospects*. Springer Science Business Media B.V. available at http://www.springer.com/gp/book/9781402082719 [18 diciembre 2017].

Rigueiro-Rodríguez, Antonio, Rois-Díaz, M. y Mosquera-Losada, María Rosa (2010), Integrating Silvopastoralism and Biodiversity Conservation, 359-373, en: Springer, Dordrecht. available at http://link.springer.com/10.1007/978-90-481-9513-8_12 [18 junio 2018].

Rois-Díaz, Mercedes, Mosquera-Losada, María Rosa y Rigueiro-Rodríguez, Antonio (2006), *Biodiversity Indicators on Silvopastoralism across Europe* (Risto Paivinen, Ed.). Joensuu: European Forest Institute. available at http://www.efi.fi/ [14 junio 2018].

Santiago-Freijanes, José Javier, Mosquera-Losada, María Rosa, Rois-Díaz, Mercedes, Ferreiro-Domínguez, Nuria, Pantera, Anastasia, Aldrey-Vázquez, José Antonio y Rigueiro-Rodríguez, Antonio (2018), Global and European policies to foster agricultural sustainability:

agroforestry. *Agroforestry Systems*: 1-16. available at http://link.springer.com/10.1007/s10457-018-0215-9 [3 marzo 2018].

Santiago-Freijanes, José Javier, Pisanelli, Andrea, Rois-Díaz, Mercedes, Aldrey-Vázquez, José Antonio, Rigueiro-Rodríguez, Antonio, Pantera, Anastasia, Vityi, A., Lojka, B., Ferreiro-Domínguez, Nuria y Mosquera-Losada, María Rosa (2018), Agroforestry development in Europe: Policy issues. *Land Use Policy*, 76(March): 144-156. available at https://www.sciencedirect.com/science/article/pii/S0264837717310670 [8 mayo 2018].

Santiago-Freijanes, José Javier, Rigueiro-Rodríguez, Antonio, Aldrey-Vázquez, José Antonio, Moreno-Marcos, Gerardo, den Herder, Michael, Burgess, Paul J. y Mosquera-Losada, María Rosa (2018), Understanding agroforestry practices in Europe through landscape features policy promotion. *Agroforestry Systems*, 92(4): 1105–1115. available at http://link.springer.com/10.1007/s10457-018-0212-z [19 febrero 2018].

Sinclair, Fergus L. (1999), A general classification of agroforestry practice. *Agroforestry Systems*, 46(2): 161-180. available at http://link.springer.com/10.1023/A:1006278928088 [16 diciembre 2017].

Swift, M. J. y Anderson, J. M. (1994), Biodiversity and Ecosystem Function in Agricultural Systems, 15-41, en: *Biodiversity and Ecosystem Function*. Berlin, Heidelberg: Springer Berlin Heidelberg. available at http://link.springer.com/10.1007/978-3-642-58001-7_2 [18 junio 2018].

Takáczs, V. y Frank, N. (2009), The Traditions, Resources and Potential of Forest Growing and Multipurpose Shelterbelts in Hungary, 415-433, en: *Agroforestry in Europe*. Dordrecht: Springer Netherlands. available at http://link.springer.com/10.1007/978-1-4020-8272-6_21 [10 abril 2018].

Tiberi, Riziero, Branco, Manuela, Bracalini, Matteo, Croci, Francesco y Panzavolta, Tiziana (2016), Cork oak pests: a review of insect damage and management. *Annals of Forest Science*, 73(2): 219-232. available at http://link.springer.com/10.1007/s13595-015-0534-1 [16 diciembre 2017].

Torralba, Mario, Fagerholm, Nora, Burgess, Paul J., Moreno-Marcos, Gerardo y Plieninger, Tobias (2016), Do European agroforestry systems enhance biodiversity and ecosystem services? A meta-analysis. *Agriculture, Ecosystems & Environment*, 230: 150-161. available at https://www.sciencedirect.com/science/article/pii/S0167880916303097?via%3Dihub [16 diciembre 2017].

Tscharntke, Teja, Clough, Yann, Wanger, Thomas C., Jackson, Louise, Motzke, Iris, Perfecto, Ivette, Vandermeer, John y Whitbread, Anthony (2012), Global food security, biodiversity conservation and the future of agricultural intensification. *Biological Conservation*, 151(1): 53-59. available at https://www.sciencedirect.com/science/article/pii/S0006320712000821 [18 junio 2018].

UE (2013a), *Estrategia de adaptación al cambio climático de la UE*. Brussels. available at https://eur-lex.europa.eu/legal-content/ES/TXT/PDF/?uri=CELEX:52013DC0216&from=EN [15 junio 2018].

UE (2013b), *Una nueva estrategia de la UE en favor de los bosques y del sector forestal*. Brussels. available at https://eur-lex.europa.eu/resource.html?uri=cellar:2c1c71af-8384-11e3-9b7d-01aa75ed71a1.0010.04/DOC_2&format=PDF [15 junio 2018].

UE (2013c), Reglamento (UE) nº 1305/2013 del Parlamento Europeo y del Consejo de 17 de diciembre de 2013 relativo a la ayuda al desarrollo rural a través del Fondo Europeo Agrícola de Desarrollo Rural (Feader) y por el que se deroga el Reglamento (CE) n o 1698/2005 d. *Diario Oficial de la Unión Europea. Serie L*, (347, 17 de diciembre).

USDA (2011), *Agroforestry Strategic Framework, Fiscal Year 2011–2016*. available at https://www.usda.gov/sites/default/files/documents/AFStratFrame_FINAL-lr_6-3-11.pdf [17 diciembre 2017].

USDA (2013), *Agroforestry: USDA Reports to America, Fiscal Years 2011-2012 - Comprehensive Version*. available at https://www.usda.gov/sites/default/files/documents/usda-reports-to-america-comprehensive.pdf [18 diciembre 2017].

USDA (2019), *Agroforestry Strategic Framework. Fiscal Years 2019–2024*. available at https://www.usda.gov/topics/forestry/agroforestry [3 noviembre 2019].

Vidrih, M., Vidrih, T. y Kotar, M. (2009), In Slovenia: Management of Intensive Land Use Systems, 397-414, en: Rigueiro-Rodríguez, A., McAdam, J. H., y Mosquera-Losada, M. R. (Eds.), *Agroforestry in Europe. Current Status and Future Prospects*. Springer Science Business Media B.V. available at http://www.springer.com/gp/book/9781402082719

Zomer, Robert J., Trabucco, Antonio, Coe, Richard y Place, Frank (2009), *Trees on Farm: Analysis of Global Extent and Geographical Patterns of Agroforestry*. Nairobi, Kenya. available at http://www.worldagroforestry.org/downloads/Publications/PDFS/WP 16263.pdf [1 marzo 2018].

Zomer, Robert J., Trabucco, Antonio, Coe, Richard, Place, Frank, van Noordwijk, Meine y Xu, Jianchu (2014), *Trees on farms: an update and reanalysis of agroforestry's global extent and socio-ecological characteristics*. Bogor.

World Agroforestry Centre. available at http://www.worldagroforestry.org/ [12 noviembre 2019].

AFTA (Association for Temperate Agroforestry). available at https://www.aftaweb.org/ [12 noviembre 2019].

EURAF (European Agroforestry Federation). available at http://www.eurafagroforestry.eu/ [12 noviembre 2019].

KM0 Slow Food. available at https://www.km0slowfood.com/?lang=es [12 noviembre 2019].

Ciudades climáticamente inteligentes. available at https://www.climatelinks.org/content/climate-smart-cities [12 noviembre 2019].

Pacto Global de los Alcaldes por el Clima y la Energía. available at http://pactodealcaldes-la.eu/ [12 noviembre 2019].

INDEX

General index

Tables

Figures

ANEXO:

RESUMEN EN CASTELLANO

LA POLÍTICA AGRÍCOLA COMÚN (PAC)

Y LOS SISTEMAS AGROFESTALES

EN LA UNIÓN EUROPEA

José Javier Santiago Freijanes

ESCOLA DE DOUTORAMENTO INTERNACIONAL
PROGRAMA DE DOUTORAMENTO EN HISTORIA, XEOGRAFÍA E HISTORIA DA ARTE

SANTIAGO DE COMPOSTELA / LUGO
2020

1 Introducción

Los sistemas agroforestales son **sistemas tradicionales de uso del territorio** que consisten en la integración deliberada de una producción agrícola en el estrato inferior **de** un componente leñoso en la misma unidad territorial, siendo una de las herramientas más poderosas para mitigar y adaptar los sistemas agrícolas y forestales al cambio climático en todo el mundo y cumplir directa o indirectamente con los **Objetivos de Desarrollo sostenible indicados por la ONU en 2013.**

Sin embargo, en la actualidad no son prácticas ampliamente utilizadas en la zona templada debido a la revolución tecnológica que implicó una **intensificación** de los sistemas agrarios y que se asocia a políticas que no promocionan las prácticas agroforestales

Como se constata en que:

• **No hay acuerdo** de lo que es una práctica agroforestal, por ejemplo**, los pastos arbustivos,** tan necesarios en el sur, **no son reconocidos** como práctica agroforestal en el **norte de Europa (**y es una diferencia de 2,6 **millones** hectáreas**).**

• **Falta de reconocimiento** de las prácticas agroforestales cuando se **implementan** (es el caso de los llamados elementos del paisaje…)

• El **diseño separado** de las **políticas** forestales y agrícolas **afecta negativamente** a unas prácticas que **participan de los dos sectores**.

• El **desconocimiento de la extensión inicial** e incluso la **definición** de las prácticas agroforestales es otro de las **trabas para su promoción política**.

Para intentar solucionar esta problemática la UE ha promovido los proyectos **AGFORWARD** dentro del 7 Programa Marco **y AFINET** desde el programa de investigación europea H2020, que financiaron esta tesis doctoral

2 Objetivos

El objetivo fundamental de esta tesis es proporcionar **una categorización y extensión de las prácticas agroforestales** vinculadas a tierras agrícolas y forestales, a nivel de región, que es la escala geográfica empleada por los **programas de Desarrollo Rural** (PDR)

en Europa, y evaluar cómo estas prácticas son promovidas por la PAC previa (2007-2013) y actual (2014-2020), con un enfoque especial en su **potencial de mitigación y adaptación que tienen al cambio climático**.

Este objetivo general se concreta en los siguientes objetivos específicos:

1) **Evaluar el marco político histórico** de políticas que afectan a los sistemas agroforestales, como forma de entendimiento de las políticas agroforestales actuales.

2) Evaluar **la extensión actual** de las prácticas agroforestales en Europa mediante el empleo de herramientas de sistemas de información geográfica, como indicador base de su importancia como técnicas de mitigación del cambio climático.

3) Caracterizar la extensión actual de los **elementos del paisaje** en toda Europa que incluyen sistemas agroforestales de difícil identificación y analizar las medidas de PDR que los promueven en el territorio europeo, dentro de las PAC 2007-2013 y 2014-2020.

4) **Evaluar el grado de implementación actual de políticas** relacionadas con la introducción de vegetación leñosa en áreas rurales europeas, como primer paso para establecer los sistemas agroforestales, tras la revisión de políticas relacionadas con la promoción de la vegetación leñosa en distintas zonas de Europa durante el siglo XX.

3 Métodos y resultados

3.1 Políticas mundiales y europeas para fomentar la sostenibilidad agrícola: agroforestería

Santiago-Freijanes JJ, Mosquera-Losada MR, Rois-Díaz M,.Ferreiro-Domínguez N, Pantera A, Aldrey JA, Rigueiro-Rodríguez A 2018. Global and European policies to foster agricultural sustainability: agroforestry *Agroforestry systems*. https://link.springer.com/article/10.1007/s10457-018-0215-9.

Se trata de un estudio de **gabinete** de las **principales políticas internacionales**, paneuropeas, europeas y nacionales en relación con las prácticas agroforestales con el objetivo de: analizar sus **definiciones**, los documentos que **los promueven** a través de estrategias para identificar los **principales motivos d**e su promoción y servir de base de la elaboración **futura de normativa europea**

La **FAO**, la organización de Naciones Unidas para la alimentación y la agricultura definió en 1989 la **agricultura sostenible y el Desarrollo Rural** y en el 2014 en este documento definió los **5 principios de la agricultura sostenible**, atendiendo a los **Objetivos de desarrollo sostenible de la ONU de 2013.**

Desde el **mundo científico**, en 2004, en los congresos de **Orlando** (Agroforestal) y **Lugo** (Silvopastoralismo), en sus declaraciones finales, destacaron el **papel de la agroforestería** para atender a las **demandas ecológicas, económicas y sociales** y pidieron políticas de apoyo a la investigación agroforestal y su transferencia.

En el 2009 en la conferencia sobre cambio climático de Copenhague se creó **la Alianza Mundial de Investigación**, la **GRA** por sus siglas en inglés, con el fin de apoyar políticas de investigación relacionadas con el cambio climático. En 2017 integrará una **red agroforestal** dentro del grupo de cultivos.

En el 2015, en la cumbre de Paris, la GRA apoya la iniciativa francesa 4x1000, que **busca incrementar un 0,4% el secuestro de carbono en suelo agrícola** Para ello cuenta con los **sistemas agroforestales** adaptados a las **condiciones locales.**

Por otro lado, en 2010, en la **conferencia de la Haya**, se presenta el concepto de **agricultura climáticamente inteligente CSA,** enfocado en el **desarrollo de condiciones técnicas**, políticas y en las inversiones destinadas al **desarrollo agrícola sostenible para la seguridad alimentaria bajo el cambio climático,** y la FAO publica este documento, que se incluye un capítulo dedicado a la agroforestería, con esta base se crea en 2014 la Alianza Mundial para la Agricultura Climáticamente Inteligente que facilita el establecimiento de las herramientas necesarias para estas prácticas agrarias.

Hay dos organizaciones trabajando a escala regional europea, la **Comisión Económica de la ONU para Europa** (UNECE) y el **Consejo de Europa**.

La primera promueve **conferencias sectoriales de ministros**, como las Conferencias Ministeriales "**Medio Ambiente para Europa**", que en **2003. 5ªConferencia. Kiev** pidió identificar las **Explotaciones con Gran valor natural** (HNV) *esenciales para alcanzar objetivo de* ***biodiversidad***.

En **2011. 7ª Conferencia,** celebrada en Astana (Kazakstán), se centró en el **manejo sostenible del agua** y en la **economía verde**.

La **Séptima Conferencia Ministerial sobre la Protección de los Bosques en Europa** que se celebró en 2015, en Madrid, destacó que los bosques y otras tierras boscosas brindan una multitud de funciones y servicios renovables, como la producción de **madera**, la **protección de los suelos**, **recursos hídricos,** la **protección** contra diversos riesgos, regulación **climática**, captura de **carbono**, usos **recreativos**, productos forestales **no madereros**, y mantenimiento de la **biodiversidad**.

La **Estrategia Paneuropea para la Diversidad Biológica** 2020 (PESB), aprobada en la 7ª conferencia intergubernamental de la biodiversidad en Europa, en Batumi (Georgia), persigue un enfoque **innovador y proactiv**o para **detener y revertir la degradación de la diversidad biológica y del paisaje** en Europa que se puede vinculara a la promoción de las prácticas agroforestales.

Desde el **Consejo de Europa** se promueve la **Convención Europea de Paisajes**, que en 2017 destaca la **importancia cultural** y el **valor social de todos los paisajes** y la necesidad de su **gestión creativa**, por ejemplo, con sistemas agroforestales.

Estas políticas internacionales fundamentan las políticas **medioambientales, Forestales** y **agrarias** de la UE como el **séptimo programa de acción en materia de medio ambiente** La **Estrategia De La Unión Europea Para La Diversidad** h**asta El 2020,** de la que ya se ha redactado una actualización. Otras políticas europeas sustentadas en las políticas internacionales están relacionadas con la **Red Natura 2000** fue creada en el 1994 por la *directiva de las aves y hábitats,* la **Estrategia europea de desarrollo sostenible** que parte de los objetivos de la ONU., el **Programa Europeo sobre el Cambio Climático** (PECC) de 2000 para poner en práctica el **Protocolo de Kioto,** la **Estrategia Forestal Europea de** 2013, que busca garantizar que el **potencial multifuncional de los bosques,** las **declaraciones de Cork** de 1996 y, sobre todo la de **Cork 2.0** de 2016 que pide, entre otras demandas, el reconocimiento de los **sistemas agrarios tradicionales** y la inclusión de la **silvicultura en la PAC** y la **política agrícola común** que se establece cada siete años y que por tanto deberían fomentar la agroforestería. La PAC consta de 2 pilares. El **pilar I**, totalmente

financiado por la UE son los **pagos directos** sujetos a la **elegibilidad** y **condicionalidad**. El **pilar II,** financiado en parte por las **administraciones de cada estado**, son los Programas de Desarrollo Rural (PDR) que elaboran las **autoridades de cada región** (118 en la última PAC) seleccionando para su territorio las medidas que la UE aprobó para toda Europa en sus reglamentos.

Los sistemas agroforestales atienden a los objetivos de estas políticas porque son sistemas agrarios **tradicionales** de **Gran Valor Natural** que contribuyen enormemente a la **estabilización de la población rural** y evitan el abandono. Por otra parte, los sistemas agroforestales o**ptimizan el uso de recursos**, como los fertilizantes que consigue **reciclar**, al tiempo que **evita la contaminación de las aguas**, gracias a la presencia de la **vegetación leñosa capaz de captar nutrientes de las capas más profundas del suelo y reciclarlos en superficie**, que también mejora el s**ecuestro de carbono**. Las prácticas agroforestales también aumentan la **biodiversidad**, frenando el **deterioro de las especies amenazadas** y sus hábitats, atienden al **potencial multifuncional** de los bosques, contribuye a **la Conexión entre los espacios naturales** y está demostrada su eficacia para **mitigar y adaptarse al cambio climático**. Todo esto hace que sean también una **forma óptima de gestión del paisaje**.

3.2 La agroforestería como instrumento de ordenación política de la tierra para combatir el cambio climático y la promoción de algunas de sus prácticas políticas como características del paisaje

Mosquera-Losada MR, Santiago-Freijanes JJ, Rois-Díaz M,.Moreno G, den Herder M, Aldrey JA, Ferreiro-Domínguez N, Pantera A, Pisanelli A, Rigueiro-Rodríguez A 2018. Agroforestry in Europe: A land management policy tool to combat climate change. Land use policy 78:603-613. https://www.sciencedirect.com/science/article/abs/pii/S0264837718303752.

Santiago-Freijanes JJ, Rigueiro-Rodríguez A, Aldrey JA,. Moreno G, den Herder M, Burgess P, Mosquera-Losada MR 2018. Understanding agroforestry practices in Europe through landscape features policy promotion. Agroforestry systems:92:1105-1115. https://link.springer.com/article/10.1007%2Fs10457-018-0212-z.

Los sistemas agroforestales pueden desarrollarse en tres formas de uso de la tierra: Agrícola, forestal y urbano o periurbano.

Atendiendo al **cultivo del estrato inferior** (pastos o cultivos) diferenciamos dos grandes grupos: **Silvopastoreo** y **Silvoarable**, pero, dados los problemas de identificación de lo que es una práctica agroforestal por parte de las autoridades, y para poder vincularlos con la PAC, hemos completado esa definición señalando **3 nuevos grupos** (Franjas riparias, Huertos domésticos y bosques cultivados).

Silvopastoreo es por lo tanto pastoreo bajo vegetación leñosa Como ejemplos en zona agraria tenemos el **monte adehesado**, y el **pastoreo en frutales**.

Silvoarable son los cultivos desarrollados entre vegetación leñosa y sólo se da en **zona agrícola**, también conocida como **cultivos en callejones.**

Las **franjas** que serán aquellas **líneas o grupos de árboles o arbustos** situados en los **lindes** de los **cultivos** o de los **prados**, por lo que se podrían vincular a silvoarable o silvopastoreo. Como franjas están los **setos vivos y cortavientos** y también las **franjas riparias**, cuyo fin particular es **mantener la calidad de las aguas**.

En **zona urbana o periurbana**, tenemos, con sus consideraciones particulares, los **huertos domésticos** o **huertos familiares.**

En la **zona forestal**, el **silvopastoreo** puede ser una **práctica tradicional**, como la explotación en **semilibertad** de los caballos de monte. Pero también puede participar de **nuevas formas de gestión del territorio**, como el **control** de la **biomasa** y el **mantenimiento de los cortafuegos** de cara **a prevenir los incendios forestales mediante el empleo del ganado.**

Además, están los **bosques cultivados** asociados a los **productos forestales no madereros**, entre los que podemos destacar los **apícolas**, la **resina**, las **setas** y las **bayas** (también conocidas como frutos del bosque).

Para poder **recomendar** la **conservación o introducción correcta** de las prácticas agroforestales es **necesario conocer su extensión a escala europea**. Tarea que no es fácil dada su complejidad.

Las dos fuentes principales de la cobertura del suelo en Europa son el *Corine Land Cover* y el LUCAS. El primero tiene una **cobertura paneuropea** mientras que el segundo se centra en el **territorio de la Unión Europa**.

Al comprobar todas las zonas que pueden ser consideradas como coberturas agroforestales vemos una mayor densidad de territorio agroforestal en LUCAS que en CLC. Esto se debe a que el **CLC se basa en la fotointerpretación** de imaginería aérea y no puede evaluar lo **que hay en los estratos inferiores de una masa arbórea**.

Además de la imposibilidad de identificar las capas inferiores de las masas forestales, el CLC presenta el problema del tamaño mínimo necesario para ser cartografiado. Las parcelas que non alcanzan las **25 ha** se agrupan señalando la cobertura más extendida. Por los que masas boscosas o elementos del paisaje lineales o árboles aislados, importantes para la identificación de las prácticas agroforestales, no son cartografiados.

LUCAS son las siglas en inglés de e**ncuesta por sondeo de superficies del uso y ocupación del suelo**. Se viene realizando cada tres años en el territorio de la UE (con excepción de las regiones ultramarinas y de los archipiélagos macaronésicos).

En una **primera fase** se seleccionan en toda Europa más de un **millón de puntos**, con un mallado regular **de 2km de lado**. Adjudicándole, por medio de la fotointerpretación, a cada punto a una de las **siete coberturas** definidas por el sistema.

En una **segunda fase** se seleccionan varios puntos, que **fueron 270 000** en la del año que estudiamos, 2012, en la Europa anterior a la incorporación de Croacia. A estos últimos puntos acudirá un **equipo de encuestadores para tomar datos** sobre usos y cobertura entre otros. El **resultado es una base de datos** de los que nos vamos a centrar en los de Cobertura (LC1 y LC2) y usos (LU1 y LU2) y LAND_MNGT o manejo de la tierra.

Como resulta que **LC1 se refiere a la cobertura de mayor altura**, hemos comprobado que la **vegetación leñosa, sea ésta de cultivos permanentes, árboles forestales o arbustos que aparece en LC1** cuando se combina con **cultivos anuales o con viñas en LC2** indica que se realiza una práctica **silvoarable**. Cuando la LC1 se combina con la cobertura de **pastos en LC2** o con **evidencias de pastoreo** en el campo de gestión **de la tierra** identificamos la práctica de **silvopastoreo**. Esta última práctica también la puede indicar **directamente**, sin necesidad de ninguna combinación, los campos de

cobertura **LC1 o LC2** cuando presentan el valor que indica **pastos con árboles o arbustos dispersos** (E10). Los campos **usos (LU1 o LU2)** nos sirven para localizar la presencia de **huertos domésticos** (U113).

Además de las observaciones realizadas en cada punto visitado, con el fin de poder realizar un mapeo de elementos lineales, los encuestadores realizan un **transecto de 250m** desde el punto **en sentido Este**, en el que se van anotando los cambios de cobertura que se encuentren. A los **códigos alfanuméricos propios de LC1y LC2** le añaden otros, exclusivamente numéricos para referirse a elementos lineales como bandas herbáceas, carreteras, líneas eléctricas, canales y por supuesto los referidos a árboles aislados y filas de árboles. **Estas observaciones se van anotando un conjunto de 80 columnas**. En cada punto **hemos contados las repeticiones** de los **elementos objeto** de nuestro estudio, que son **10** en el caso árboles aislados, **11** en el de filas de árboles, **12** en el de setos de coníferas, **13** en el de setos con alguna evidencia de manejo como por ejemplo poda y **14** en los setos sin evidencia manejo. Además, en **unos pocos puntos de toda Europa (1283 de los 270 000**) no sólo se enumeran las coberturas sino también se midió el tramo coincidente del transecto, lo que nos permite estimar una **dimensión media para cada uno de los elementos**. Las **franjas riparias**, las establecimos de forma automática, gracias a los **algoritmos** creados para **localizar las líneas de árboles** que estaban *en contacto con los* ***cuerpos y cursos de agua***, para después contarlos y dimensionarlos de la misma forma que los setos vivos.

Por otro lado, tenemos que constatar que no hay datos disponibles para identificar ni para mapear la cantidad de territorio dedicado a los **bosques cultivados**, este hecho **dificulta la evaluación del impacto** de las políticas en esta práctica agroforestal.

En Europa, las prácticas agroforestales totales ocupan casi 20 millones de hectáreas. Alrededor del 90% de los 19,77 millones de hectáreas están vinculadas a prácticas de **silvopastoreo,** asociadas principalmente a los países del **sur de Europa**, donde se aprovecha la vegetación leñosa como recurso alimenticio durante la sequía de verano y su **sombra para extender la temporada de crecimiento del pasto**.

El dilvopastoreo está presente en casi el **10% de las zonas de pastos permanentes** de Europa, es decir, tiene su gran expansión potencial.

La práctica silvoarable ocupa cerca de **360.000** hectáreas en Europa, es decir un 0,08% del territorio, un 4% de las tierras de labor, con lo que su expansión potencial también es enorme.

Se nota la **tendencia hacia el sur, especialmente Ibérica e Itálica**. Aunque la región con mayor presencia de prácticas es **Baleares con** apenas un **2,5% por ciento de su territorio**.

Los **huertos domésticos** comprenden la vegetación de varios estratos verticales que rodea a los hogares, suministran frutas y hortalizas para autoconsumo. La proporción de tierra asignada a huertos domésticos es **más alta** en **Europa del Este**, como consecuencia de las políticas realizadas en esos países en la 2ª mitad del siglo pasado (por ejemplo, República Checa, Eslovaquia, Rumania) y más baja en países ubicados en Europa Central y del Norte. Algunas regiones atlánticas como Asturias y Galicia tienen una cierta proporción de huertos domésticos.

Las **Franjas riparias** suponen 1,78 millones hectáreas representando un 0,42% del territorio de la UE. Se presencia es menor en la mayor parte de España y en las regiones del centro y norte de Europa.

Los elementos puntuales y lineales (árboles aislados y setos vivos) tienen una importancia muy grande al promocionarse su **conservación y recuperación** como elementos del paisaje**.** Los árboles aislados se distribuyen por toda Europa. Su ocupación es de alrededor de 300 000 hectáreas en la UE-27, con el mayor número de hectáreas por región (Nivel NUTS2) correspondientes a España, Francia y Lituania. Mientras que porcentualmente destacan las regiones de Francia, Portugal, Italia y Reino Unido. Aunque la proporción máxima de árboles aislados en Europa es realmente baja, con un máximo del 0,48% de la superficie total en Irlanda del Norte. Se estimó una extensión de **los setos vivos** de 1,8 millones de hectáreas para la UE-27. Las regiones españolas más extensas presentan una **gran cantidad de terreno** ocupado por este tipo de setos, junto con las de Francia, Irlanda y el Reino Unido. En el norte de Europa, destaca la gran cantidad de

hectáreas por región de Finlandia. El mayor **porcentaje de setos** se encuentra principalmente en Francia, Irlanda y el Reino Unido, pero también en Portugal e Italia, Países Bajos y Bélgica. Aunque los setos nunca llegan al 2,5% del territorio. En cuanto a la **extensión** de los cuatros tipos **de formaciones lineales** de vegetación leñosa definidos por LUCAS las **avenidas de árboles** de son el tipo de seto más ampliamente representado en toda Europa con alrededor de **826 000 hectáreas**. A su vez, los **setos de coníferas** son del tipo de seto con la presencia más pequeña de Europa con un total de **14.882 hectáreas**.

La mayoría de los **setos de arbustos o árboles no se gestionan** y representan alrededor de **640.000 hectáreas** La mayoría de los **manejados** que se encuentran en el **Reino Unido, Irlanda, Francia y Finlandia.** En términos porcentuales, las **avenidas arbóreas y los setos de coníferas** están presentes principalmente en el **norte de Europa**, con una menor presencia de los setos, manejados o no. Los **setos manejados** y que **no presentan signos de manejo** se encuentran principalmente en el **Reino Unido, Francia, Bélgica y los Países Bajos**, así como en **el norte de Italia.**.La promoción de los sistemas y prácticas agroforestales es muy parecida en los PDR de los dos periodos analizados.

Con relación a las medidas políticas de promoción de las prácticas agroforestales distinguimos dos períodos asociados a la PAC:

En el periodo 2007-2013, la medida que más fomenta las prácticas agroforestales en Europa es la **214**, **la medida agroambiental.** En la **zona agraria** especialmente también actúa de forma significativa la medida **216** (**apoyo a las inversiones no productivas),** mientras que en **zona forestal** la medida **121** favorece los bosques **cultivados, especialmente la apicultura**, para **modernizar las explotaciones**. El **elemento apoyado por más medidas** de los PDR son los **setos vivos**, muy por encima de la **instalación de bosquetes** y de la **práctica de pastoreo en frutales**.

En relación al periodo de la PAC 2014-2020, la **medida agroambiental**, ahora denominada **10.1** sigue siendo **la que más fomenta** las prácticas agroforestales en Europa. En **zona agraria** especialmente también actúa de forma significativa la medida **4,4 (apoyo a las inversiones no productivas** relacionadas con el cambio

climático), mientras que en **zona forestal** la medida **8.6** favorece los **bosques cultivados (no apícolas)** para las **inversiones en tecnologías**. El elemento **apoyado por más medidas** de los PDR vuelve a ser **los setos vivos**, muy por encima de **la instalación de bosquetes** y de la **práctica de pastoreo en frutales** y la **apicultura**. En cuanto a los elementos lineales: Los **árboles aislados** aumentan el número de medidas habilitadas por los PDR en el periodo 2014-2020, pasando de 39 a 61, aunque, como se puede ver en los mapas de esta tesis, se debe, en una gran proporción, a la **conversión del Hexágono francés en 21 regiones** en el periodo 2014- 2020. Los **setos vivos** por su parte son en los dos periodos la práctica agroforestal favorecida por un mayor número de medidas, pasando de 99 a 122.Por lo tanto, **en ambos periodos** la **medida** más empleada fue la **agroambiental** (214 en 2007-2013 y 10.1 en 2014-2020) y se utilizaba fundamentalmente para fomentar el **mantenimiento y la conservación** de estos elementos.

La **plantación o instalación** de árboles y setos prefirió fomentarse en los dos periodos con la medida que promueve las **inversiones no productivas** (226 y 4.4).

Gracias a la **encuesta LUCAS** pudimos comprobar que en **el 96,4% del territorio arable** y en el **90% del territorio de pastos no** se dan prácticas agroforestales, por lo que su expansión potencial en Europa es enorme, **especialmente en el Norte**, y debería ser fomentada por la acción política y por tanto por la PAC. Dada la mayor existencia de estas prácticas en el Sur de Europa, las medidas políticas deberían también garantizar al menos su conservación y mantenimiento en esta zona.

La gran **promoción de los elementos del paisaje** en los Programas de Desarrollo Rural **no compensa** la falta de una clara categorización de estos elementos y su promoción en diferentes partes de la PAC (Pilar I y Pilar II) lo que dificulta su interpretación y la evaluación del impacto de las políticas a escala territorial.

Los **bosques cultivados** es una actividad **difícil de mapear**, y menos a una escala como Europa, por lo que se debería de **buscar alguna fórmula para poder evaluar el impacto** de su promoción política.

3.3 La política y el desarrollo agroforestal en Europa

Santiago-Freijanes JJ, Pisanelli A, Rois-Díaz M, Aldrey-Vázquez JA, Rigueiro-Rodríguez A, Pantera A, Vityi A, Lojka B, Ferreiro-Domínguez N, Mosquera-Losada MR 2018. Agroforestry development in Europe: Policy issues. Land use policy 76, 144- 156. https://www.sciencedirect.com/science/article/abs/pii/S02648377 17310670.

La política y desarrollo agroforestal en Europa debe entenderse a través de **dos situaciones recientes e históricas de partida**, resultado de las **diferencias políticas** entre los **dos bloques**, en la **segunda mitad del siglo XX**.

En la **Europa Oriental** había una **tradición de empleo de silvopastoreo** en frutales y en zona forestal, a partir de **1945 las reformas colectivistas** comenzaron a destruir la mayor parte de los sistemas agroforestales. Aunque algunos países, afectados por fuertes vientos, como Chequia, Bulgaria o Hungría, se vieron obligados a recuperar prácticas agroforestales para mantener y mejorar su producción agrícola. Así **Hungría** comenzó a **plantar setos cortavientos en los sesenta** del siglo pasado, llegando a las **17 000** ha a comienzos de este siglo.

En los **países occidentales** de la zona europea el **modelo productivista** llevó a la **intensificación**. La PAC nacida en 1962 por la búsqueda de la autosuficiencia alimentaria dio paso a la detección **de problemas ambientales** y **paisajísticos** derivados de este modelo (pérdida de biodiversidad, falta de polinización, desaparición de elementos paisajísticos…) que precisan de **soluciones políticas**. Así, en 1975 comienzan los **pagos relacionados con las zonas menos favorecidas** y en 1988 comienzan a pagar por **dejar tierras en barbecho**, lo que favorece la presencia de vegetación leñosa y finalmente en 1992 se comienza a pagar para **realizar plantaciones en tierras agrarias**.

En los PDR del periodo 2007-2013, regulados por el Reglamento (Comisión Europea) 1698/2005) las Medidas **221, 222 y 223** promovieron la plantación de árboles para incrementar el uso del territorio forestal, sea con la expansión de los **recursos forestales en tierras agrícolas** (221) o **forestales** (223) o con la **promoción de la combinación de sistemas agrícolas y forestales extensivos** (222).

Estas medidas tienen **impactos diferentes**. En particular, las Medidas 221 y 223, que se centraron en el aumento de las tierras forestales en la Unión Europea, con el objetivo de mitigar el cambio climático, cumpliendo del compromiso del protocolo de Kioto, **consiguieron llegar al 43,7 y 42,7%** respectivamente de las medidas previstas mientras que la 222, que promovía la implantación de sistemas agroforestales, se quedó en el **4.1%**, partiendo de un objetivo mucho menos ambicioso.

El principal motivo de este **fracaso** parece estar en que la medida **no iba acompaña de coste de mantenimiento**, como las otras dos y menos aún de la **compensación por lucro cesante** que tiene la 221.

En el **segundo periodo estudiado** (2014-2020) estas medidas se repiten con algunos cambios: **221 y 223** se unifican en la submedida **8.1**, mientras que 222, ahora como **8.2, admite costes de mantenimiento**, además con la reforma que se introdujo con el **Reglamento Ómnibus** en medio del periodo de ejecución la medida **no sólo cubre la implantación**, sino también su **regeneración y renovación**, por lo que **se puede aplicar en sistemas agroforestales ya existentes**.

En el periodo 2007-13 de la PAC, la primera reforestación de tierras agrícolas (221) fue presupuestada por casi todas las regiones, mientras que la implantación de sistemas agroforestales (222) sólo se presupuestó en los PDR de 9 Regiones PDR, quedando la 223 (primera aforestación de tierras NO agrícolas) en un punto intermedio.

La **diferencia se acentúa** al ver como fue la **ejecución de los programas**, pues mientras la **221 y la 223** fueron llevadas a la práctica por la casi **totalidad** de los programas que la presupuestaron, la 222 sólo ejecutaron **la mitad de las regiones**.

Si hacemos una comparación entre los dos periodos vemos que la medida 8.1 tiene una acogida menor que la 221, aunque más que la medida 223, mientras que la 8.2 triplica el número de programas de la medida 222, y **no sólo** porque el hexágono francés se regionalizase.

Como ya mencionamos, las medidas del periodo **2007.2013** que promueven la **primera implantación forestal** en tierra agrícola (medida 221) y no agrícola (medida 223) se continúan en **2014 -2020** por una única **submedida, la 8.1.**

En el primer periodo la reforestación de **tierras agrarias** (221) promueven las prácticas agroforestales de **bosques cultivados, las franjas forestales y bosquetes y los setos vivos.** La reforestación en terrenos **no agrarios** sólo promueve las prácticas agroforestales de s **bosques** cultivados así como las las **franjas** forestales y bosquetes.

En el **segundo periodo**, la **8.1**, aunque promueve en Aragón el **pastoreo forestal**, que no se promovía en la PAC 2007-2013, sólo promueve una práctica agrícola más: los **Bosques cultivados**.

Por lo que se refiere a **la medida y submedida agroforestales**, recordemos la 222 promovía la implantación de estos sistemas y la **8.2** promovía su implantación y mantenimiento. La 222 se programada por Sicilia y Las Marcas para promover **Franjas forestales y bosquetes, Setos vivos** y también **Árboles aislados**. Mientras que el PDR Portugal continental usa la medida **8.2** para promover f**ranjas forestales y bosquetes**, y unto con Azores, **setos vivos** y con Veneto y Umbría el **pastoreo forestal** en el periodo de la PAC 2014–2000.

En **conclusión**, con la introducción del **mantenimiento en la medida 8.2** aumenta el número de PDR que fomentan la implementación de las prácticas agroforestales, sobre todo, hay más prácticas promovidas desde la 8.2 y disminuyen su promoción desde la 8.1.

4 Conclusiones

1. Hay un reconocimiento, tanto a nivel mundial como europeo del rol de la agroforestería para producir bienes tangibles al tiempo que presta servicios medioambientales. Sin embargo, la promoción de la agroforestería no está aún bien orientada en la PAC. Se necesita una clara identificación de las prácticas agroforestales que conecte con los planes de fomento agroforestal y que establezca una densidad arbórea final elegible para los pagos del Pilar I.

2. Los sistemas agroforestales son un tipo de gestión sostenible el territorio capaz de mejorar la productividad por unidad de superficie gracias a la ecointensificación, entendida como la mejora u optimización en el uso de los recursos tanto aéreos (por ejemplo, luz) como edáficos (como los nutrientes). Esto hace que, en un mundo cada vez más necesitado de productos del sector primario, los sistemas agroforestales se estén valorizando y se consideren prácticas a

promover para producir más por unidad de superficie y mejorar la biodiversidad y la calidad del agua, así como para combatir el cambio climático a través de su capacidad para mitigar y adaptar los sistemas agrícolas al mismo.

3. Con relación a las políticas actuales que fomentan el uso de las prácticas agroforestales consideramos que no están bien diseñadas. En primer lugar, porque el agricultor precisa del pago directo para poder subsistir en el actual nivel de vida, por lo que si las medidas agroforestales reducen la posibilidad de pago directo como ocurre en la actualidad, entonces no resultan atractivas para el agricultor y no se están fomentando adecuadamente. Por otra parte, la medida agroforestal 222 no se diseñó acertadamente, ya que no preveía el abono pecuniario vinculado al mantenimiento ni al lucro cesante, lo que sí tenían en cuenta las medidas forestales, por lo que los agricultores optaban por éstas últimas.

4. El fomento agroforestal debe realizarse mediante el establecimiento de una única medida que reconozca un uso del territorio en diversas coberturas, garantizando el pago directo y ayudas que contemplen el mantenimiento y el lucro cesante, como las medidas de forestación.

5. La metodología fundamentada en la encuesta LUCAS es muy adecuada para estimar la evolución de las prácticas agroforestales a nivel europeo, pero insuficiente para caracterizar la práctica agroforestal de "bosques cultivados".

6. Los sistemas agroforestales destacan, sobre todo, en zonas tropicales, presentando en el caso de la zona europea un gran potencial de implementación ya que nuestros estudios señalan que en el 96,4% del territorio arable y en el 90% del territorio de pastos de la zona europea no se emplea este tipo de técnicas de gestión del territorio y sería perfectamente aplicable.

7. Aunque se encuentran en toda Europa, los sistemas agroforestales se asocian, sobre todo, con los países del sur. Por eso se debe acentuar el esfuerzo en fomentar el establecimiento de prácticas agroforestales en los países del norte y en favorecer su conservación y mantenimiento en el sur.

8. Los elementos del paisaje están ampliamente promovidos por diferentes medidas en los Programas de Desarrollo Rural de las administraciones regionales y estatales de Europa. Sin embargo, la falta de una clara categorización de estos elementos y su promoción por las diferentes partes de la PAC (Pilar I y Pilar II), así como la falta de datos sobre el gasto de las diferentes acciones políticas y medidas promotoras en estos elementos, dificultan la evaluación del impacto de estas en el medio rural. Esto sugiere la necesidad de un registro estandarizado a escala europea del gasto de estado miembro o región en la promoción de cada elemento del paisaje, probablemente asociado al SIG-PAC.

9. La promoción agroforestal en la PAC es compleja, pues pone en práctica unas 25 medidas para promover cinco prácticas agroforestales. Una simplificación de las medidas facilitaría la burocracia relacionada con los pagos y su seguimiento por la Comisión europea de la implementación de las prácticas agroforestales.