

# EVOLUTION AND DEFRAGMENTATION OF THE VINEYARD LANDSCAPE IN THE RIOJA ALTA (SPAIN) IN THE PERIOD 1956-2000

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## I. INTRODUCTION

Vineyard landscapes have undergone significant transformations in recent decades in all wine producing countries, but especially in the European Union. The mechanization of rural areas, the opening up producing regions to very competitive international markets, the evolution of consumption, or the measures taken by the WTO (World Trade Organization) have resulted in major changes in the extent, location and tillage systems of the vineyard.

In Spain, the vineyard surface has declined from 1,600,000 ha in 1986 to 967,055 in 2012. In addition, vineyards has migrated from the poorer soils to some of the best lands because of the high economic interest of the vineyard farm.

This paper focuses on a region which belongs to the DOCaRioja (Denominación de Origen Calificada Rioja) where the wine industry has a large tradition since the end of the 19th century. Vineyards and their landscapes in La Rioja have changed since the 80s of the last century, showing in some cases the same evolution that other Spanish vineyards (increase of irrigated surface as well as vineyards cultivated on trellises system), but differing in their surface evolution and little variety renewal. In La Rioja the vineyard experiences a considerable expansion from 38,349 ha in 1983 to 62,153 ha in 2012.

The main objective of this work is to study the evolution, defragmentation and shape of the vineyard in a temporary period of 44 years (from 1956 to 2000). The year 2000 is a key date to identify the WTO changes prior to the 1999. A next study will be necessary to analyze the variations from 2000 to current. Moreover, the study provides information on the inter-relationships between physical environment and vineyard landscape.

## **II. STUDY AREA**

The study has been carried out in La Rioja Alta (Spain), located in the western sector of the Ebro Depression. The average altitude of the study area varies between 500 and 600 meters above sea level. The materials of the area correspond to Tertiary and Quaternary detritic lithologies. The climate is Mediterranean with Atlantic influences, with an annual rainfall of 400-500 mm and maximum values registered in Spring and Winter. The average annual temperature ranges between 12-13°C.

In the year 2010, vineyard was the main crop (21,247 ha), followed by cereals, with 10,924 ha. 80.2% of the vineyard is located in rainfed land and 19.8% in irrigated land. The size of the plots is small, dominating those of less than 1 ha. The vineyards occupy flat or slightly inclined areas, although the presence of vineyards is also common on hillslopes. 18.7% of the vineyards of La Rioja Alta is cultivated on slope of 20% of gradient. It is a landscape of young vines: less than 15% of vines exceeding 40 years.

## **III. MATERIAL AND METHODS**

The work analyzed vineyard surface on three dates: 1956, 1977 and 2000. To this end, we used white and black photographs, scale 1:33000 (year 1956) and scale 1:18000 (years 1977 and 2000). These were scanned with maximum resolution and georeferenced. The plots of vineyards were mapped in detail with the help of a software GIS (ArcView). The images used covered a total area of 517.37 km<sup>2</sup>. Once the maps were generated, information was exported to software GIS raster and Fragstats 3.3, in order to be able to analyze the data.

GIS raster allowed to visualize the distribution of the vineyard at different dates and to generate a map of synthesis. With the purpose of manage database, the original map of 5 m/pixel was transformed into a 20 m/pixel resolution.

Fragstats is a program of geostatistical analysis specialized in fragmentation and landscape metric. It calculates a series of indexes that show the properties of the landscape: sizes of areas, configuration and dispersal, fragmentation, etc. Landscape Shape Index (LSI) was used to learn about the forms of the vineyard units.

In order to complete information and link the vineyard area with geomorphological and topographical variables, a geomorphological map was drawn. This map included: high terraces (levels 6-9), middle terraces (levels 4 to 5), low terraces (levels 2-3), terrace 1 and floodplains, high glacis (levels 6 to 12), middle glacis (levels 4 to 5), lower glacis (levels 2-3), glacis 1 and alluvial cones, paleo-channels and valleys, regularized hillslopes, gullies, rills and badlands. A digital elevation model (DEM), with a resolution of 5 m/pixel, from which it was obtained a cartography of altitudes, slopes and orientations was available.

Cartographic files were exported to statistical analysis SPSS 15 program to work with large databases.

## **IV. RESULTS**

In the period 1956-1977, traditional agriculture, based on polyculture, becomes a more intensive, mechanized and market-oriented agriculture. With regard to La Rioja, in 1977 the

vineyard located in areas with erosion problems, above 700 m of altitude, on slopes exceeding 40% and northern orientations was abandoned. On the other hand, the vineyard was replaced for other crops in favourable areas with good outputs to markets and easy mechanization (cereals and tubers). Thus, the vineyard disappears in middle and lower terraces (a 25.8 and 27.1%, respectively), and slopes below 5% (15.7%). Ultimately, in 1956 there were 12,802 ha of vineyards in the study area that were reduced to 11,490 ha in 1977.

The decades of 1980s and 1990s represent a rapid recovery of the vineyard surface. The imposition of a market economy in the rural areas, the increase in demand, the modernizing of the productive structures, the high prices of the grape and the successive years of good harvests boosted the increase in the vineyard, so that in the year 2000 its surface already reached 15,497 ha in the study area (an increase of 34.8% with respect to 1977). The vineyard occupied high terraces and glacis, valley bottoms and regularized hillslopes, spaces traditionally devoted to cereal. Definitely, the territory cultivated with vineyards was obtained at the expense of other crops or occupied territories with difficult topographical conditions, but profitable given the performance and benefits of this crop.

The decreases or increases in surface involved changes in the vineyard landscape. The relationship between the growing surfaces of the vineyard is inverse to the number of areas or cultivated units (fragments, patches or tiles) and its size average. 5,125 homogeneous areas of cultivation of the vineyard were mapped in the study area in 1956 (2.49 ha/unit). In the year 2000, the surface of the vineyard is much larger (15,497 ha), but the number of units decreases to 3,348 and then increases its size (4.62 ha).

The changes of the vineyard landscape in 44 years have proved to be complex. The 5.233,3 ha of vineyards that have remained unchanged in the three analyzed dates set up fragments of 0.84 ha while, on the other hand, the surface of vineyard abandoned, both in the period 1956-77 and 1977-00, would be identified with fragments of smaller dimensions: 0.39 and 0.28 ha. The vineyard incorporated after 1956 or 1977 has configured units of larger size: 0.47 and 0.56 ha. Therefore, with the passage of time, the vineyard landscape has gone densifying, becoming a monoculture in certain municipalities.

The results of the index morphometric LSI in the three studied dates indicate that the lowest median of the index corresponds to the structure of the landscape in the years 1977 and 2000, with a value of 1.28. On the contrary, the morphometry of the year 1956 reveals a slightly higher value (1.33). These data show that the units of the vineyard have not substantially changed in terms of its shape in the period studied, although they evolve slowly into a simpler and proportionate geometry.

## **V. DISCUSSION AND CONCLUSIONS**

The surface of the vineyard in La Rioja Alta has increased in the period studied, standing for 24.7% of the surface of the region in 1956 to 29.9% in the year 2000. In this process, however, we must distinguish a first period, from 1956 to 1977, with cultivated surface abandonments, and a second one from 1977 to 2000, where, on the contrary, the vineyards are retrieved.

The expansion of the vineyard area in the period 1977-2000 has resulted in a greater homogeneity of the landscape of the vineyards, approaching the monoculture in some munic-

ipalities. At the same time larger patches have been configured and many of the isolated or smaller plots have been eliminated. In 2000 we have a landscape of vineyards less fragmented than in previous decades, a process that also took place in other European landscapes. However, the shapes of the units do not seem to have substantially changed.

It is too early to recognize the main environmental consequences of the new structure of the landscape, characterized by the defragmentation process. However, the simplification of complex landscapes in environments of hilly topography tends to be a factor of erosion, especially when this simplification involves also the decrease in the number of plots due to the concentration. In that case, the boundaries between fields decrease. These are an important erosion control because they stop erosion locally and produce intermediate zones of sedimentation, limiting the export of materials and the connectivity between the upper and lower slopes.

On the other hand, the decrease in fragmentation favours the disappearance of species adapted to landscapes in mosaic, where different crops and small fallow areas alternate. The elimination of some field boundaries often involves the disappearance of areas that act as green corridors with very negative implications for biodiversity.

The trend towards homogenization, defragmentation, expansion of plantations in trellis, as well as, migration of vineyards in slope toward plains and most fertile areas is threatening to transform a unique, beautiful and cultural landscape into a very monotonous landscape, similar to other European landscapes of vineyards. Environmental conditions and tillage systems of farmer generations resulted in a diverse landscape, rich in biodiversity and aesthetic, unique and exceptional; a landscape that has evolved into the homogeneity imposed by mechanization and the uniform legislation of the European Union, which constitutes a threat to the maintenance of the vineyard cultural landscape.