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Understanding agroforestry practices in Europe through landscape features policy promotion

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Abstract
Agroforestry understood as the combination of a woody component (forest tree, shrub, fruit tree) with an agricultural use of the understory is not clearly identified as such by the European Common Agricultural Policy (CAP). Despite the protection and promotion of the woody component in different parts of the CAP political text, the identification of agroforestry is not clear, although it can be recognised in the description of some landscape features, such as isolated trees and different types of hedgerows. Moreover, it is important to identify the extent of such woody components promoted by the CAP in agricultural lands to validate the impact of current and future measures. This paper aims at the characterisation of the current extent of landscape features all over Europe by analysing the Rural Development Program (RDP) measures within the CAP 2007-2013 and 2014-2020 that promote said features in Europe to increase the ecosystem service delivery. Isolated trees and hedgerows are protected unsatisfactorily through the Cross-compliance and Greening of CAP Pillar I. In contrast, Agri-environment measures associated to Pillar II are used in most European countries to protect both isolated trees and hedgerows and to promote them as boundary elements. The promotion of hedgerows and isolated trees mainly related to silvoarable and silvopastoral agroforestry practices is aimed at the promotion of the ecosystem services (such as water protection and biodiversity) and improvement in resilience (such as adaptation to climate change) they provide; therefore, the agroforestry environment benefits are indeed recognised. Landscape features comprising woody perennials should be associated with agroforestry when present in arable and permanent grasslands.

Keywords: inventory, hedgerows, isolated tree policy, Common Agrarian Policy

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Introduction

Agroforestry is a sustainable land-use practice (UN 2015, FAO 2015) typically associated with tropical and developing countries. Developed countries have recently recognised the role that this type of land use has to ecointensificate the land and farm system production by optimising the use of resources and delivering more ecosystem services (European Environment Agency 2012). USA has launched an agroforestry strategy where clear agroforestry practices are implemented (USDA 2011, 2013), while the European Union has included Measure 222 in the Common Agricultural Policy (CAP) 2007-2013, which has been extended in the current CAP period with Measure 8.2 (Mosquera-Losada and Nair 2016). Although there is clear understanding of the benefits of agroforestry practices (Place et al. 2012; Nair and Toth 2016) through the preservation and promotion of woody perennials across the whole CAP, they are not linked to the word 'agroforestry', which is instead typically associated with arable lands and grasslands. These benefits are mainly linked to the concept of landscape features, which comprise many types of structures (i.e. ponds, walls...), among which isolated trees and hedgerows are included.

The European CAP consists of two pillars, with Pillar I being completely funded by the European Commission and Pillar II co-financed in different percentages by the Member States (Mosquera-Losada et al. 2016). Landscape features are protected within the conditionality and Pillar I (Greening) of the CAP and usually promoted through the establishment of adequate management practices in agricultural lands (mainly croplands but also permanent pasture) within Pillar II. Landscape features protection has not been very successful due to the difficulty of Member States to control (European Court of Auditors 2009) their extent and the reluctance of farmers to declare landscape features such as isolated trees that may render their land ineligible for Pillar I payments.

Agroforestry, defined as the combination of a woody component (forest trees, shrub, fruit trees) with an agricultural use of the understory, is difficult to identify since most land-use categorisation is based on land cover and not on land use. LUCAS (Eurostat 2013) solved recently this problem by integrating the type of cover and type of use in a given area all over Europe. This facilitates the development of an inventory of those agroforestry practices linked to the presence of woody perennials where an agricultural activity is carried out in the understory, which will help policy makers to establish a baseline to understand what the current situation of isolated trees and hedgerows associated to agricultural activities is all over Europe. This methodology is essential to determine how to establish and adequately develop policies, as well as to evaluate their impacts. This paper aims at the characterisation of the current extent of landscape features all over Europe and the analysis of the Rural Development Programs (RDPs) measures that promote them in Europe within the CAP 2007-2013 and 2014-2020.

Materials and Methods

Current extent of landscape features

The land use/cover area frame statistical survey, abbreviated as LUCAS, is a European field survey program funded and executed by Eurostat. Its objective is to set up area frame surveys for the provision of coherent and harmonised statistics on land use and land cover in the European Union (EU). LUCAS includes data relative to linear elements such as isolates trees (EUROSTAT 2016). The LUCAS survey micro-data of cover and land uses are freely available on the LUCAS website (EUROSTAT 2013). LUCAS surveys were carried out in 2009, 2012, and 2015. In this paper, we have analysed the

2012 data, the year before Croatia became the 28th EU Member State, and thus the results refer to EU-27.

The LUCAS survey was carried out in two phases. In the first phase, more than one million points across Europe were checked and assigned to one of the seven cover classes (arable land, permanent crops, grassland, shrubland and wooded areas, bare-land, artificial land, and water). In a second phase, 270,267 points were selected and visited by surveyors unless they were inaccessible.

On these 270,267 points, surveyors took note of the features included in the 250-m transects. The different features were identified in each transect. In addition, the length occupied by the different characteristics of these points was measured in 1283 transects, allowing to some extent the quantification of the number of meters occupied by a particular feature, identified as the landscape feature mean length (LFML). The estimation of the hectares occupied by each landscape feature was based on the number of times a feature appeared in each specific transect multiplied by the LFML. The results were added up for all 250-m transects at a regional level and divided by the total number of transects, thus obtaining the percentage of a specific landscape feature length in each transect.
The percentage of a feature per transect was multiplied by the total surface of each region to provide an indicator of the number of hectares that each landscape feature occupied, which could also be used in the future to estimate the evolution of landscape features across LUCAS surveys.

Measurements from the RDPs in Europe
A policy analysis evaluating the promotion of landscape features related to agroforestry was carried out for the deployment of the 88 and 118 RDPs of the periods 2007-2013 and 2014-2020, respectively, available in October 2016 from the internet.

The obtained geographical indicators from LUCAS (percentage and number of hectares), as well as the policy indicators (number of measures promoting the introduction or maintenance of isolated trees and hedgerows), were upscaled and mapped per European region using QGIS 2.18.

Results

Extent of isolated trees and hedgerows landscape features

Isolated trees

Figure 1 shows the total number of hectares and percentage of the whole territory for isolated trees per region in Europe. Isolated trees are distributed all over Europe, with the largest number of hectares corresponding to Spain, France, and Lithuania, but poorly represented in Central Europe. The total amount of hectares occupied by isolated trees in Europe accounts to around 300,000 hectares. In terms of the percentage, isolated trees are mainly linked to France, Portugal, part of Italy, and UK, where the presence of trees in land is more common. However, Spain is the country with the largest amount of equivalent hectares of isolated trees in Europe, due to the large extension of its region. Moreover, the maximum proportion of isolated trees in Europe is really low, with less than 0.48% of the total surface of the land.

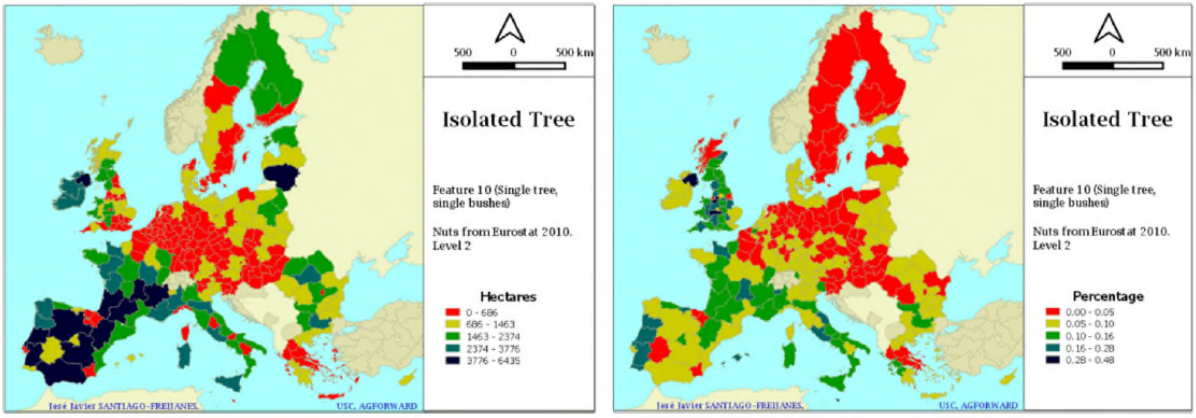

Figure 1. Hectares and percentage of isolated trees in Europe

Hedgerows

The highest percentage of hedgerows is mainly found in France and UK, but also in Portugal and Italy (Figure 2), where this landscape feature is more extensively present than in other European countries. However, hedgerows never represent more than 2.5% of the territory. Again, Spain, due to the extent of its region, includes a large amount of hectares of hedgerows, together with France, Ireland, and UK. In Northern Europe, Finland presents also a large number of hectares allocated to hedgerows. The total amount of hectares was estimated to be 1.8 million for the EU-27.

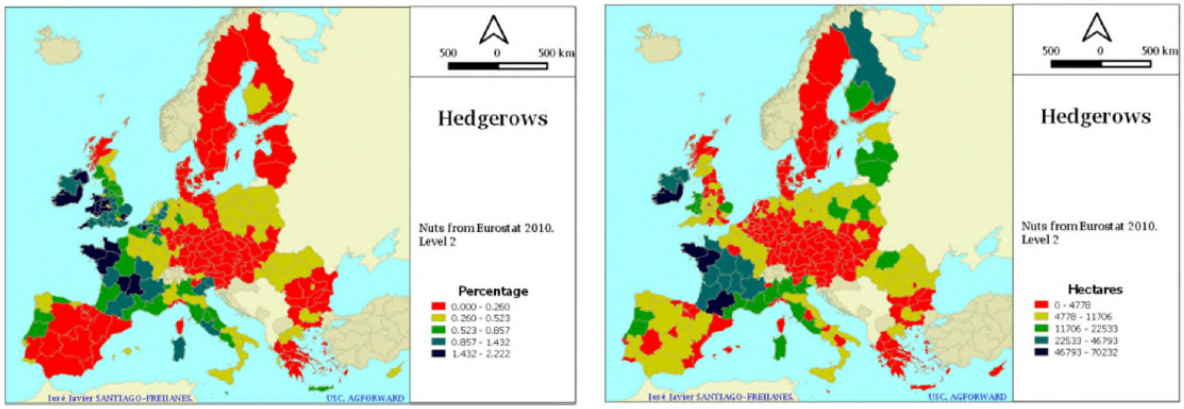

Figure 2. Hectares and percentage of hedgerows in Europe.

Figure 3 presents the percentage and number of hectares of landscape features considered part of agroforestry practices (avenue trees, conifer hedges, bushes, and tree hedges/coppices visibly managed and unmanaged). Avenue trees and managed bushes, trees, and hedges/coppices are better represented across Europe than the other two categories (conifer hedges and unmanaged bushes, trees, and hedges/coppices).

Avenue trees are the most broadly represented hedgerow type across Europe with around 826,000 hectares (Figure 3). In turn, conifer hedges are the hedgerow type with the smallest presence in Europe with a total of 14,882 hectares, mostly located in Southern Europe. The majority of the bush/tree hedges are not managed and account to around 640,000 hectares, being most of those managed found in UK, Ireland, France, and Finland. In terms of land percentage, avenue trees and conifers are mostly present in Northern Europe, with reduced percentages of managed bushes and

tree hedges/coppices. Managed bushes, tree, and hedges/coppices are mostly found in UK, France, Belgium, and the Netherlands, as well as in the North of Italy.

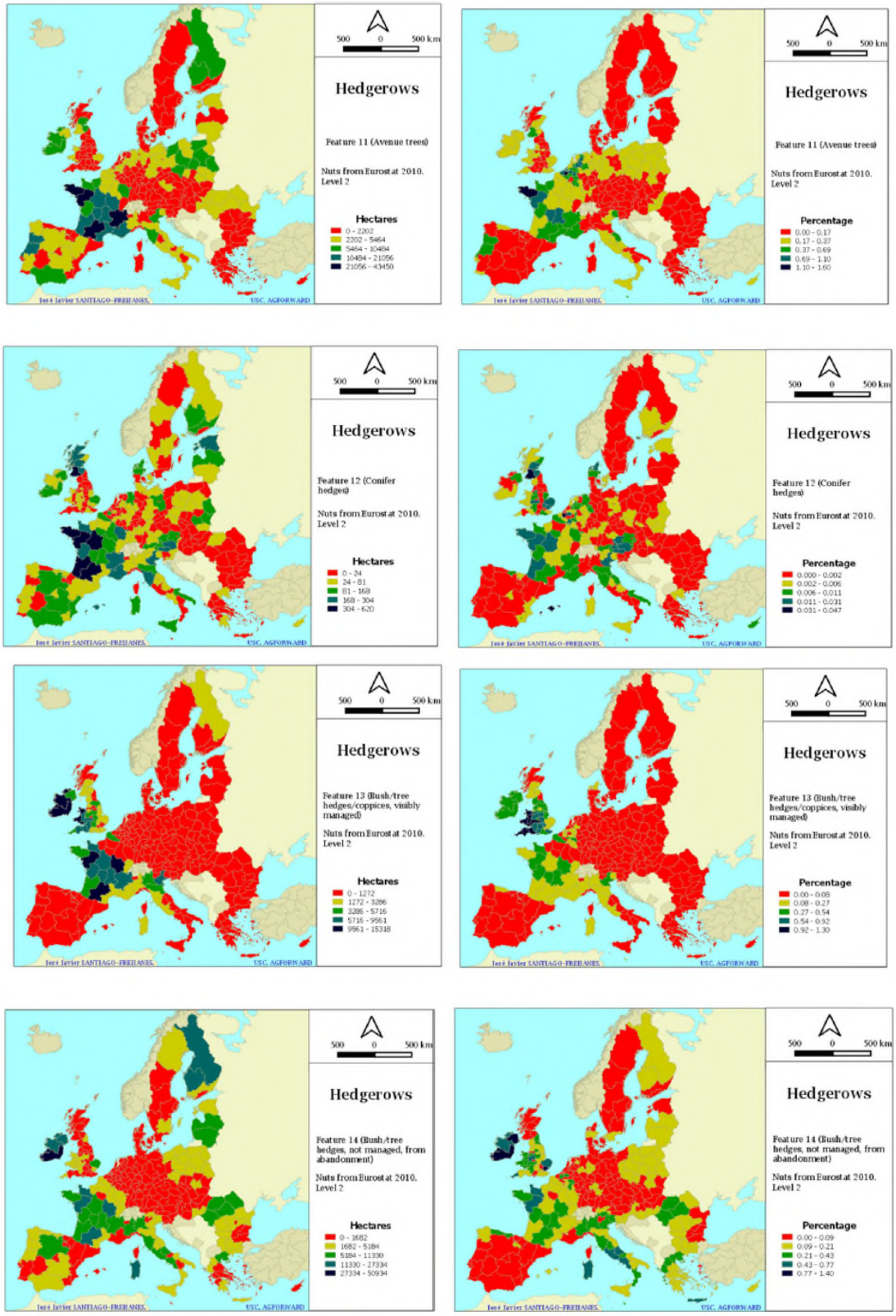

Figure 3. Percentage and hectares of hedgerow types (avenue trees, conifer hedges, bush/tree hedges visibly managed, and bush/tree hedges not managed, from abandonment) across Europe

Rural development promotion of landscape features

Landscape features are extensively promoted through the different Rural Development Programs in Europe, with specific measures linked to isolated trees and hedgerows. In the CAP 2007-2013, isolated trees were protected across Europe, in particular in France, with less support in other regions/countries, such as Andalusia, UK, and some regions in Central Europe (Figure 4).

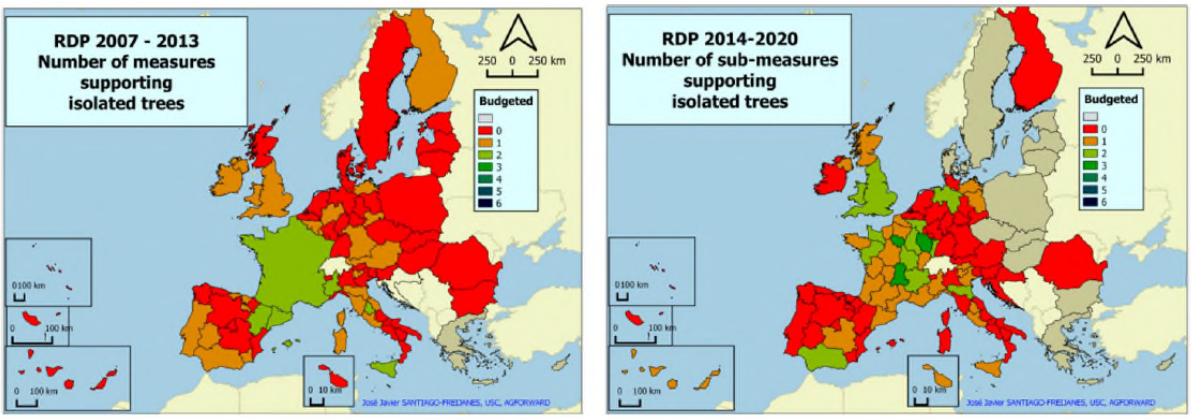

Figure 4. Number of measures promoting the introduction or maintenance of isolated trees

Two measures were implemented in 86% of the Regional RDPs: Measure 214 (20 RDPs, Agri-environment measure) and Measure 216 (12 RDPs, Support for 180 non-productive investments in agricultural lands).Measure 214 was implemented to preserve and maintain this landscape feature, while Measure 216 was oriented to planting trees and promoting crops with sparse trees, as occurred for forest strips and small stands and for hedgerows. In Italy, the Sicily and Marche regions promoted the planting of sparse isolated trees within Measure 222 (agroforestry measure). Some RDPs (3) included isolated tree management through support for non-productive investments in forest lands (Measure 227), while the Toscana region also supported its introduction and promotion. Within Axis 3 of the RDPs 2007-2013, only four RDPs implemented Measure 323 (Conservation and upgrading of the rural heritage) to extend the number of isolated trees, mainly by supporting the tree management and considering the cultural value of the trees (Tables 1, 2, and 3).

Table 1: List of transect landscape features. In grey, the cells associated with agroforestry features in this paper

Code	Label	Code	Label
1	Grass margins < 3 m	23	Fences
2	Heath/Shrub, tall herb fringes < 3 m	24	Electric lines
10	Single tree, single bushes	31	Ditches, channels < 3 m
11	Avenue trees	32	Rivers, streams < 3 m
12	Conifer hedges < 3 m	41	Ponds, wetland < 3 m
13	Bush/tree hedges/coppices, visibly managed (e.g., pollarded) < 3 m	51	Rock outcrops with some natural vegetation
14	Bush/tree hedges, not managed, with single trees, or shrubland deriving from abandonment < 3 m	61	Tracks
15	Grove/woodland margins (if no hedgerow) < 3 m	62	Roads
21	Dry stone walls	63	Railways
22	Artificial constructions (other than dry stone walls)	71	Other linear elements

Table 2. Definition of the main hedgerow types described by EUROSTAT (2013)

Code	Name	Definition
10	Single bushes/trees	These are really single trees being a 'landmark' in a grassland/bushy or cropped area
11	Avenue trees or other line of trees	One line of trees, not clustered trees; two lines of trees (avenue trees) separated by a road
12	Conifer hedges	When they are narrower than 3 m; if the feature is wider than 3 m appears codified as C2x, D10, D20, or E30
13	Bush/tree hedges/coppices visibly managed (e.g. pollarded)	Those hedges are generally under 5 m height; when the features is wider than 3 m it's codified as C10, C2x, or C3x
14	Bush/tree hedges, not managed, with single trees, or shrubland deriving from abandonment	Shrub or wood margins are found as field boundaries within agricultural land or alongside roads or water courses. When wider than 3 m, the code is C10, C2x, C3x, D10, or D20

Table 3: Average length of each landscape feature estimated from the LUCAS (2013) value

Feature number	Name	Measure mean (m)
10	Single bushes/trees	4.76
11	Avenue trees or other line of trees	7.30
12	Conifer hedges	1.5
13	Bush/tree hedges/coppices, visibly managed (e.g., pollarded)	3.64
14	Bush/tree hedges, not managed, with single trees, or shrubland deriving from abandonment	3.85

Within the 2014-2020 RDPs, over 90% of the analysed RDPs currently apply Measure 10.1 (Agri-environment) to promote isolated trees. All RDPs aim at maintaining isolated trees through the Sub-measure 10.1, while Bremen und Niedersachse (Germany), Wales (UK), and Malta aim also at creating such landscape elements. Thirty-seven percent of the RDPs have selected Sub-measure 4.4 (Support for non-productive investments linked to the achievement of agri-environment-climate objectives) to promote the planting of isolated trees. Sub-measure 7.6 (Support for studies/investments associated with the maintenance, restoration, and upgrading of the cultural and natural heritage of villages, rural landscapes, and high nature value sites including related socioeconomic aspects, as well as environmental actions) supports the use of isolated trees in the Berlin und Brandenburg RDPs (promotion of isolated trees) and in four French RDPs (maintenance of isolated trees). On the other hand, Measure 12 is related to the maintenance of isolated trees in Champagne–Ardennes, Auverne, and Lorraine (France) and Sicily (Italy) through Sub-measure 12.1 (Compensation payment for Natura 2000 agricultural areas), while Sub-measure 8.5 aims at promoting and restoring isolated trees in Andalusia (Spain). Sub-measure 13.2 is implemented in Walloniae (Belgium) to maintain farms carrying out environmentally friendly agricultural activities necessary for the conservation of the traditional landscape of this area (individual trees, hedgerows, and copses (groups of trees)). Finally, the Trento Autonomous Province (Italy) has implemented Measure M16 (cooperation) through Sub-measure 16.5 (Support for joint action undertaken with a view to mitigating or adapting to climate change and for joint approaches to environmental projects and ongoing environmental practices) to

support the development, management, and recovery of functional articulation elements of agro-ecosystems, such as by planting isolated trees and other natural elements of the local agricultural landscape.

Hedgerows

Figure 5 shows the distribution of the number of measures and sub-measures supporting hedgerows in the RDPs of the CAP 2007-2013 and 2014-2020. Most countries have increased the number of sub-measures allocated to hedgerow promotion between the previous and current RDPs, in particular in those areas where they are really relevant (e.g., France, UK, and Denmark) and funded by several measures.

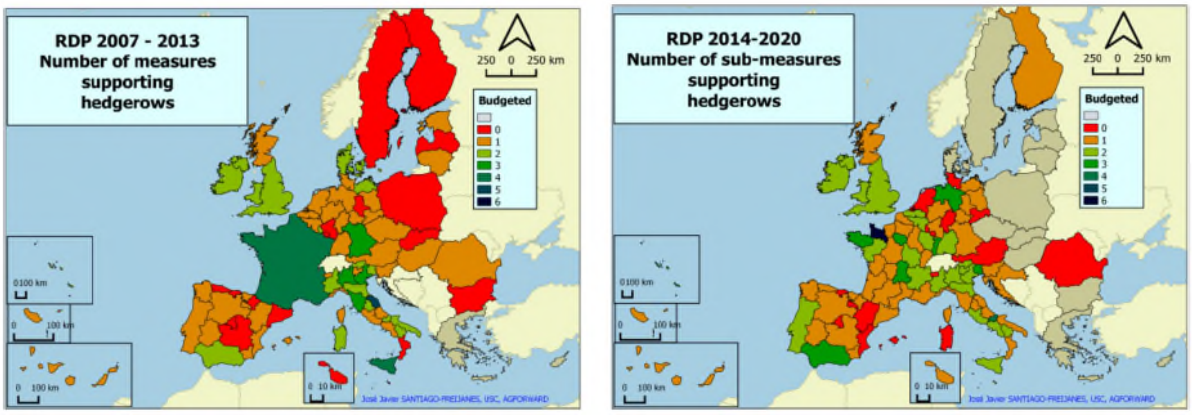

Figure 5 Number of measures promoting the introduction or maintenance of hedgerows

Within CAP 2007-2013, hedgerows were promoted by 13 measures: two in Axis 1, six in Axis 2, four in Axis 3, and one in Axis 4. Again, Measure 214 (39 RDPs) and 216 (30 RDPs) were implemented by 80% of the RDPs to promote isolated trees. Measure 214 was mainly related to hedgerows maintenance, while Measure 216 was usually linked to their establishment. The main aim of the promotion of hedgerows was usually to enhance the ecosystem services. For example, Measure 121 (Modernisation of agricultural holdings) promoting hedgerows was implemented in two RDPs (French continent and Sardinia region), aiming at planting vegetation structures in sensitive areas (France) and the protection of water and landscape recovery (Sardinia). Measure 213 guaranteed Natura 2000 payments and payments linked to Directive 2000/60/EC, which in some RDPs required a commitment to the prohibition of eliminating already existing hedgerows, while the RDP of Marche (Italy) included payments for the introduction of hedgerows as a means for the conservation of avifauna birds.

The establishment of wooded hedges was explicitly eligible using Measure 221 in Romania and Puglia (Italy), as long as they were at least 20 m wide and identified as forest belts. In Italy, the Sicily and Marche regions described hedgerows explicitly as eligible for Measure 222. A number of RDPs (4) mainly included the improvement of hedgerows within the support of non-productive investments (Measure 227). However, hedgerows were also seen as a way to improve the economic value of forests, such as in the RDP of Madeira (Portugal), which used Measure 122 to promote the introduction of discontinuous elements (including hedgerows). Rural activity diversification and infrastructure purchase, including hedgerow promotion, are linked to Axis 3. The RDP of the Marche region promoted the inclusion of hedgerows in arrangement with the neighbouring open space in properties used for farm tourism through Measure 311 (Diversification into non-agricultural

activities). With Measure 312 (Support for the creation and development of micro-enterprises), Lombardia (Italy) supported, among other activities, the adaptation, construction, and purchase of equipment and machinery needed for the 'implementation of hedgerow pruning'. Denmark used Measure 322 (Village renewal and development) to promote hedgerows.

Thirteen RDPs used Measure 323 (Conservation and upgrading of the rural heritage) to promote hedgerows, generally supporting their restoration or improvement and, in some cases, such as in the French hexagon RDPs, also their introduction. Finally, La Rioja (Spain) used Measure 412 (Local development strategies. Environment/land management) of Axis 4 to fund non-productive investments, such as the recovery of hedgerows and boundaries between farms.

Within the current CAP (2014-2020), 75 RDPs promote hedgerows, around 93% of which are implemented by Measures 10.1 and 4.4, as in the case of isolated trees. Measure 10.1 (Agri-environment) is used by 70% of the RDPs to promote the maintenance and conservation of hedgerows. Forty three regional RDPs from Italy, France, Spain, UK, Germany, Belgium, Bulgaria, Croatia, and Ireland use Measure 4.4 (Investments in physical assets) aiming at supporting non-productive investments linked to the achievement of agri-environment-climate objectives in order to plant and/or restore land, while the RDP of Toscana (Italy) describes a second operation to promote its conservation. Bretagne (France) also uses Sub-measure 4.3 (Support for investments in infrastructure related to development, modernisation, or adaptation of agriculture and forestry) to improve existing hedgerows. Vocational training and skill acquisition aiming at increasing the added value of hedgerows are linked to Sub-measure 1.1 in Basse-Normandie (France), while demonstration activities and information actions are endorsed by Sub-measure 1.2. Advisory services are targeted in Basse-Normandie to evaluate hedgerows as an item with two operations from Sub-measures 2.1 (Support to help benefiting from the use of advisory services) and 2.3 (Support for training of advisors).

The Azores (Portugal) RDP uses Sub-measure 5.1 to support investments in preventive actions aimed at the reduction of the consequences of natural disasters, adverse climatic events, and catastrophic events by using hedgerows, as well as to guard natural-disaster protecting crops from wind and rain and consolidate the soil to avoid erosion. This region also promotes the establishment of shelterbelts of trees to protect pasture and animals as one of the eligible operations of the agroforestry measure (sub-Measure 8.2). Sub-measure 7.4 also supports hedgerows in mainland Portugal. Seven RDPs (three in Germany and four in France) implement Sub-measure 7.6 (Support for studies/investments associated with the maintenance, restoration and upgrading of the cultural and natural heritage of villages, rural landscapes and high nature value sites including related socioeconomic aspects, as well as environmental) to promote the introduction and maintenance of hedgerows. Through Sub-measure 8.5 (Support for investments improving the resilience and environmental value of forest ecosystems), hedgerows are promoted in Navarra and Andalusia (Spain) and Madeira (Portugal).

Molise (Italy) includes hedgerows in the list of prizes regarding organic farming (Measure 11), both for conversion (11.1) and maintenance of organic farming (11.2), while Friuli-Venezia-Giulia (Italy) pays fees for the obligation of 'band buffer maintenance' included in Measure 12 (Sub-measure 12.1: Compensation payment for Natura 2000 agricultural areas). Sub-measure 12.1 is also used in Auvergne (France) for the promotion of hedgerows as a source of economic activity and biodiversity conservation and in Sicilia (Italy) to improve the retention of landscape features, including, where

appropriate, hedges, ponds, ditches, and trees in line, in group, or isolated. Wallonia (Belgium) aims through Measure 13.2 at maintaining holdings with favourable agricultural activities and the environment required for the conservation of landscape features, including hedgerows which are traditional in those rural areas. Finally, Sub-measure 16.5 (Support for joint action undertaken with a view to mitigating or adapting to climate change and for joint approaches to environmental projects and ongoing environmental practices) is used in Trento (Italy) to support the development, management, and recovery of functional elements of agro-ecosystems, such as hedgerows and other natural elements of the agricultural landscape.

Discussion

Landscape features including isolated trees and hedgerows are not uniformly defined across Europe in the CAP (Pillar I and RDPs), with evident differences in terms of the length and width and species composition across the different countries. The lack of a global definition and the different specific characteristics finally approved hampers the creation of a record of the different types of landscape features promoted by the CAP and the evaluation of the impact of landscape feature policies at the European level, as well as the development of better policies to extend the use of these landscape features focused on a specific type of isolated trees or hedgerows. Isolated trees are broadly distributed in Europe, in particular in Southern countries, while hedgerows are more associated with Northern and North-Western Europe. The larger presence of isolated trees in the South may be linked to the benefits they provide for the adaptation of crops and grassland to climate change, but also to act as a fodder for animals, since most of them serve to feed animals during summer and winter. Hedgerows are more present in areas where strong winds reduce the crop production (Kachova et al. 2016 and Krčmářová et al. 2016) and in those suffering most from Karstic winds, such as Eastern Europe. In particular, UK has already an important policy system (DEFRA 1997) to protect hedges, reflected in their still-managed hedgerow percentage. Hedgerows, linked in some cases to water courses, are promoted in different RDPs with different measures, and are thus related to riparian buffer strips.

Most isolated trees correspond to ancient trees and, as hedgerows, they are protected under National Laws and Regulations. UK and Ireland created in 1997 a specific Regulation to promote hedgerows in order to maintain the biodiversity and reduce the negative effects of wind on the crop production (DEFRA 1997). In those countries, hedgerows are fully eligible and can be used to receive Greening payments. These landscape features are especially important in countries like Ireland, where weather variability makes it difficult to fulfil the diversification requirements of Pillar I due to their short growing season period. Other countries like France, The Netherlands, or Belgium have been using the Agri-environment measures within Pillar II of the previous and current CAP to introduce hedgerows or hedges. Hedgerow-related activities are linked to Cross-compliance, Greening (Pillar I), and mainly Agri-environment (Pillar II) measures, which complicate the evaluation of the support to these landscape features. The condition to receive payments in any of the different sections of the CAP is that the same activity cannot be paid twice within the same landscape feature. However, all payments coming from different CAP sections can be complementary. Surveys carried out on the managing authorities of the CAP claim that the creation of an inventory of these landscape features (i.e., isolated trees meaning tree canopies over 4 m) is too complicated, because it means that a strong control over their maintenance has to be carried out later on. Therefore, they prefer to choose other landscape characteristics easier to audit.

The evaluation of the impact of the CAP with regard to hedgerows and isolated trees as part of Cross-compliance, Greening, and Agri-environment measures is complex due to the existence of three places in EU regulations where they can be selected to receive CAP payments. The selection of hedgerows and isolated trees by some Member States is also poor due to the difficulties in auditing them. This in turn hampers the evaluation of the real impact of CAP on both specific landscape features. Easier approaches to control them should be developed in order to really improve their protection at the field level.

Measure 214 (currently mainly linked to Sub-measure 10.1) has been the most popular measure to preserve landscape features within the current and previous CAP RDPs, while Measure 216 (currently mainly linked to Sub-measure 4.4) is usually related to their introduction. However, other measures used in different regions (and for different reasons) are available that promote these landscape features in other regions of Europe. The promotion of forest strips and small stands, hedgerows, and isolated trees mainly linked to silvoarable agroforestry practices considers the ecosystem services (water protection, biodiversity) and resilience (climate change) they provide, and thus agroforestry ecosystem benefits are indeed recognised. Landscape features comprising woody perennials should be associated with agroforestry when present in arable and permanent grasslands.

Conclusion

The extent of landscape features across Europe is rather small in terms of the percentage of land use per region, being avenue trees the most represented feature in Europe. Landscape features are indeed broadly promoted by different measures in the Rural Development Programs of the European Member States. However, the fact that landscape features are not (i) clearly categorised across Europe and (ii) promoted in different parts of the CAP (Pillar I and Pillar II), as well as the lack of data of the level of expenditure of different policy activities and measures on such landscape features, hamper the evaluation of the impact of the CAP on the promotion of landscape features. Therefore, a standardised record across countries of the degree of expenditure on each type of landscape features should be carried out at the European level.

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