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Technology or policy? Drivers of land cover change in northwestern Spain before and after the accession to European Economic Community

Eduardo Corbelle-Rico[a,*], Van Butsic[b], María José Enríquez-García[a], Volker C. Radeloff[c]

[a] Land Laboratory, Department of Agricultural and Forest Engineering, University of Santiago de Compostela, Escola Politécnica Superior, Campus Universitario, 27002 Lugo, Spain
[b] Department of Environmental Science, Policy and Management, University of California-Berkeley, 130 Mulford Hall #3114, Berkeley, CA 94720, United States
[c] Department of Forest and Wildlife Ecology, University of Wisconsin-Madison, 1630 Linden Drive, Madison, WI 53706, United States

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ABSTRACT

Major changes in land cover can result from distant political, social, and environmental forces. Over the last 50 years, many technological innovations and political changes have transformed agriculture in Europe, resulting in substantial decrease of farmland area in many parts of the continent that potentially signify a shift in European land use systems. However, the relative importance of technological advances and agricultural policy to these changes is not well understood, and our goal here was to disentangle them. Because of its unique political context, Spain offers an ideal laboratory to investigate the impacts of technological and political innovations to regime change in land systems. During the time when agricultural innovation was at its peak (1960–1980) Spain was not part of the European Economic Community (EEC). The Spanish agricultural sector then experienced a shock after joining the EEC in 1986. Using historical aerial photographs, land use maps, and Farm Structure Surveys as our reference data, we compared changes in land cover in Terra Chá, a district of Northwest Spain from 1956–1984 and 1984–2005, i.e., approximately before and after the EEC accession in 1986, using spatially explicit multinomial logit models to quantify the relative impacts of technological innovation and political change on agriculture and forest lands. In our study area much more substantial shifts in agricultural and forest land took place after EEC accession than before. The dominant shift was a substantial increase in forest cover (from 7% to 31% of the landscape) and concurrent loss of agriculture (from 45% to 38%) and shrubland (from 46% to 27%). The role of drivers acting at parcel level was constant between time periods, which suggests that accession to EEC was a strong driver of change.

Introduction

Patterns of land use changes in agrarian landscapes are the result of complex, multi-dimensional processes. Social, economic, technological, and policy issues intertwine, often acting at different scales (Baldock et al., 1996; Geist et al., 2006; Rey Benayas et al., 2007). Rapid changes in land use systems can be triggered by technological innovations (Hasselmann et al., 2010), political change (Hostert et al., 2011), and environmental forces (e.g. Wang et al., 2011; Silva et al., 2011), but the relative impacts of these forces vary across space and time. Occasionally, these triggers can result in shifts in land use systems where new modes of land use dominate the landscape. Such land use system changes can have profound impacts on the livelihood of people (Carr and McCusker, 2009), biodiversity (Reidsma et al., 2006; de Chazal and Rounsevell, 2009), and the provisioning of ecosystem services (Metzger et al., 2006).

The importance of land system changes makes it important to understand their drivers, but assessing the relative impact of technological innovation and political changes is challenging because these two typically co-occur and interact (Voss et al., 2006). Political institutions can foster innovation but also constrain it through regulation. Similarly, changes in technology influence the political realm and impact market integration (Weare, 2002). Disentangling these disparate forces, especially when they affect large areas, is thus challenging.

* Corresponding author. Tel.: +34 982 823 324.
E-mail address: eduardo.corbelle@usc.es (E. Corbelle-Rico).

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In Western Europe, agricultural land systems have changed substantially since the mid-20th century due to depopulation of rural areas, the mechanization of farming operations, and European Union agricultural policy. While varying in onset and pace among regions, the overall impact has been large change to rural communities, economies, and environments (Rabbinge and van Diepen, 2000; Krausmann et al., 2008). For example, in the United Kingdom mechanization and specialization of farming, resulted in declining agricultural land area since at least the 1960s (Bibby, 2009; Angus et al., 2009), and similar patterns occurred in France (Mottet et al., 2006), or Italy (Falcucci et al., 2007).

At the same time that mechanization and specialization was taking place in the agricultural sector, the economic integration of Europe also began in earnest. Starting with the founding of the European Economic Community (EEC) in 1963 and advancing to the present day Common Agricultural Policy (CAP) subsidies, the core European countries have shared policies that regulate prices and quantity of agricultural products. Furthermore, as these policies increased trade and market integration, they further fueled mechanization and specialization. As such, the combination of mechanization, specialization, and European agricultural policies has fundamentally changed Europe's landscapes, but the relative impact of these factors is not clear.

Spain offers a unique context in which to disentangle the relative impacts of technological innovation and political changes on land systems due to its relative political isolation from 1950 to 1980. Mechanization and industrialization became common in Spanish agriculture about a decade later than in other European countries (Naredo-Pérez, 1996) when a period of considerable growth started in 1960 (Prados de la Escosura, 2002). Specialization and mechanization have thus been a feature of Spanish agriculture for 50 years leading to intensification of agricultural use in the most productive soils, and farmland abandonment in the more remote, marginal areas (e.g. Nainggolan et al., 2012; Muñoz-Rojas et al., 2011; Calvo-Iglesias et al., 2009).

However, many of these technological changes took place while Spain was politically and economically isolated. Spain did not join the EEC until 1986, more than 20 years after most of the other major European economies. Although mechanization and specialization were certainly present when Spain joined the EEC, the new political situation resulted in a major transformation in agricultural markets and concurrently in the agricultural landscape. This event was particularly disruptive because it coincided with major changes in the European Union's (EU's) CAP in the mid-1980s and early 1990s. Specifically, the CAP moved away from its original aim of price support and focused more on limiting the production of goods which were overly abundant. While the original policy instruments that provided price support remained in place after 1992, they were much reduced in importance and complemented by other measures (Baltas, 1997). These additional measures included: (a) compensation for price cuts in the form of payments based on historic acreage or livestock numbers, but severing the link to the quantities produced; (b) measures to limit land use (i.e., set-asides of arable land and stocking rate criteria) and retention of earlier supply management measures such as the milk production quotas (established in 1984); (c) agri-environmental and afforestation regulations and subsidies, and support for early retirement.

Because of its unique history, Spain is an interesting natural experiment in which to research the roles of agricultural innovation and market integration in regime shifts of land use systems. Spain's political and economic isolation during the period of innovation (roughly 1950–1980) offers the chance to observe the impacts of these technological innovations relatively separate from the impacts of economic integration. Likewise, Spain's accession to the EEC in 1986 is an excellent point to look at the impact of economic integration on land cover change, since many major technological changes had already taken place by then, and the accession exposed Spanish farmers rapidly to a large number of market changes.

Our goal was thus to understand the relative impacts of landscape shifting forces – technological and political innovation – on agricultural and forest lands in a district of Northwest Spain, Terra Chá.

Our specific questions were:

1. Which were the main land cover transformations before and after integration to the EEC?
2. How did these transitions and their drivers differ between the pre and post EEC accession periods?

Methods

Study area

We studied land cover change in the district of Terra Chá, located in the northwest of Spain, in the autonomous region of Galicia. The district comprises nine municipalities (Fig. 1) and covers a total area of 1822 km^2, from 1950 to 2005. The study area consists of a central plain (Terra Chá is Galician for "flat land"), surrounded by mountains some of which mark the border with neighboring districts. Climate is generally maritime, although short episodes of drought are not infrequent during summer.

Agricultural production in the mid-20th century was dominated by a two-year rotation including wheat, turnips, potatoes, and maize for human consumption. Integral to the system were also extant shrubland areas which were grazed, but also periodically harvested and mixed with manure to create fertilizer. By the early 21st century, most family farms specialized in dairy production, and the dominant agricultural system became a combination of permanent pastures and corn for forage.

As in most other rural areas of Spain, depopulation took place during the whole study period (from 76,000 inhabitants in 1950 to 46,000 in 2005). The number of farms decreased from 16,000 in 1962 (INE, 1964) to 10,700 in 1999 and 5580 in 2009 (INE, 2013), with many small farms ceasing to exist in particular after 1989 (Corbelle-Rico and Crecente-Maseda, 2008). Nevertheless, by 2005, the average farm size was only 11 ha (including parcels not used for crops or pastures), and farmland was highly fragmented, with a total number of 440,000 parcels according to cadastral data, resulting in a mean parcel size of only 0.5 ha.

Land cover data

We used two types of historical land cover data. First, we mapped land cover types by interpreting historical aerial photographs from 1956 and 1984 (corresponding to series B and D of the Spanish National Photogrammetric Flight at 1:30,000 scale). The dates in which both photographic datasets were originally acquired are placed slightly earlier than the economic boom of 1960 and the access to EEC in 1986, which we think can help to better identify their actual impacts. Second, we used a land cover map (*Mapa de Cultivos y Aprovechamientos*, MCA) published by the Spanish Ministry of Agriculture in 2010. For our study area, this map depicted land cover in 2005. Aerial photographs were scanned, orthorectified, and prepared as a mosaic for the entire study area. Land cover for 1956 and 1984 was determined by visual interpretation of the aerial photographs, while land cover in 2005 was automatically taken from the MCA land cover map.

From the land cover maps, we drew a stratified random sample of 2638 points that were at least 500 meters apart to limit spatial autocorrelation. Sampled plot allocation was proportional to the area of each municipality. For each point, land cover was classified

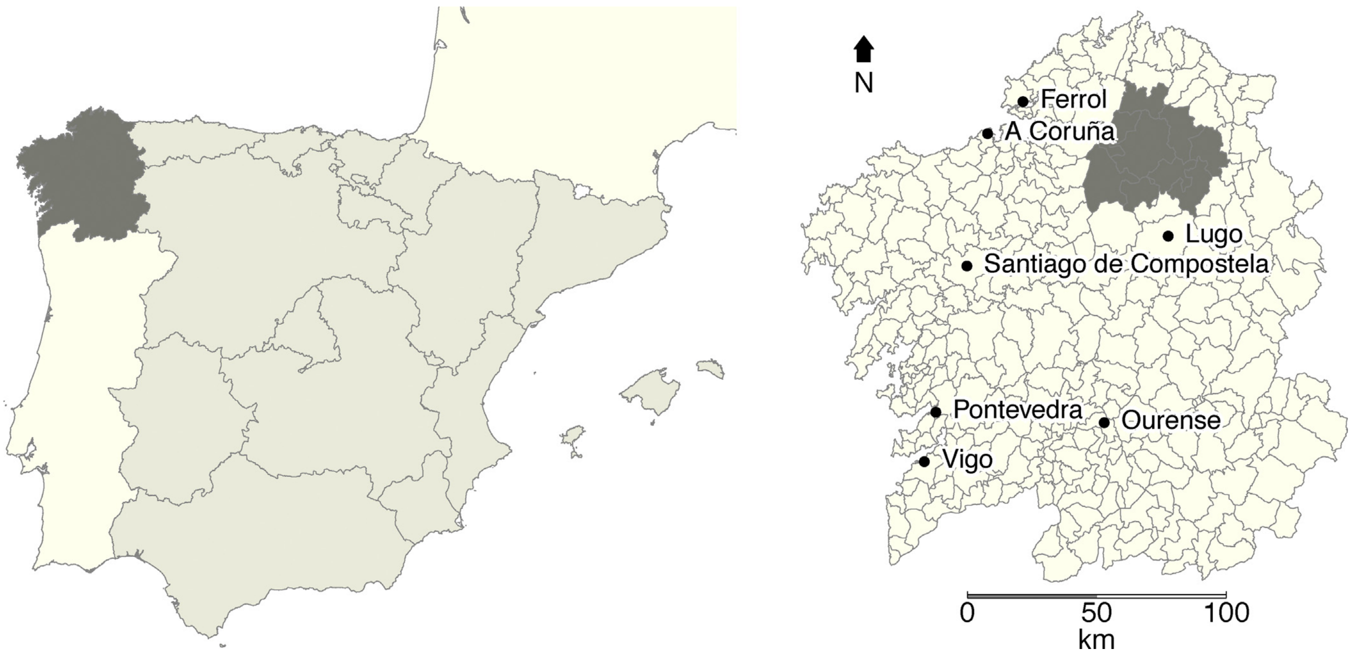

Fig. 1. Location of the study area in Galicia (right, with main cities shown) and Spain (left).

into one of four categories: agricultural land (Ag; including categories arable land, permanent pastures, orchards and vineyards in the MCA land cover map of 2005), forest (Fo), shrublands (Sh; including areas covered by low standing woody plants), or unproductive (Un; including artificial impervious surfaces, water courses, rocks and bare earth in areas where vegetation might not grow). Each point was sampled in each period, creating a database of 2638×3 observations of potential land cover changes which we were able to integrate into our modeling framework.

In our study area, the relationship between land cover and land use varied among different land covers and time periods. We assumed that agricultural land cover is consistent with agricultural use in all time periods. However, shrubland cover was associated with agricultural use in the first time period (1956–1984) when it was needed for fertilizer production, but not in the second period, when it was more often associated with farmland abandonment. Likewise, forest cover may or may not be associated with timber production. Therefore, what we modeled were changes in land cover, and from these changes we made inferences about the land use system.

Other data used for modeling

In addition to land cover data we collected spatial data on a host of explanatory variables that may influence land cover transitions. These variables were derived from various ancillary cartographic and statistical sources of different public agencies, at the most detailed scale available. Variables related to parcels and their structure were derived from the Spanish Land Parcel Information System[1] (*Sistema de Información Geográfica de Parcelas Agrícolas*, SIGPAC). These variables included parcel area (m^2), parcel shape (using a non-dimensional coefficient calculated as $4\sqrt{\text{Area}(m^2)}/\text{Perimeter}(m)$), adjacency to public roads (true/false), and adjacency to water courses (true/false).

Information about the elevation (m) and average slope (%) of a given sample point was derived from the Digital Elevation Model published by the Spanish Geographic Institute with pixel size of 5 m (IGN, 2013). Soil suitability for maize, grasslands and pines was extracted from a map published according to FAO (1976) recommendations by Díaz-Fierros Viqueira and Gil Sotres (1984). Distance from sample observations to nearest buildings and towns was derived from information available at the Local Infrastructure Survey of the province of Lugo.[2] Other variables (see Table 2) were derived from different databases produced for the Regional Administration, including location of common lands, colonization areas and land consolidation projects. Each of these three variables was coded as 1 for sample points located in a given area, and 0 otherwise.

We analyzed three policy variables to capture both the ownership of the land, and the policies that influence ownership. Communal lands are collective private properties in Terra Chá where ownership is determined by place of residence. Rights of use are granted to any family with permanent residence in the town to which the land is assigned. Collective use is typically regulated by decisions made in assembly. Common lands were the main source of fuelwood, biomass for manure production, and extensive grazing lands in the 1950s (Balboa López, 1990), when they were mostly covered by shrubs. Today, management of communal lands is often a source of conflicts (Gómez-Vázquez et al., 2009). In our models communal lands were indicated by a dummy variable equal to one if the point fell in a communal parcel.

The National Colonization Institute (created in 1939) established three colonization areas within our study area (out of the almost 300 colonization areas created in Spain between 1945 and 1970 (Centellas Soler, 2010)). Their main objective was to serve as examples of innovative agriculture, providing farmers with plots of adequate size and shape, and usually irrigation. The three colonization areas in our study area were created by decree in 1956 and 1957, occupying what were communal lands before, and settlers arrived in 1966 and 1967 (Cardesín Díaz, 1987). We modeled the presence of colonization lands by using a dummy variable (equal to

[1] SIGPAC is based on cadastre maps and was created in 2003–2004 to comply with European Union Council Regulation 1593/2000.

[2] http://www.idealugo.es.

1) if a point falls within the colonization lands. Furthermore, land consolidation programs were established since the early 1950s in our study area to reduce land fragmentation (Miranda et al., 2006). Parcels were consolidated so that each landowner retained the same area of land but in larger parcels.

Modeling

The purpose of our models was to quantify the impact of a host of variables on the four main land cover transitions in the study area: Agriculture to shrub (usually associated with farmland abandonment), agriculture to forest (often but not always a forest management decision), shrub to forest (usually but not always through succession) and shrub to agriculture (agriculture expansion). A variety of different models can be used for this purpose, including logit regression (e.g. Choi et al., 2011; Xu et al., 2013), hierarchical partitioning (e.g. Prishchepov et al., 2013) and data mining techniques (Zaragozí et al., 2012). We chose a multinomial logit model because in our case landowners face three transition choices. The multinomial logit model allowed us to quantify each land cover transition in relationship to the other possible choices making it superior to multiple logit models. Because we had repeated observations, we clustered the standard errors at the observation level to account for possible correlation among observations over time.

Land cover transitions often have a spatial dimension where neighborhood changes can affect land cover. We accounted for this in our models via spatial lag variables that represent the number of neighbors undergoing a given transition. In each model we included a spatial lag variable for each possible transition. For example, in the model for transitions from agriculture we included a term depicting how many neighbors (out of a possible four) also transitioned to shrub and how many neighbors to forest. In addition to describing the spatial process of land cover transition, these variables can correct for spatial correlation, which may be present in models of land cover change.

Our models were rich in explanatory variables because we were interested in the impact of biophysical (elevation, slope, soil type), locational (distance to buildings, distance to towns, adjacent to main roads, adjacent to parks), parcel (size, shape), policy (communal land, land consolidation, and colonization) and neighborhood effects (number of neighboring points which transitioned) on land cover transitions (Table 2).

Finally, to test for differences in underlying drivers between time periods we also ran the models with a time dummy variable, which we interacted with each independent variable. The impact of the interaction term can be interpreted as the difference between the pre- and post-accession effect of the variable. Due to collinearity caused by including all the interactions at once, we added interactions only one at a time to quantify whether the addition of the interaction variable was statistically significant or not.

Results

We observed a reduction of agricultural area (45–38% of total district area) from 1956 to 2005 and a notable increase in forest area (7–31%). The decrease of the agricultural area was particularly rapid after 1984, while the increase in forest area was more evenly distributed among the two periods. Shrublands also showed major declines from 46% to 27%. Among our 9 municipalities agricultural area actually increased in six of them prior to 1956, but decrease in all nine thereafter (Fig. 2).

The main land cover changes from 1956 to 1984 were the conversion of former shrublands to agricultural use (10% of total district area) and the abandonment of former agricultural lands resulting in the growth of shrublands (7%). After 1984, the two major processes were the abandonment of agricultural land, either resulting in forests (8%) or shrublands (5.6%). Conversion of former shrublands and wooded areas to agricultural use also occurred (in total 6.5% of district area), but this was not enough to compensate the loss of agricultural land elsewhere. In total, 18% and 12% of agricultural area changed to tree-covered areas and shrublands respectively after 1984 (Table 1).

The results of the multinomial logit models from agriculture were largely intuitive and similar to other land change studies. Parcels that had steeper slopes were further away from buildings and towns were more likely to transition from agriculture to either shrubland or forest. Land consolidation and colonization policies tend to reduce the likelihood of transitions from agriculture. Soil quality (at least as we have classified it) was a prime driver land cover transitions. The likelihood of conversion differed between municipalities but conversion was always more likely in the second time period. The number of neighbors who transitioned suggests that there may be a homogenization process occurring (Table 2).

The transitions from shrub to agriculture and forestry were somewhat similar. Steep slopes increased transition to forest, and decreased transitions to agriculture. Similarly, further distance from buildings reduced the likelihood of a transition to agriculture. The likelihood of a transition to forest increased after 1984 and parcel shape was influential in this transition. Land colonization made parcels more likely to transition to agriculture and less likely to transition to forest. Soils identified as highly suitable for grass production increased transitions to both agriculture and forest.

When interaction terms were added one at a time to the multinomial logit model, the only interaction variable that was statistically significant at conventional levels was parcel size in the transition between agriculture and shrub. In both periods, larger parcels were more likely to transition, but much more so in the first period. The inclusion of the interaction terms did not change the significance of any of the other variables. Therefore, there was little evidence that the main parcel-level drivers of land cover transitions changed between periods. Rather, point attributes tended to impact transitions evenly in each time period. This suggested that the large changes in the landscape that took place during the post-EU period were not the result of changes in what type of parcels were valuable, but rather due to changes that affected all landowners.

Discussion

Main land cover changes before and after access to EEC

We investigated dynamics of land cover changes in Terra Chá, a district of Northern Spain, paying special attention to the timing of changes in relationship to technological and political changes. The study area went through a major rearrangement of land cover where shrubland went from the dominant land cover class to the least common class, while forest land increased by over 400% due to widespread succession and man-made afforestation. Furthermore, the magnitude of the impacts of the EU accession may have been even larger since many of 2005 the shrublands occurred on farmland abandoned since 1984 and may transition to forest in the long run.

Technological innovation, especially the availability of synthetic fertilizers, resulted in the decline of traditional farming methods where extensive shrublands supplied biomass for fertilizer production as well as low intensity grazing (Balboa López, 1990). Agriculture mechanization favored the use of synthetic fertilizers over traditional fertilization methods, and this often caused shrublands to transition to pastures, cropland, or forests. Indeed our results showed that shrublands decreased both before and after

Table 1
Transition matrix for the periods 1956–1984 and 1984–2005 (in % of total district area).

	From	To				
		Agriculture	Forest	Shrublands	Unproductive	Total
1956–1984	Agriculture	32.9	4.0	6.6	1.1	44.6
	Forest	2.1	4.6	0.3	0.2	7.2
	Shrublands	10.3	4.4	30.6	0.6	45.9
	Unproductive	0.3	0.2	0.0	1.7	2.2
	Total 1984	45.6	13.2	37.5	3.6	100
1984–2005	Agriculture	30.9	8.2	5.6	1.0	45.7
	Forest	1.6	9.4	2.1	0.1	13.2
	Shrublands	4.9	12.8	19.4	0.5	37.6
	Unproductive	1.0	1.2	0.4	1.0	3.6
	Total 2005	38.4	31.5	27.5	2.6	100

Table 2
Results of multinomial logit regression. Numbers indicate estimated values and standard error (in brackets) of regression coefficients.

Variable name	Definition	From: Agriculture To: Forest	From: Agriculture To: Shrub	From: Shrub To: Agriculture	From: Shrub To: Forest
Parcel shape	Shape of parcel between 0 and 1 where 0 equal to a line and 1 a square	0.729 (0.453)	0.244 (0.462)	1.662*** (0.410)	0.719* (0.400)
Ag neighbor to forest	Number of neighbors (out of 4) that transition from agriculture to forest	0.242** (0.123)	−0.0145 (0.144)		
Ag neighbor to shrub	Number of neighbors (out of 4) that transition from agriculture to shrubs	−0.177 (0.144)	0.249** (0.120)		
T2	Time dummy = 0 for pre EU time period, 1 for post EU time period	0.969*** (0.139)	0.0996 (0.139)	0.172 (0.144)	1.518*** (0.141)
Adjacent to water	Equal to 1 if parcel is adjacent to water	0.432** (0.197)	−0.237 (0.212)	−0.180 (0.208)	0.154 (0.175)
Adjacent to road	Equal to 1 if parcel is adjacent to a public road	0.0443 (0.159)	0.0890 (0.162)	0.0854 (0.167)	0.374** (0.164)
Parcel area	Log of parcel area	0.0597 (0.0502)	0.114** (0.0468)	−0.0294 (0.0474)	0.00696 (0.0476)
Elevation	Log of elevation	−1.450* (0.794)	1.865** (0.736)	−0.896 (0.656)	−3.565*** (0.583)
Slope	Log of slope	0.703*** (0.104)	0.505*** (0.0995)	−0.504*** (0.0969)	0.0901 (0.0910)
Building	Log of the distance to nearest building	0.571*** (0.0846)	0.918*** (0.0961)	−0.585*** (0.105)	−0.0673 (0.0961)
Distance	Log of distance to nearest town	0.247*** (0.0861)	0.131 (0.0873)	−0.0761 (0.119)	−0.0303 (0.108)
Common lands	Equal 1 if lands is held in common ownership	−0.112 (0.283)	−0.130 (0.272)	−0.286 (0.226)	0.0580 (0.177)
Colonization	Equal 1 if lands has been colonized	−1.254** (0.508)	−0.951** (0.384)	0.612* (0.333)	−11.14*** (0.668)
Land consolidation	Equal 1 if part of land consolidation program	−0.00959*** (0.00334)	−0.00833** (0.00345)	0.00115 (0.00288)	−0.00415 (0.00305)
Maize	Equal to one if soil is good for maize	−0.0522 (0.178)	−0.131 (0.172)	0.0723 (0.171)	0.240 (0.160)
Pine	Equal to 1 if soil is good for pine	−0.0498 (0.216)	−0.504** (0.216)	0.207 (0.256)	0.212 (0.277)
Grass	Equal to 1 if soil is good for grass	0.651 (0.512)	0.159 (0.380)	0.871** (0.373)	0.445* (0.269)
Shrub neighbors agriculture	Number of neighbors (out of 4) that transition from shrub to agriculture			0.420*** (0.114)	0.0814 (0.130)
Shrub neighbors to tree	Number of neighbors (out of 4) that transition from shrub to forest			0.0553 (0.131)	0.602*** (0.0909)
Constant		−0.881 (4.761)	−20.39*** (4.431)	6.960* (3.762)	18.33*** (3.295)
Observations		2300	2300	2147	2147

Asterisks summarize signification levels: * for p-values lower than 0.05, ** for p-values lower than 0.01, *** for p-values lower than 0.001.

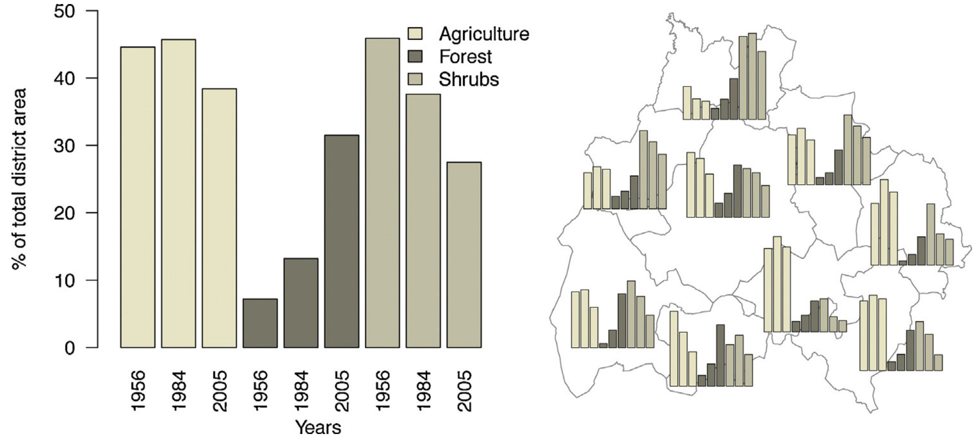

Fig. 2. Proportion of land covers for the whole study area and the nine municipalities in 1956 (first bar of each class), 1984 (second), and 2005 (last).

1984, making it difficult to identify precisely when and why this shift took place. However, it appeared that shrubland declines were mainly connected to farm mechanization, but that political changes may have exacerbated the trend. It is interesting to note that the results in our study area are consistent with the reduction in shrubland area in the whole region of Galicia from 33% in 1985 to 26% in 2005 (Corbelle-Rico and Crecente-Maseda, 2014). However, there are also local increases of shrubland cover, particularly in remote and mountainous locations where human activity has greatly diminished as a consequence of depopulation (Cascos Maraña, 2013; González Díaz, 2013; Corbelle-Rico and Crecente-Maseda, 2014).

The second main land cover change that we identified was the very substantial increase in forest area, remarkably higher than the average increase in Spain during the same period (Guerra Velasco, 2013). The gain in forests was caused by both the abandonment of farmland, and the abandonment of shrublands as a distinct land cover type. Expansion of forests took place both before and after 1984, but at a higher rate in the second period. This expansion can be explained as a consequence of natural succession (on former shrublands) public afforestation efforts (both on former shrublands and farmland) and private initiative (ditto, Marey-Pérez and Rodríguez-Vicente, 2009). The influence of CAP programs in the expansion of forests is likely to have been both direct and indirect. Direct effects result from subsidies for afforestation of former agricultural land (Council Regulation 2080/92 instituting a Community aid scheme for forestry measures in agriculture). Indirect effects are related to measures put in place to reduce the number of farms (e.g. the early retirement program) that encouraged owners to turn to afforestation as a surrogate land use and income source. Similarly, indirect effect resulted from the integration of prices of agricultural products as a result of the liberalization proposed by the General Agreement on Tariffs and Trade (GATT) in the frame of the 8th round of multilateral trade negotiations (Uruguay), starting in 1995 (Baldwin, 2009). Because of this integration and the associated decrease in prices of forage products, farmers had less incentives to crop forage themselves, making afforestation an attractive option for parcels no longer needed for that purpose.

Major technological innovations were introduced into Spanish agriculture in the late 1950s and resulted in changes in agricultural land cover in the first period of our study, even though the amount of area in agriculture remained relatively stable. The response to mechanization of agriculture in the first period differed among municipalities, resulting in expansion of agriculture where soils were better and farmland abandonment where they were worse. This reallocation of agricultural use seems logical if we consider that by 1956 almost a third of the area classified as good agricultural soil (classes S1 and S2 for maize) by Díaz-Fierros Viqueira and Gil Sotres (1984) was occupied by shrublands, and that their role as a source of fertilizer disappeared soon thereafter. This result is similar to other parts of Spain, both before and after EU accession (Muñoz-Rojas et al., 2011; Piquer-Rodríguez et al., 2012; Nainggolan et al., 2012; Calvo-Iglesias et al., 2009; Stellmes et al., 2013). After EU accession, however, agriculture lands decreased in all municipalities, indicating that market integration was a pervasive force on agricultural land use.

Differences in relevant drivers

Our modeling results suggested that drivers of land cover related to biophysical aspects and parcel structure remained relatively constant in importance throughout the study period. This is further evidence that the differences in land cover change before and after Spain's accession to the EU were probably driven by market changes and political actions, rather than changes in production conditions at local level. Indeed the amount of land cover change which took place after 1984 dwarfed the prior period, despite rapid changes in mechanization and specialization before Spain joined the EU. This result echoes others which have demonstrated that substantial land cover changes can result from a changed political context (Kuemmerle et al., 2006; Kuskova et al., 2008; Baumann et al., 2011; Hostert et al., 2011).

Given the rapid land cover changes, it is important to consider their environmental consequences. While increased forest cover can be associated with higher levels of biodiversity and ecosystem services that is not necessarily the case in our study area. Recently, a part of the remnant shrublands in our study area has been selected as natural habitat types of interest according to Annex I of Directive 97/62/CE. These selected habitat types include European dry heaths and temperate Atlantic wet heaths with *Erica ciliaris* and *Erica tetralix* (Natura 2000 codes 4030 and 4020, respectively). A Natura 2000 site was designated in 2004 to preserve these types of habitat. However, the agricultural systems that maintained these shrublands through grazing and periodic cuttings have largely vanished. Thus the remaining habitat is largely decoupled from the production systems which maintained it and could eventually go through successional stages toward a more forested system or be converted to more intensive agricultural uses, thus no longer supporting the species it currently does.

The rapid changes that we observed in response to past EU policies also raises the question how future policies may affect land cover. The latest reforms of the CAP in 2013–2014 included the complete decoupling of payments to farmers from actual production, and the stronger focus on farmland area makes it even more important to forecast the estimated extent of farmland abandonment in Europe (Renwick et al., 2013), to identify where it is likely concentrated (Terres et al., 2013), and to better understand its drivers. Our results show how much these policies can impact land use systems and are particularly relevant for other peripheral regions of Europe. Among these, the Eastern European countries that more recently joined the EU now face increasing competition in their agricultural sector with the rest of Europe, and some of these countries regions may go through similar trends as our study area. In particular, traditional farming systems that support high levels of biodiversity are potentially threatened. In our study these areas have all but disappeared, and the farming system which maintained biodiversity-rich land cover types no longer exist. Innovative policies which can promote the maintenance of the agricultural systems may be key for maintaining traditional farming practices throughout Europe (Baur et al., 2006; Babai and Molnár, 2014).

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.landusepol.2015.01.004. These data include Google maps of the most important areas described in this article.

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