D.O. CARIÑENA

EL VINO QUE NACE DE LAS PIEDRAS

ENVIRONMENTAL FACTORS OF THE CARIÑENA PROTECTED DESIGNATION OF ORIGIN REGION

CHAPTER 1. THE PHYSICAL

Given the importance of the different elements of the physical environment for viticulture and the adaptation of the different species, as will be explained herein, we consider that a chapter dealing extensively with these questions is of great interest within a paper whose title refers to the competitive commitment to its uniqueness and the quality of wines of this PDO. Although the physical environment is not the only factor, it does explain many aspects of this uniqueness and quality.

1.1. Influence of the natural environment on vine cultivation. General considerations

The characteristics of the natural environment are essential for the development of any agricultural activity. They partially or fully explain many aspects, such as the existence of different types of crops, cultivation systems or zoning methods. In the case of the vine, it is interesting to note that it is one of the crops with the widest range of varieties on different analysis scales. This is due to the incidence of multiple factors, among which the characteristics of the physical environment are particularly noteworthy. Dating back to other periods of history, a wine's reputation depended, to a large extent, on the natural conditions of the area in which the vine was cultivated: relief, soil and climate, in particular. For example, this explains why merchants from the north of Europe travelled to the Mediterranean countries in search of sweet wines, as they could not produce them, given the characteristics of their climates. It is true that in recent years, there has been greater independence with respect to the conditions of the physical environment, mainly due to advances in technology.

The topography and type of soil are also important factors in viticulture. There is a firm belief that a certain type of soil may determine the success of a local crop. However, this is not always perceived in the same way. For example, American winegrowers believe that soil is of little importance. The French, on the other hand, defend the strong influence of soil. However, it must be remembered that terroir does not only allude to soil and its chemical composition, but also refers to the union of climate, soil and landscape (Unwin, T; 2001: 80). It is usually said that the best wines come from poor soils, since the wine will be better if the plant suffers some stress during its annual development. Along with soil characteristics, local climate and the variety cultivated are important but not the only factors that favour a high grape harvest and also determine the characteristics and quality of the wine to a large extent.

Climate is undoubtedly another of the most important factors for the development of viticulture (Unwin, T; 2001: 55). The existence of certain climate characteristics explains and delimits the different scales of analysis, the most appropriate areas for the cultivation of vines and their subsequent wine making. Vitis vinifera develops better and hence reaches its optimum ecological scope in those areas in which summers are long and warm and winters are cool. Warm and sunny climates particularly favour the grape ripening quickly and being characterised by a high sugar content and lower acidity. Wines have a higher alcoholic content than those that come from colder climates. Rainfall is another important factor in viticulture. In almost all wine-growing regions worldwide, it ranges between 400 and 800 mm a year. If this figure is not reached, irrigation is required, especially in very warm areas (Unwin, T; 2001: 77 - 79).

Climate conditions particularly explain which places across the world are more favourable for the cultivation of vines. Average annual temperatures and seasonal distribution, in particular, also has a significant impact. Average annual temperature should be around 15 degrees centigrade. The winter minimum should be around 3 degrees centigrade and the summer peak should exceed 22 degrees, as high summer temperatures are required for the grape growth and ripening process. The cool winter allows the vine to rest.

On the other scale of analysis, it is worth mentioning the incidence of the different micro-climates within a certain region as a result of the topography, the partitioning of the relief or its orientation. Abnormal situations may have an extremely adverse impact on the crop. Therefore, for example, spring frosts lead to severe crop losses. Cold and rainy weather at the end of spring is also detrimental: the flowers are lost and the stem growth process (Unwin, T; 2001: 76 and 77). In normal years, the flowering of the vine depends on the temperatures recorded in May. If flowering is brought forward to March or April, this means that it has been too warm. On the other hand, the rainier and warmer the climate, the more difficult it is to control the diseases that affect the vines. Good harvests are obtained in hot but not too dry summers. Production details, considering a certain period, are reflected in the harvest obtained each year and in the quality of its production, the incidence of the climate characteristics and weather situations. This has been verified in this paper.

It is extremely important to identify the vine varieties that best adapt to each of the climate areas and specific environmental conditions. This question, which has led to different innovation processes in viticulture, is the basis for the appearance of a large number of hybrids and rootstock (crosses of species), so that the vines are more resistant to disease and to conserve the characteristic flavour of a certain variety. Recent changes in cultivation techniques have also contributed to the transformation of the wine sector.

Finally, it is worth noting the concern raised by the potential impact of climate change on wine cultivation and its spatial location. Warming on a global level and in the south of Europe will logically be affected. This question is the subject of analysis by many scientists and scholars, who are concerned about the evolution, development and possible spatial changes in cultivation worldwide. The expansion of the traditional European wine area and the bringing forward of the harvesting dates are clear consequences of this (Unwin, T; 2001: 366).

The reduction in rainfall, for example, in the Mediterranean region and in other subtropical areas of the planet, may give rise to some crops having to withstand less favourable conditions for their optimum development. In spite of being a species that allows for wide variation ranges in rainfall and temperature, the vine will be affected in terms of the distribution of the crop and the varieties cultivated, but it can be verified that there is no danger of this in Spain. The increase in temperatures and sunshine will lead to wine producers being forced to change some varieties in certain districts or regions due to the reduced availability of water, whereby they will opt for vines that are better adapted to the new climate conditions, which may lead to the appearance of new plagues.

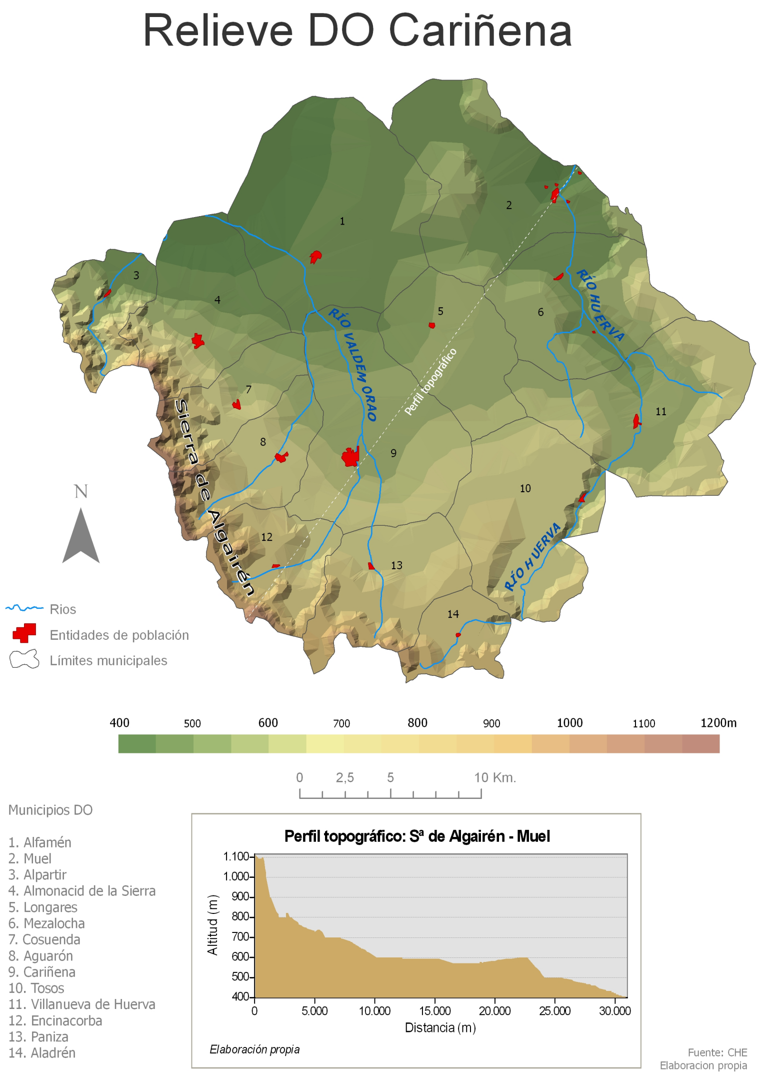
On the other hand, the altitude limit of the vine cultivation area will reach higher levels. Therefore, areas that are less favourable for their cultivation today, due to their characteristics, may become more favourable in the future.

Furthermore, it will be necessary to increase irrigation or introduce a crop watering system so that the agricultural space is adapted to the demands of this crop. Generally, if the type of wine that a region produces is down to a certain climate, climate variations may determine qualitative differences in the wine, or in other words, its characteristics may change (Gonzalez Perez, E; 2008). Furthermore, as the type of wine in a region is the result of a certain climate, any climate variations caused by climate change may alter the production of the entire crop and the type of wine (Jones, G. V; 2008).

1.2. Orographic conditions

The Cariñena PDO region is located between the central sector of the Ebro Valley and the Iberian System. This area is also delimited to the east by the River Huerva and to the west by the terraces of the River Jalón. It forms an extensive foothill that extends from the Iberian Sierras to the first tabular reliefs that indicate the presence of the Ebro Valley. The Iberian Sierras close and delimit the PDO region to the south-west. The Algairén, Paniza, Vistabella and Peco and Herrera sierras stand out as the most important units of relief. Among its main peaks, the following can be highlighted: El Espino (1,170 m.), Valdemadera (1,276 m.), Atalaya (1,235 m) or Peña de Abanto (1,193 m.).

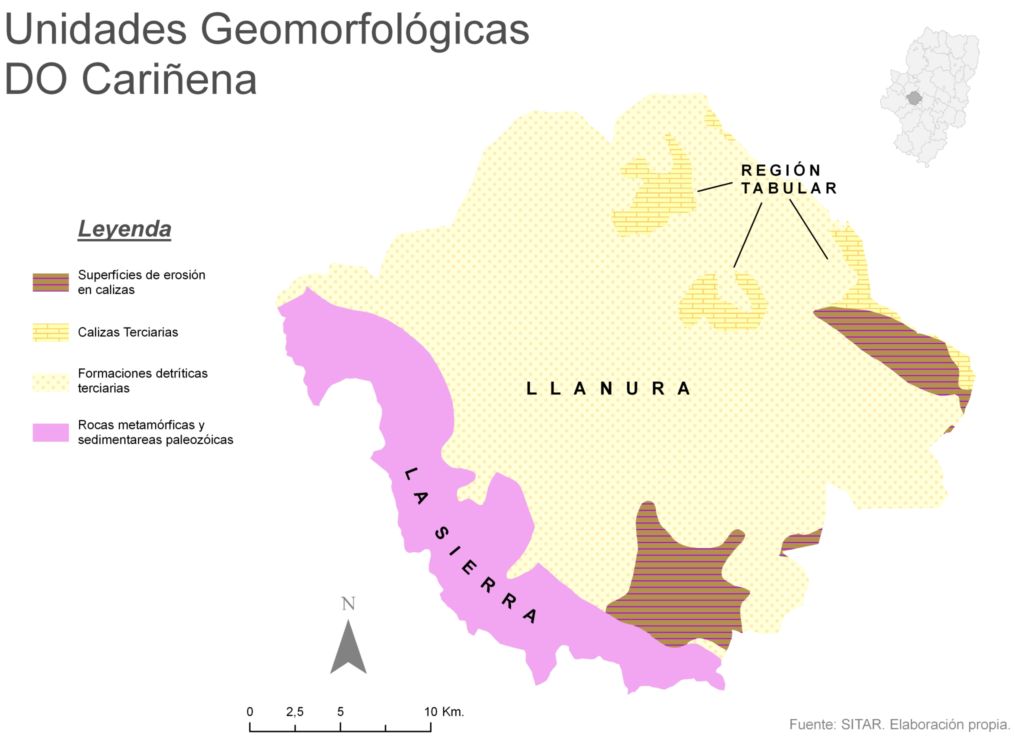
MAP 1



The graph accompanying the relief map of the Cariñena PDO shows a cut or topographic profile in which the altitude gradient between the Iberian Sierras and the Ebro Valley can be clearly seen, as well as the extension and height of the Iberian Somontano. In the PDO area, there is a relief of gentle slopes so that the altitude gradient does not exceed 300 metres in just over 22 kilometres. Most of the municipalities that form part of this region are located in this area. Aladrén (771 m) or Encinacorba (750 m) are located at the foot of the Iberian Sierras and have the highest altitude. Cariñena (590 m) or Longares (530 m) are the municipalities of the Iberian Somontano and have a lower average altitude.

From the geomorphological point of view, some authors, such as Ferrer Regalés, have identified up to three different geomorphological units in the PDO area (Map 2). The first of these units, the Sierra, is located to the south-west and forms a mountainous arc that encloses and delimits the PDO region. Made up of Palaeozoic materials (quartzite and slate), it is characterised by its heavy and solid appearance. In spite of this, it does not form a continuous unit, as it is fragmented by the river network. It is characterised by an Appalachian-style relief, in which quartzite flourishes in the summits, due to its greater solidness, forming crests, whilst the slate gives way to gentle valleys (Cuadrat Prats, J. M., 2007: 26). To the south of the region, as Ferrer Regalés indicates, there appears an eroded surface, which levels out the relief of the sierras at around 1,000 or 1,100m. In spite of this, some reliefs stand out for being higher than this, such as the Herrera (1,346m) and Algairén (1,242m) sierras.

MAP 2



The plain is the region's second geomorphological unit and it extends between the Sierra, the Jalón and Huerva Rivers and the tabular relief that culminates in La Muela. Detritic in character, it is made up of angular and rounded edges from the sierra, which give rise to loose and well-aerated soil, suitable for vine cultivation. The contact between this unit and the Sierra does not occur linearly, but rather it forms inlets and outlets (buttresses in the form of hills), mainly in the western and central area of the Sierras.

Unlike the contact between these two units, the contrast between the eastern part and the central and western part of the plain must be pointed out. The western part, whose waters flow into the Jalón, forms a lower plain (500 - 600m), slightly undulating and sloping between the Sierra and the southern foot of La Muela (Ferrer Regalés, M., 1957: 16). Its layout explains the greater prevalence of water courses. Its eastern part is higher, reaching an average altitude of between 700 and 800 m and it has fewer water courses, among which the River Huerva can be highlighted. Dams have been built in it, of which that of Torcas can be highlighted.

The Jalón-Huerva tabular area makes up the third unit. It is located to the north of the region and is the contact area between the Plain and the Ebro Basin. Made up of clay and sandstone, it is scattered with hills and ridges, crowned by narrow limestone tables, forming a tabular relief that is characteristic of the Ebro Basin. With this sector, the Iberian Somontano gives way to the morphological domain of the Ebro Basin.

1.3. Main climate factors in this region

In the Cariñena DO, the influence of the climate has been particularly decisive in the development of vine cultivation. The area's climate conditions depend on diverse factors, among which the latitude and regional atmospheric dynamics stand out, on one hand, as well as the relief, which determines the climate variables on a local level within the region (Saz Sánchez, M. A. 2006). The position of the Cariñena PDO within the warm latitudes (latitude 40° North), guarantees the rhythmic seasonal nature of the weather throughout the year and influences the regional atmospheric dynamics. Depending on the time of the year and due to seasonal variations that the planetary pressure belts undergo at latitude, the characteristics typical of temperate flow dominate in winter and there is a greater subtropical influence in summer.

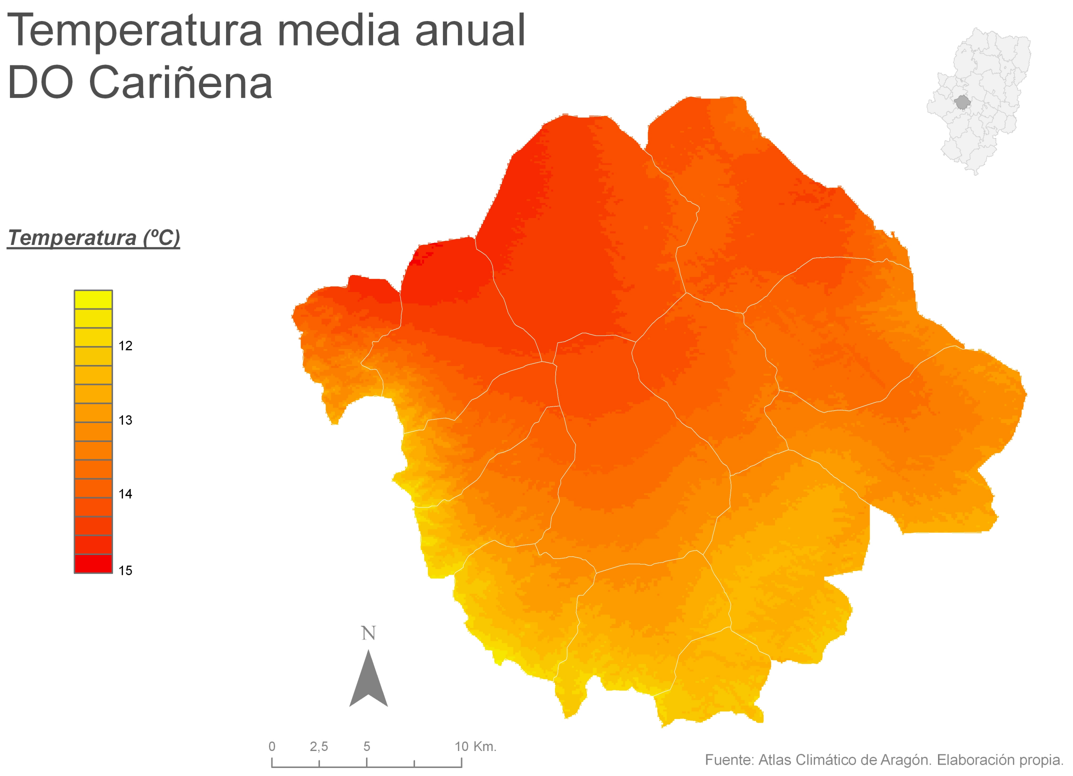
Equinoctial seasons are periods of transit between the two aforementioned situations, whereby the predominance of one or the other is what determines the weather in those months (Saz Sánchez, M. A. 2006). Rainfall is generally scarce during the winter and summer. In winter, the thermal high pressures originating in the Eurasian continent may expand and link up with the Iberian high pressures, preventing the entry of storms from the Atlantic, and logically, rainfall. In summer, the Azores anticyclone reaches the north-east of the Iberian Peninsula and almost completely stops the arrival of the Atlantic storms which could bring rain. Rainfall at this time of the year is usually typical summer storms caused by the intense heating of the atmosphere in its lower layers.
These facts explain the behaviour of the rainfall to a large extent and its distribution in the DO region. On the other hand, the orography determines the volume of rainfall and its distribution in the DO region. The situation in areas sun or shade causes significant thermal differences in nearby areas.

In the DO region, as previously mentioned, the relief slopes gradually from NE to SW, hence explaining the contrasts in the spatial distribution of the temperatures and rainfall.

1.3. 1. Points of interest in relation to temperatures

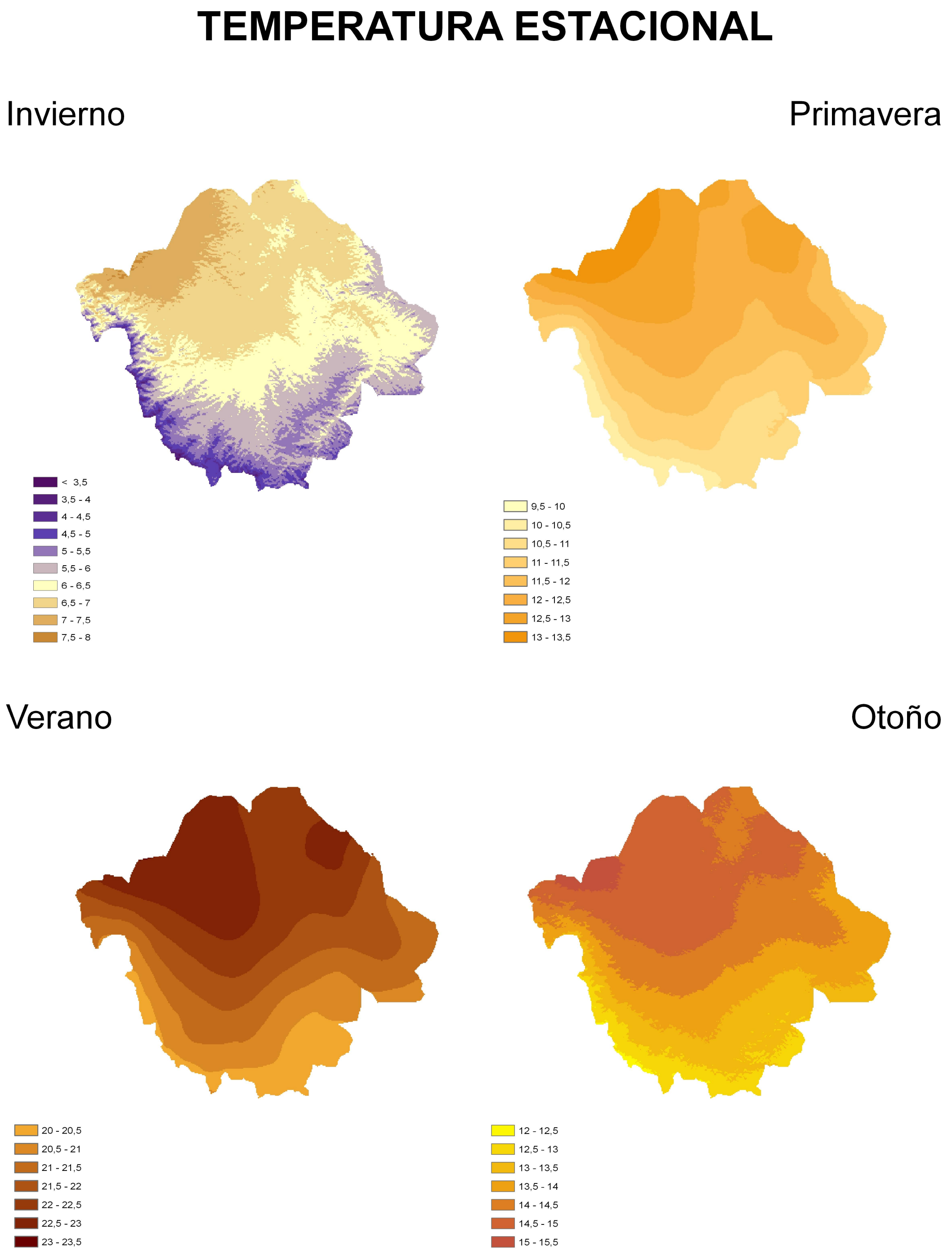
The spatial distribution of temperatures, as previously indicated, is determined by latitude. However, the energy of relief generates altitudinal gradients that explain the presence of different thermal regimes in reduced areas, as occurs in the Cariñena PDO.

MAP 3



Areas of lower altitude have higher average annual temperatures. This occurs in the north of the region, mainly in Alfamén or Muel, where the highest average values exceed 14°C. By contrast, the lowest average values, less than 12°C, occur just 25 km further south, more specifically in the Iberian Sierras. The rest of the area registers annual averages of between 12 and 14°C. This is the case of Cariñena (13.6°C) and Tosos (12.8°C). In the river valleys of Huerva or Valdemorao, the temperatures rise slightly. A parallel can be drawn between the thermal grading and the relief of the area, as can be seen in the seasonal maps.

MAP 4

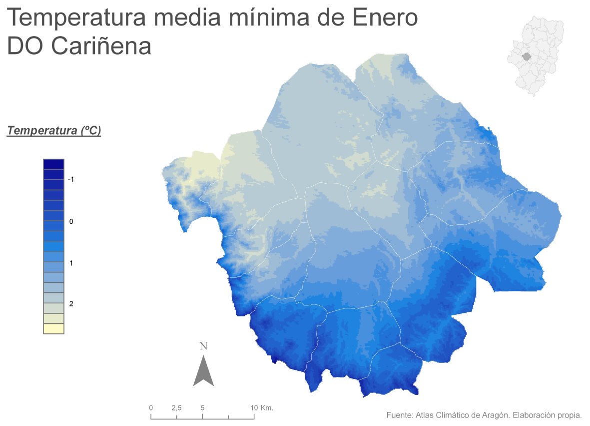


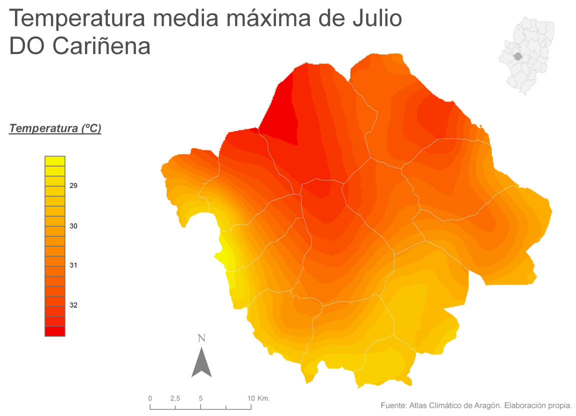
Fuente: Atlas Climático de Aragón. Elaboración propia

The coolest temperatures are found in the Iberian Sierras and, on the other hand, the temperatures are always higher in the flatter areas. Mapping of the monthly average for the hottest month (July) and the coldest month (January) highlights this thermal grading related to height (Maps 5 and 6). The map recording the maximum average temperature (Map 7) clearly shows this. The 29°C recorded in the municipality of Aladrén and the 30° in Cosuenda and Almonacid de la Sierra are lower than the 31.3 °C in Cariñena and the 31.5 °C in Mezalocha or the 32 °C recorded in Alfamén and Muel.

The map recording the average temperatures for the coldest month (January) shows that the lowest values occur in the Iberian Sierras and the mildest ones are in the foothills of the Ebro Valley and on the terraces of the River Jalón.

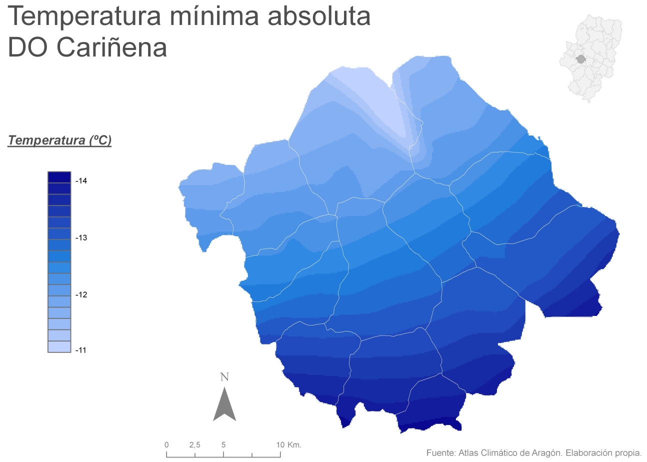
MAPS 5 and 6

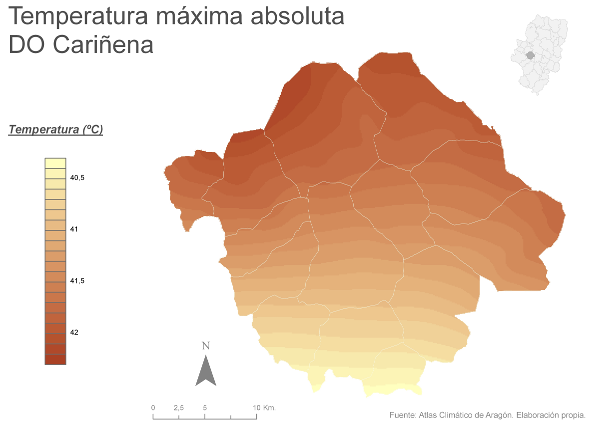




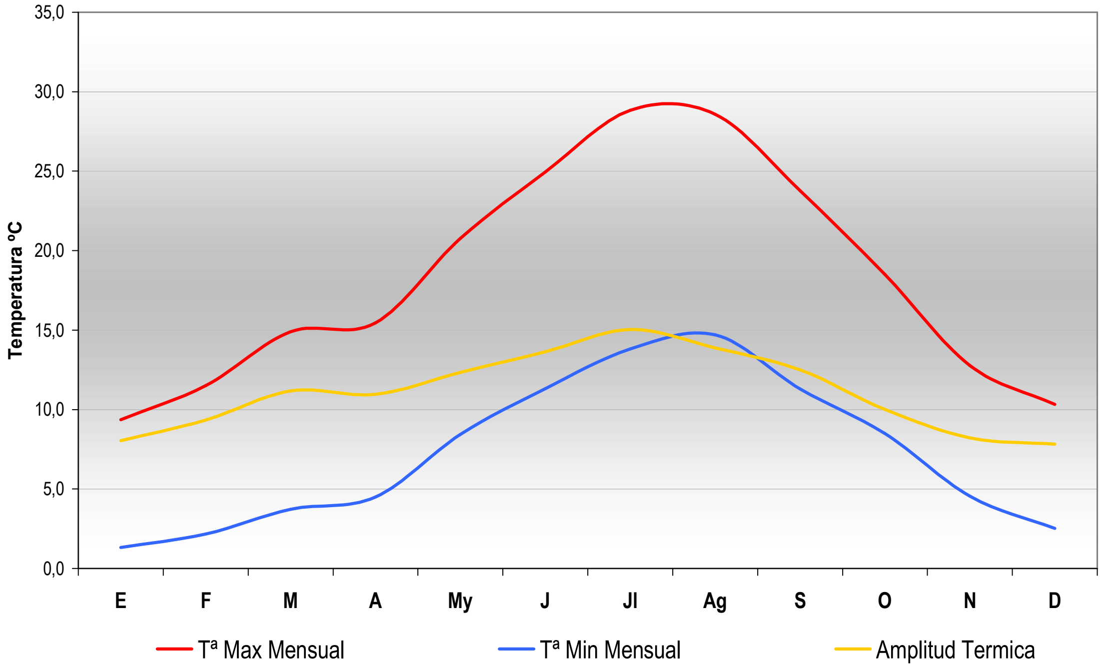
The miniature maps of the absolute maximum and minimum temperatures (Maps 7 and 8) show the existence of a north - south grading of temperatures. In the case of the absolute maximum temperature, it can be observed how the highest temperatures of 42°C are reached in the surroundings of the Ebro Valley and the River Jalón, where the altitude is lower. In contrast, the increased altitude in the Iberian Sierras reduces the temperatures. On the other hand, the map of absolute minimum temperatures registers the lowest temperatures in the highest areas of the PDO, whilst the milder values are more prevalent as we descend in altitude.

MAPS 7 and 8





Graph 1. Maximum and minimum temperature in Aguarón 1988- 2002 Series



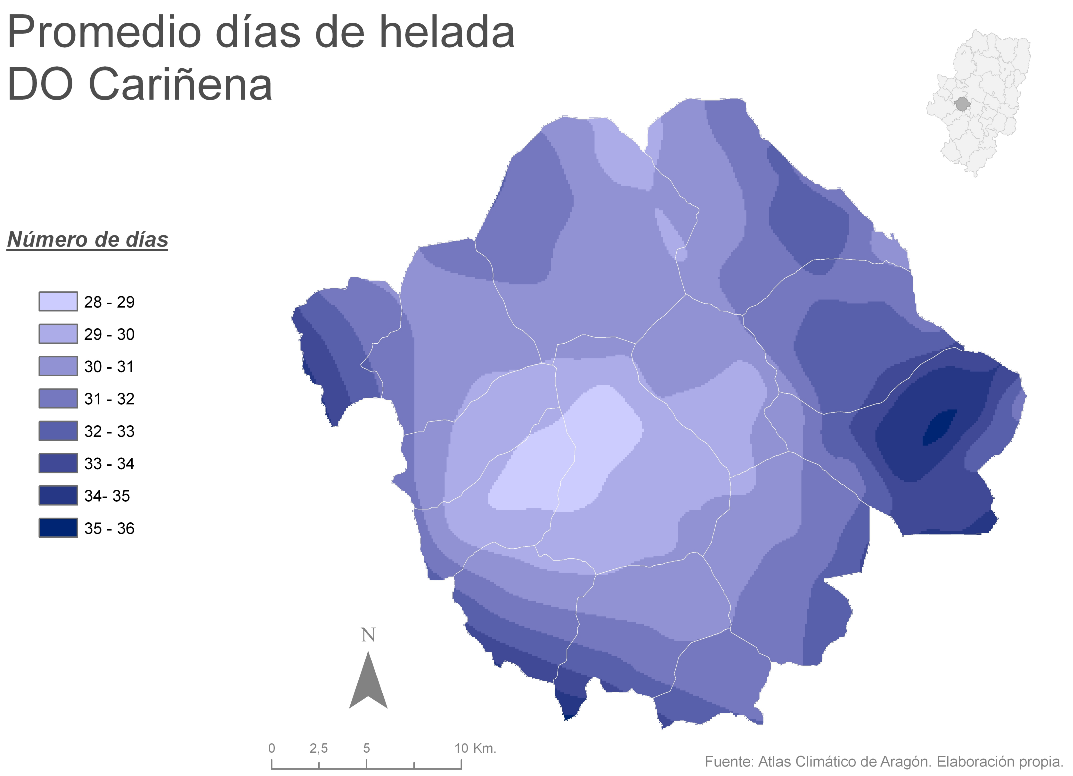
Source: Atlas Climático de Aragón. Own compilation

The graph showing the maximum and minimum temperatures in Aguarón (Graph 1) reveals how the maximum temperatures occur around the summer solstice, as the anticyclonic situations and the latitudinal position of the PDO region favour the rise in temperatures. Despite this, the atmospheric stability causes them to drop as night falls, due to the absence of clouds that enable the solar and thermal energy received throughout the day to be maintained. It is in summer when the greatest thermal amplitude occurs, reaching a difference of 15°C between day and night in the month of July. On the other hand, the thermal amplitude is lower in winter even though temperatures have fallen significantly.

It can be confirmed that the Iberian Sierras have a lower thermal amplitude than that of the plain and the Iberian foothills. The annual thermal amplitude is less than 28°C in the sierras and above 30°C in the plains and river valleys of Huerva or Valdemorao tributary of the River Jalón on its right bank. Frosts cause a major impact on the development of the vines, like on other crops in Aragón. Their effects may be devastating and may even make the work of an entire year futile and destroy the crop. For this reason, it is of great interest to know the average number of days with frosts each year and their spatial distribution. The high number of days, between October and May, is related to the previously mentioned anticyclonic situation, with continental characteristics and the high average altitude of some areas. All of these factors are conducive to the number of days with frost, in which the minimum temperature falls below 0°C, being relatively high. This occurs in the whole of Aragón (Lopez Martín, F; Matilde Cabrera, M.; Cuadrat Prats, J. M.ª; 2007).

As shown on the map, the average number of days with frost a year in the Cariñena PDO region varies between 28 and 36. The high altitude areas of the Iberian Sierras and the most continental areas, located in the extreme north-east of the region, are those that register the highest number of days with frost, in excess of 30. By contrast, the detritic plain of Cariñena, an area where vine cultivation is more significant, the days with frost amount to 28.

MAP 9



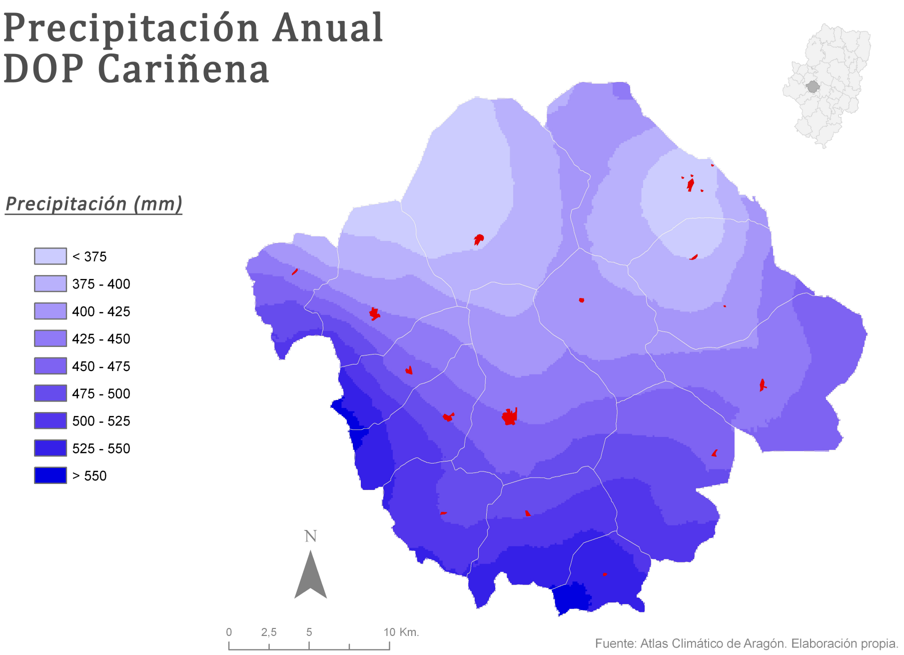
1.3. 2. Rainfall intensity and spatial contrasts

Rainfall throughout the Cariñena PDO region has a north - south grading, similar to that of temperatures. In the highest area, located in the south of the region, average rainfall throughout the year exceeds 500 mm. (Encinacorba- 518 mm, Aladrén 541 mm, Algairén Sierra 552 mm). By contrast, on the plains, rainfall descends. The total values hardly exceed 425 mm in Longares and Mezalocha. In Alfamén and Muel, average rainfall does not reach 375 mm. As for the seasonal distribution of rainfall, it can be said that spring is the time of the year when the highest volumes are registered, reaching more than 170 mm in the Iberian Sierras, which represents a third of the total average rainfall.

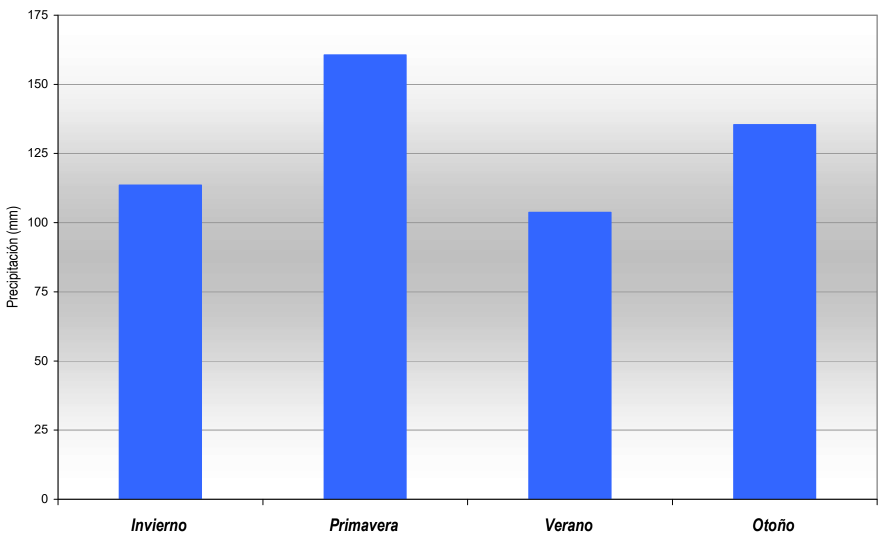
In the rest of the PDO region, the total values obtained are far lower, but they also represent a high percentage of the total volume collected. Autumn is the second rainiest season, although values are far less than those in spring.

In both seasons, rainfall responds to the atmospheric instability that affects this region, given the incidence of Atlantic storms and, to a lesser extent, those originating in the Mediterranean. Winter and summer are the seasons when the least rainfall is registered in the Cariñena PDO. Both periods are under the influence of the atmospheric stability caused by the polar anticyclones in winter and from the Azores in summer.

MAP 10



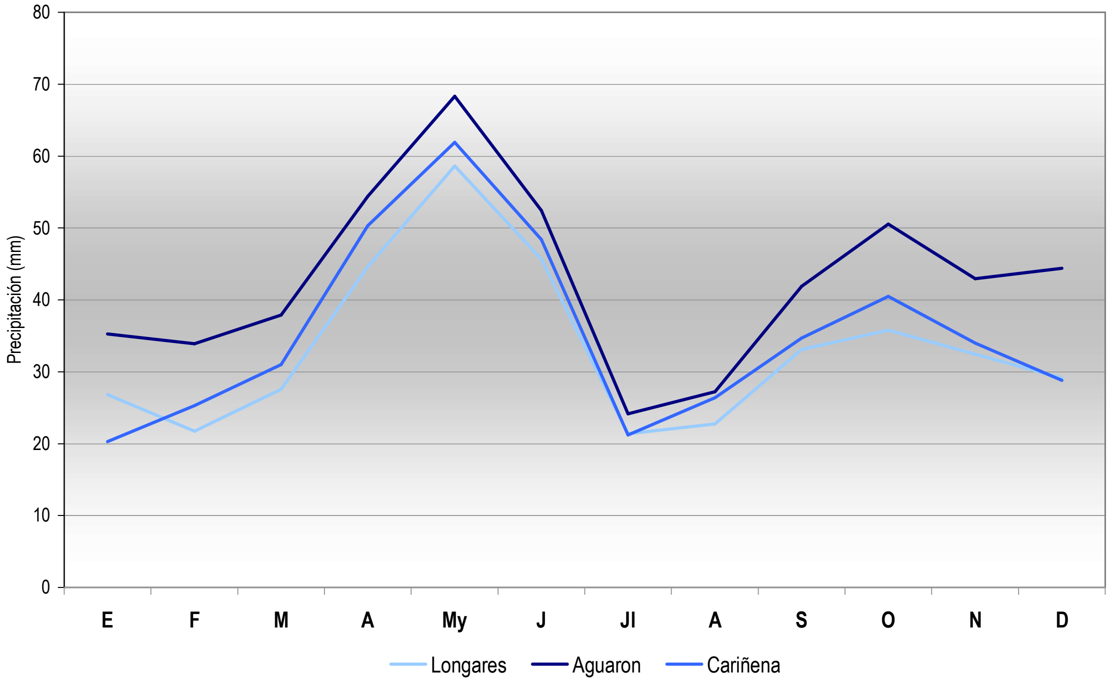
Graph 2. Average seasonal rainfall in Aguarón



Source: Atlas Climático de Aragón. Own compilation.

As can be seen in the graph of average monthly rainfall by municipalities (Graph 3), spring and autumn are the months that register the highest volumes. In the different places selected, May is the dampest month and July is the driest month. The second maximum occurs in October, whilst January and February are the months with the second minimum in this area. Rainfall maximums occur in the months of greatest atmospheric instability (spring and autumn), whilst the minimums are registered in the winter and summer solstices, when the atmospheric stability is the predominant situation.

Graph 3. Average monthly rainfall by municipalities



Source: Atlas Climático de Aragón. Own compilation.

Table 1. Average monthly rainfall by municipalities (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Apr	Sep	Oct	Nov	Dec	Total
Longares	27	22	28	45	59	46	21	23	33	36	32	29	400
Aguarón	35	34	38	54	68	52	24	27	42	51	43	44	513
Cariñena	20.3	25.3	31	50.3	61.9	48.4	21.2	26.4	34.7	40.5	34	28.8	434

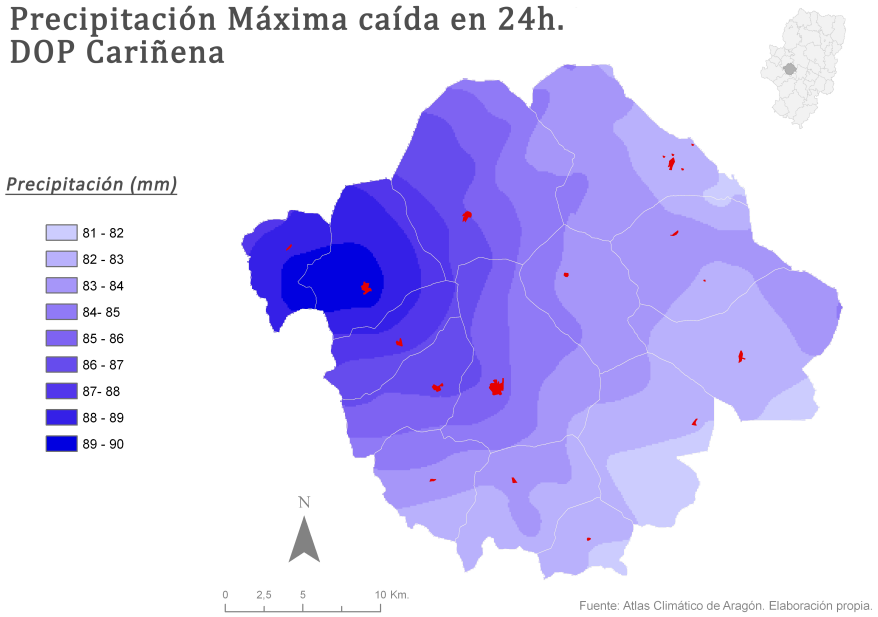
Source: Atlas Climático de Aragón. Own compilation.

Rainfall day is that on which the pluviometers exceed the height of 0.1 mm (Lopez Martín, F; Matilde Cabrera, M.; Cuadrat Prats, J. M[a]; 2007). In the Cariñena PDO region, the number of days of rainfall varies between 52 and 70, whilst the average number of days of rainfall in the Autonomous Community of Aragon is 60. The areas with the highest number of days of rainfall and those where the highest annual volume is reached are located in certain areas of the Iberian Sierras. On the plains, the number of days of rainfall drops.

The N and NE sector of the Ebro Basin contact area is the area with the lowest number of rainfall days and their volume is also less, as shown on the map. In the sierra, the higher topography creates a barrier for the different fronts that cross the area, causing a cooling of the masses of air as they rise, which leads to orographical rainfall.

The variable related to the maximum rainfall in 24 hours is one of the most used within climate analysis. Its mapping indicates which areas are more prone to the accumulation of rainfall in a short period of time and the maximum amount collected. Knowledge of this helps to prevent potential problems that such volumes of rainfall could generate for the population, infrastructures and the natural environment. In spite of this, the unexpected nature of weather means that its inhabitants are sometimes surprised by this type of events. The falling of a greater volume of water occurs in the western part of this area, more specifically in the municipalities of Alpartir and Almonacid de la Sierra. Rainfall descends in the eastern part of the region, although only slightly, whereby a difference of hardly 9mm can be observed in total volume of annual rainfall. On crossing the different mountainous barriers, the fronts from the Mediterranean discharge a higher rainfall. The layout of the relief explains that this occurs particularly in the extreme west of the PDO region. Therefore, the effect of topography on the intensity of rainfall is significant.

MAP 11



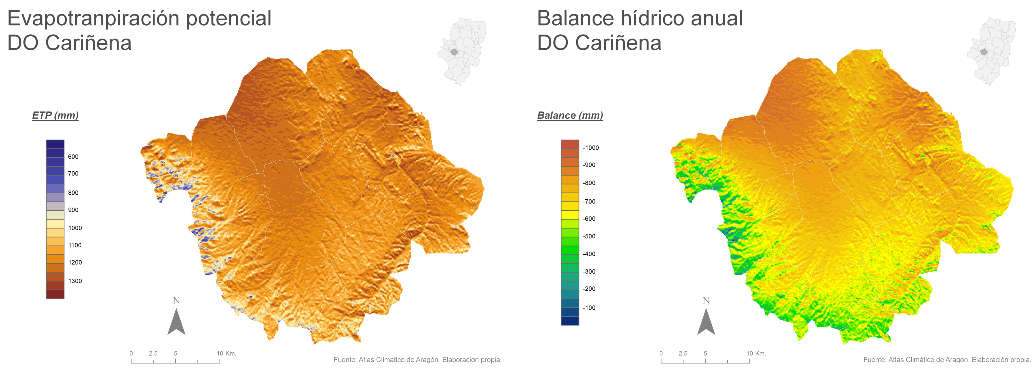
1.3.3. The DO region’s water balance

Classifying an area as dry or very dry due only to the shortage of rainfall and its irregularity is not quite accurate. The role played by the evaporation of water from the soil and the transpiration by plants and vegetation must be added to this.

These latter two processes are known jointly as evapotranspiration. This is a slow but continued process of water loss from the land surface to the atmosphere. It is necessary to differentiate between actual evapotranspiration (ETR) and potential evapotranspiration (ETP). The former refers to the amount of water evaporated and this cannot exceed the region's water availability. Potential evapotranspiration is the maximum amount of water that could be lost to the atmosphere if there were no limitations to its supply (Lopez Martín, F; Matilde Cabrera, M.; Cuadrat Prats, J. Mª; 2007, 128).

On a regional scale, it can be said that the average pondered value for ETP in Aragon is 1,114.2 mm, although the maximums reach values in excess of 1,250 mm. 90% of the PDO region exceeds the average pondered value for the Autonomous Community of Aragon. The highest ETP values are in the centre of the detritic plain of Cariñena and in the valleys of the Valdemorao and Huerva rivers, areas with a lower altitude, where there are high thermal values, particularly in summer. The lowest ETP values can be seen in the areas with the highest altitude, particularly in some shaded areas of the Iberian Sirerras.

MAPS 12 and 13



The water balance is an indicator that links Potential Evapotranspiration (ETP) and the accumulated rainfall for a region. This indicator enables the dryness of the area under study to be known. If the values are negative, there is a deficit and therefore the area is dry. The map shows a negative water balance, although it is not homogeneous throughout the PDO region. The Cariñena plains and the valleys of the main rivers are the areas that register a more acute negative water balance, reaching values of less than -800mm. This is the case of Villanueva de Huerva (-713 mm.) and Cariñena (-738 mm.). These areas have a lower volume of rainfall and the highest temperature values, particularly in summer. By contrast, although the values are slighter in the sierra (Aladrén – 413 mm.), they are still dry. In the shaded areas, with a higher volume of rainfall and milder temperatures, the negative water balance is reduced. To conclude, it can be confirmed that the negative water balance is typical of the dryness of the region. However, there are spatial differences between the sierra and the flatter areas.

The municipality of Cariñena is an example of this. Its water balance is negative between March and October, worsening in the summer months, in which it more than exceeds a deficit of -100 mm in each of these months. The high temperatures and the lack of rainfall in this period of the year are the cause of this situation. Less acute water balances are observed in spring and autumn, registering a deficit that reaches between 40 and 80 mm. It is then when most of the rainfall occurs, but the evapotranspiration of the vegetation and the high temperatures explain these negative values.

The low temperatures in November, December and January explain the positive water balance, although rainfall hardly exceeds 20mm.

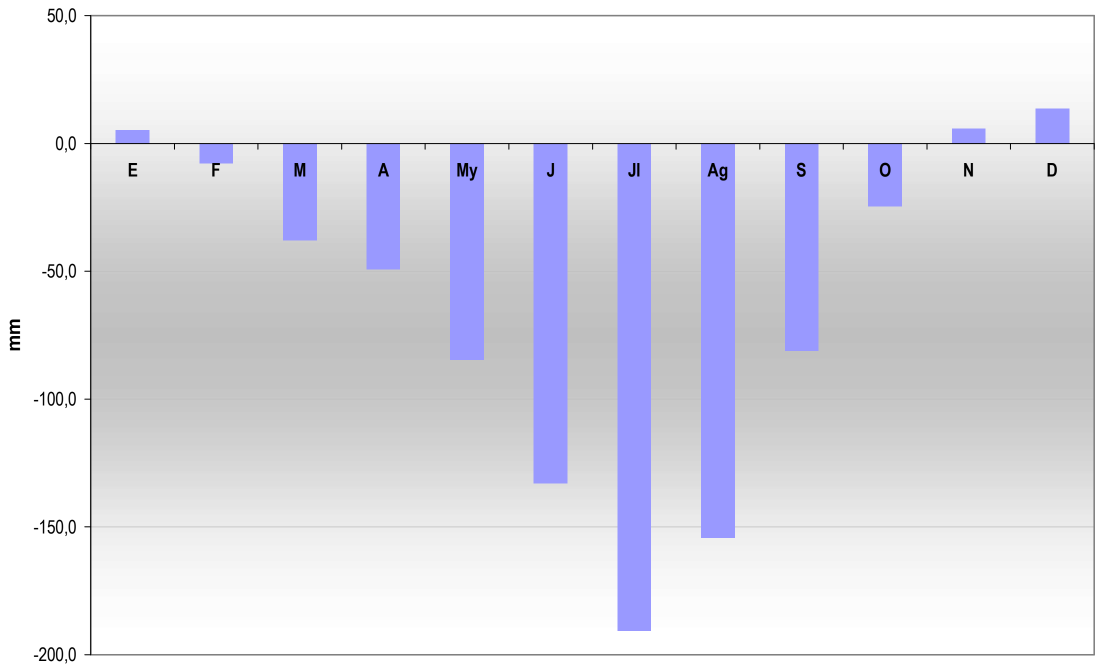
Table 2. Monthly water balance in Cariñena

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Evapotranspiration	23.0	35.2	68.6	99.0	148.0	184.3	213.5	180.9	115.4	63.1	30.5	20.6	1,182.1
Rainfall	20.3	25.3	31	50.3	61.9	48.4	21.2	26.4	34.7	40.5	34	28.8	422.8
Water Balance (mm)	5.2	-7.7	-37.9	-49.2	-84.6	-133.0	-190.7	-154.2	-81.0	-24.6	5.7	13.7	-738.3

Source: Atlas Climático de Aragón. Own compilation.

Graph 4 refers to the water balance of the municipality of Cariñena. It shows that there is a water deficit in 9 out of the 12 months, which is exacerbated in summer. In November, December and January, there is a surplus of low volume. This data shows that the Cariñena PDO region is marked by a dry and even arid climate.

Graph 4. Monthly water balance in Cariñena.



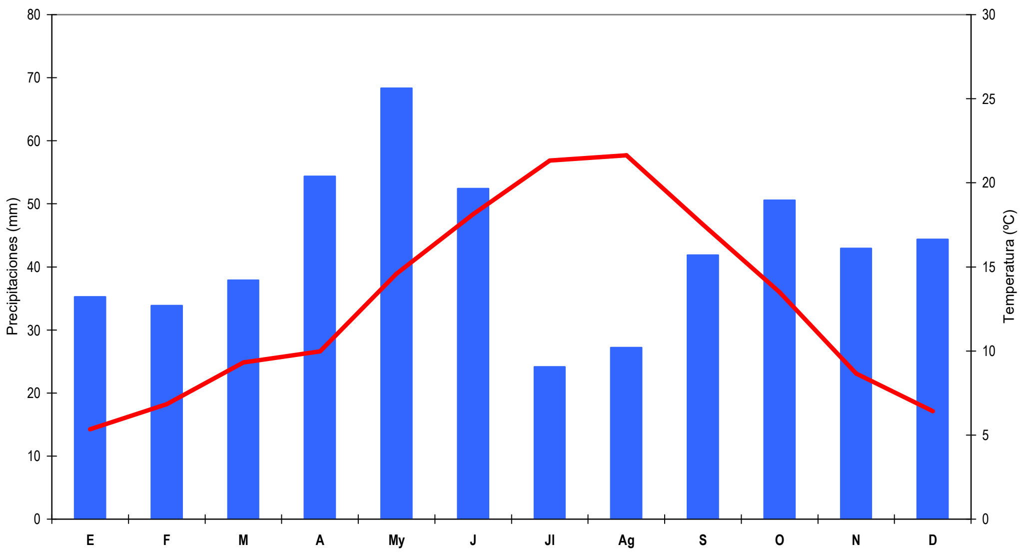
Source: Atlas Climático de Aragón. Own compilation.

1.3. 4. Overview of the main climate aspects in the Cariñena DO

The climate in the Cariñena PDO is continental Mediterranean. It is characterised by average annual rainfall of between 350 and 550 mm, with a seasonal rainfall system of equinoctial highs. Its temperatures register high seasonal contrasts. Winters are very cold and summers are very hot. This reflects the continental Mediterranean nature of the climate. Winds, which commonly blow throughout the region and the torrential nature of its water courses influence the rainfall and give rise to its semi-arid landscape, which is softened in some areas due to the orography (Climate and Viticulture Congress, 2007).

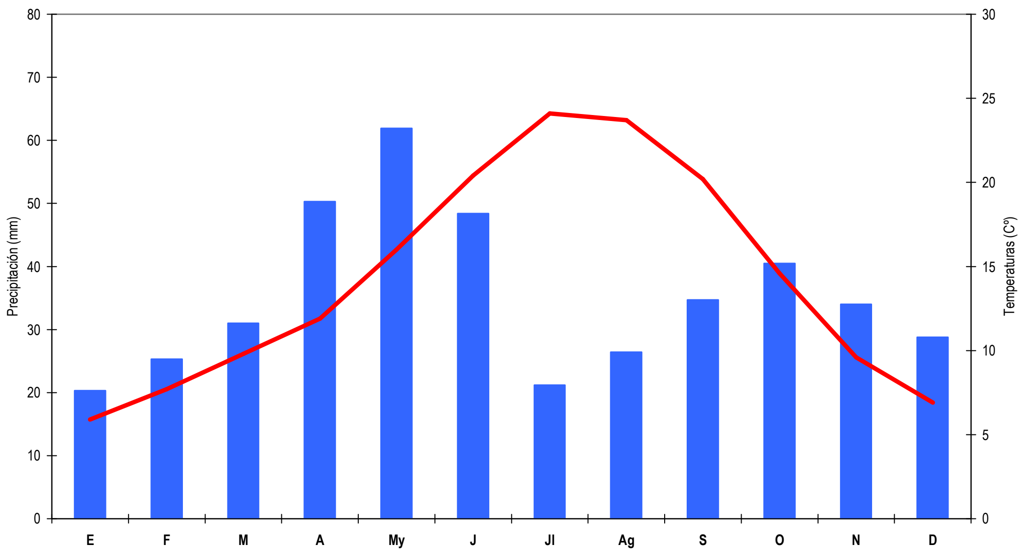
It can also be added that there is a clear contrast between the Iberian Sierras and the plains. The relief is undoubtedly the main factor, as it determines the total volume of rainfall and the behaviour and values of temperature and other climate variables, such as evapotranspiration or the water balance. In this area, marked by drought, the continental nature and the relief are the main factors of the rainfall system and the temperatures.

Graph 5. Climograph of Aguarón



Source: Atlas Climático de Aragón. Own compilation.

Graph 6. Climograph of Cariñena



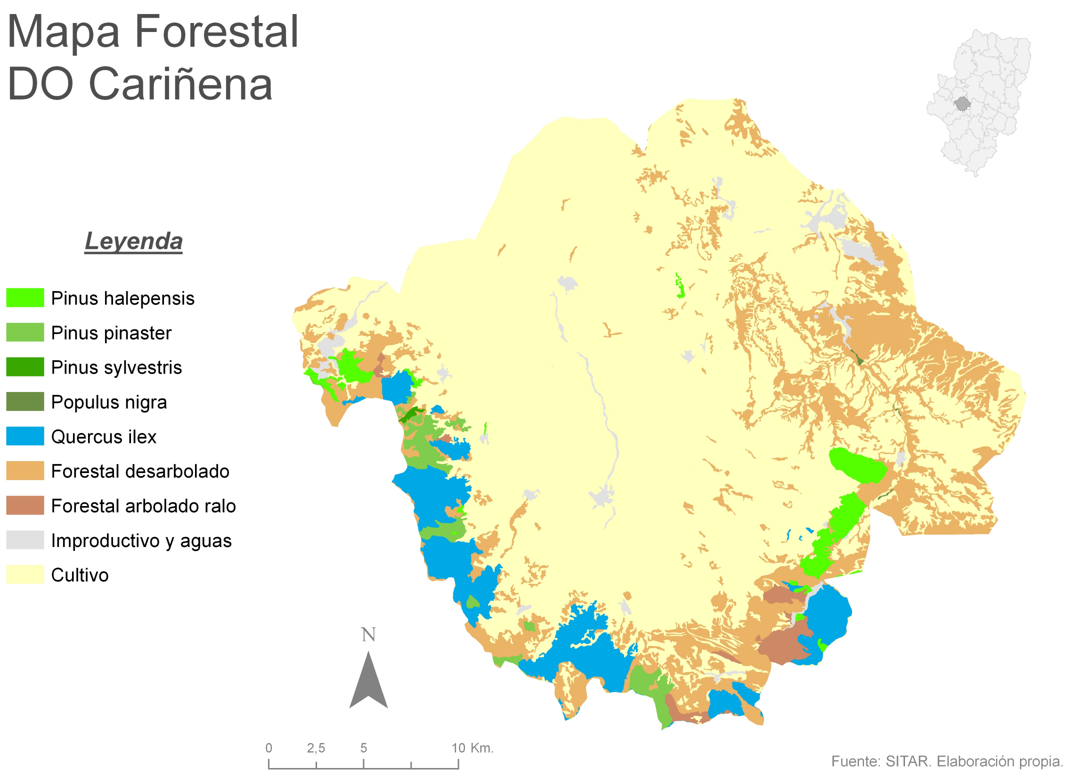
Source: Atlas Climático de Aragón. Own compilation.

1.4. Characteristics of the natural vegetation and soil

Within the limits of the Cariñena PDO, the areas devoted to cultivation have been increasing in detriment to the natural vegetation. This explains that the main cause for the shortage of vegetation, particularly trees, has been the deforestation by different groups of humans over the centuries, especially in the mountains. In the plain, the most extended unit over most of the PDO region, cultivated areas, particularly of vines, prevail. In spite of this, aromatic species can be found on the different boundaries that separate the plots. On the other hand, the presence of trees is scarce in the Iberian System.

Existing woods are mainly pine and holm oak. The former are located in the Herrera Sierra and around the River Huerva, in Tosos and Villanueva de Huerva. At times, these have been developed recently due to the different replanting actions. Holm oak woods appear as large patches, mainly in the municipalities of Aguarón, Encinacorba and Paniza. In the municipalities of Aladren, Tosos, Mezalocha and Alpartir, vegetation species typical of the Mediterranean prevail, such as rosemary, gorse and mastic.

MAP 14

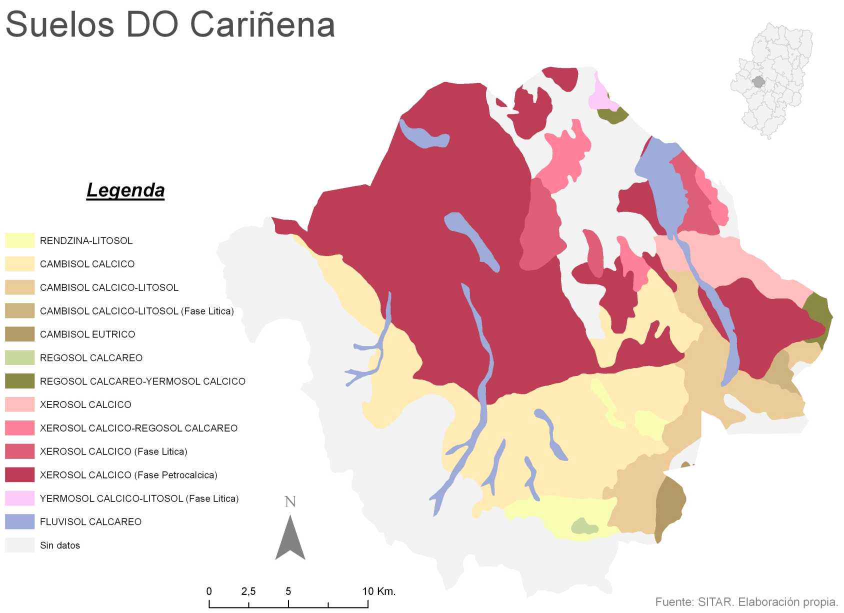


As previously indicated, soil and climate are mainly responsible for the quality of wine production. To address this part of the analysis of the physical environment, we have used the map available in the Regional Documentation and Information Service for Aragon, SITAR. Addressing the soil study is no easy feat as, unfortunately, no map is available to a scale that is acceptable for an analysis that enables the question to be studied in greater depth. In the PDO region, there is no data on the soil characteristics in the sierra areas and in the tabular reliefs. However, there is data for the detritic plain, which is the most agricultural area of the PDO.

The most widespread type of soil is calcium xerosol, which is mainly found in the petrocalcium phase. This is located in the western and central part of the detritic plain. It is characterised by having a light coloured surface layer and very poor in hummus. Patches, dust or agglomerations of lime and chalk crystals are often found at a certain depth. These soils present a natural vegetation of scrubland and grazing. They are highly suitable for the cultivation of vines, which may five high yields. Erosion is low, except in sloped areas. Cambisol soils are the next group of soils that are most widespread in the PDO. This type of soil is typical of the warm climate.

Within the Cariñena PDO, it can be found mainly in the eastern part of the detritic plain. Regosols are another group of soils present in the eastern margins of the PDO. There is hardly any agricultural activity on these soils. Fluvisols have a stratified profile, in which the organic matter decreases irregularly or is abundant in the deepest areas. They are found close to the rivers that drain the Cariñena plain on recent or very recent fluvial materials.

MAP 15



In the foothills of the PDO region, as is the case of the Algairén Sierra, there are poor quality soils, which are not very thick and have low agricultural potential. The serious difficulties for the introduction of machinery have favoured their forest vocation. By contrast, as we descend towards the detritic plain, the soil is mainly made up of alluvial and colluvial deposits (glacis), which is suitable for vine cultivation. In conclusion, the study of the natural characteristics of the region (relief, climate and composition and nature of the vegetation and the soil) is of great interest to understand the production aspects of the vine and many other characteristics and qualities of this production (MAPA, 1996), the extension of this cultivation, its inter-annual fluctuations and the development of the vine in particular and viticulture, in general.

This explains why we have characterised the physical geography of this area, focusing particularly on the different elements and factors that characterise the region. However, along with the physical factors that make up the region, historic or human factors cannot be ignored. Logically, they are also subject to analysis on the following pages.

1.4. 1. Edaphology

Campo de Cariñena is a plain enclosed to the south-west by the Iberian Sierras, in such a way that material depositions descending from the mountains to the plains, define the use of the soil in each particular case.

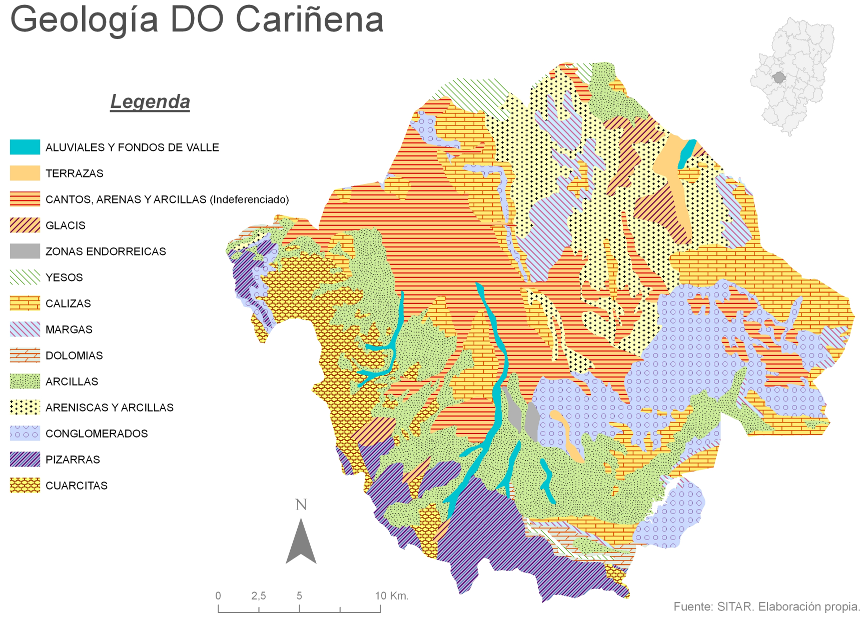
In the mountainous foothills, the soils are of poor quality with rocky substrate nearby, producing poor yields and posing serious difficulties for the use of agricultural machinery. As the mountain range loses altitude, the slopes descend gently until they become the Cariñena plain. At a certain altitude, the soil is made up of gravel from alluvial and colluvial deposits and has the necessary conditions for vine cultivation, as this crop does not require a lot of moisture although it does retain it once obtained. In these areas, the climate is milder and vines find the ideal place for growth.

Moreover, in the plain which stretches parallel to the Algairén Sierra, where more than 80% of the Protected Designation of Origin is located, miocene clay soils can be found. There are four main types:

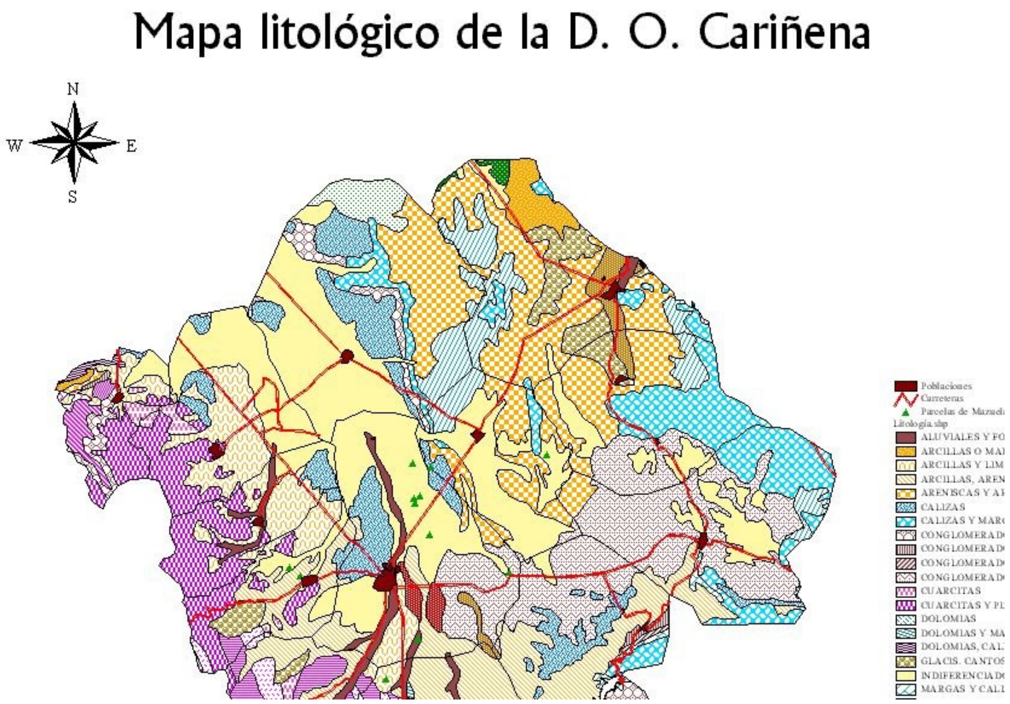
- Chipping Brownish limestone soils on top of allochthonous deposits, with reddish-brown soil patches. This is the most widespread soil in the Protected Designation of Origin.
- Royal. Southern brownish soils mainly on slate and quartzite, with xeroranker and litosol patches. This type of soil is the second most widespread in terms of extension within the Designation of Origin.
- Strong clay. Terraced soil on brownish limestone soil on eroded glacis or allochthonous limestone deposits.
- Calar. Soil of xerorendxinas on loams, sandstones, and sometimes gypsum levels, with litosols together with dark brown and chalky soils.

Another type of soil which occupies less extension within the Designation of Origin is alluvial, from the sedimentation of the Jalón and Huerva Rivers, near the towns of Almonacid de la Sierra, Alfamén, Muel, Mezalocha and Villanueva de Huerva.

MAP 16



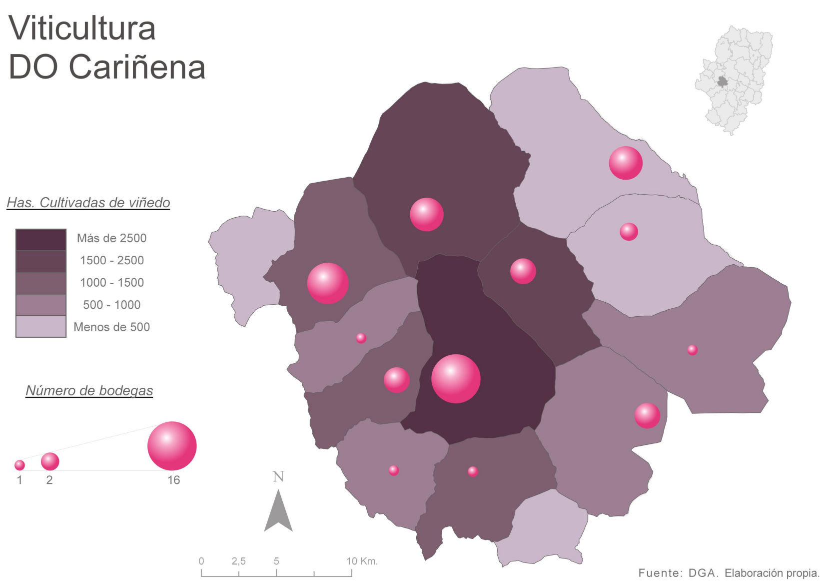
MAP 17



1.5. Viticulture

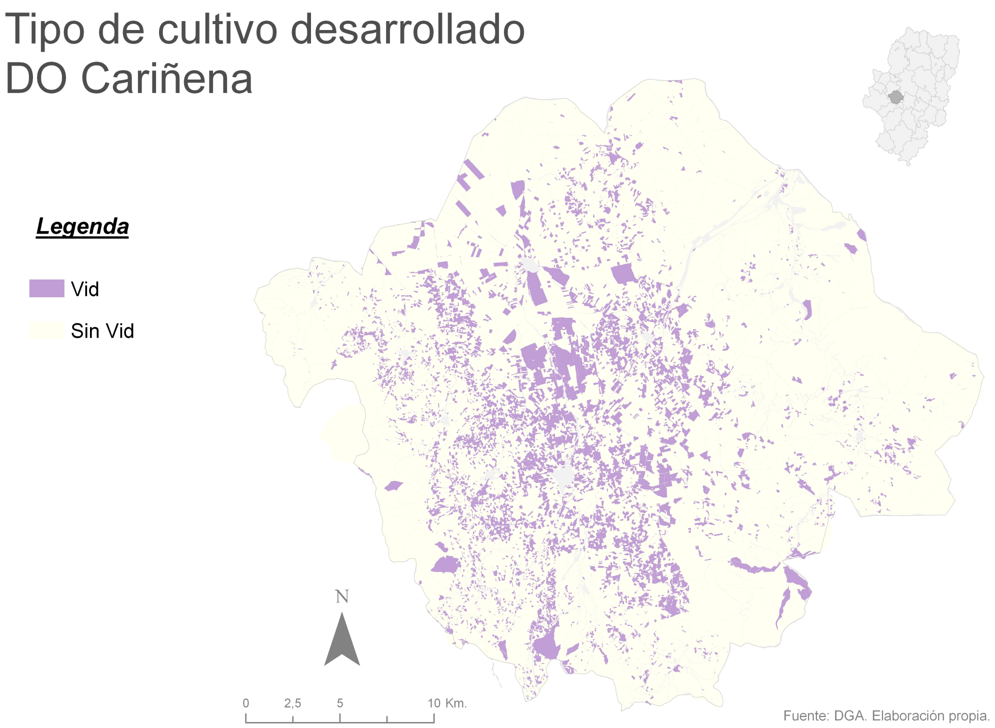
The map with the viticulture of the Cariñena PDO and the number of wineries per municipality is shown below.

MAP 18

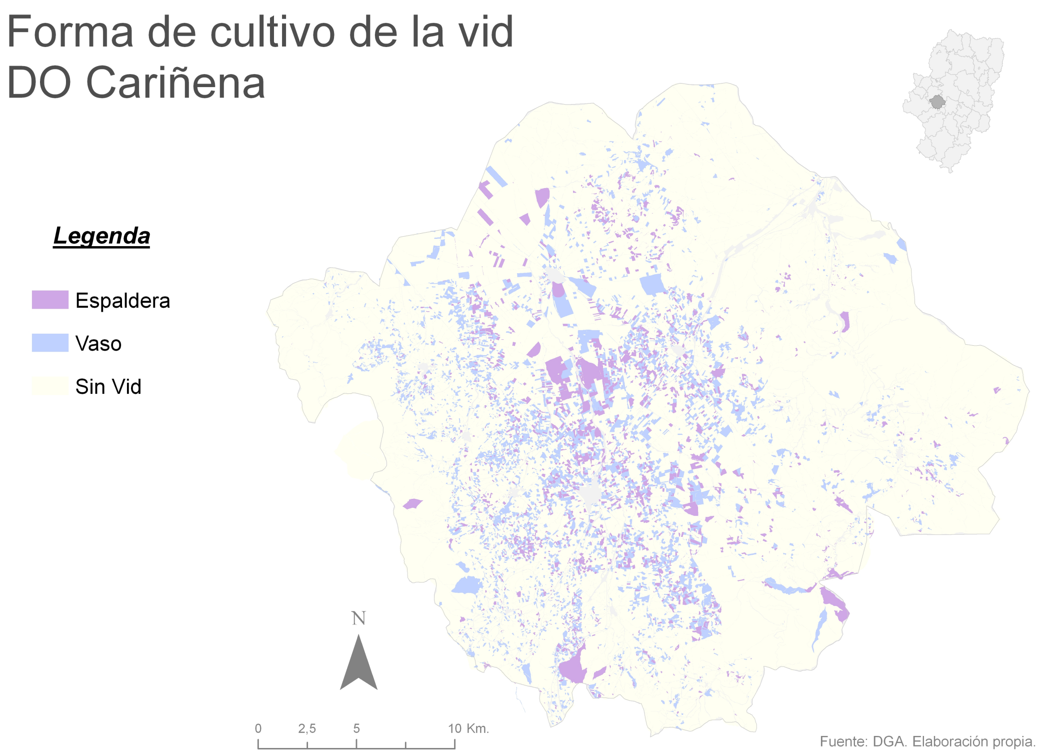


The maps of the location of the vineyards, land with vines and without vines, as well as the way of cultivating the vine, differentiating between their formation on the bush and on trellising, and the drying and watering system are shown below.

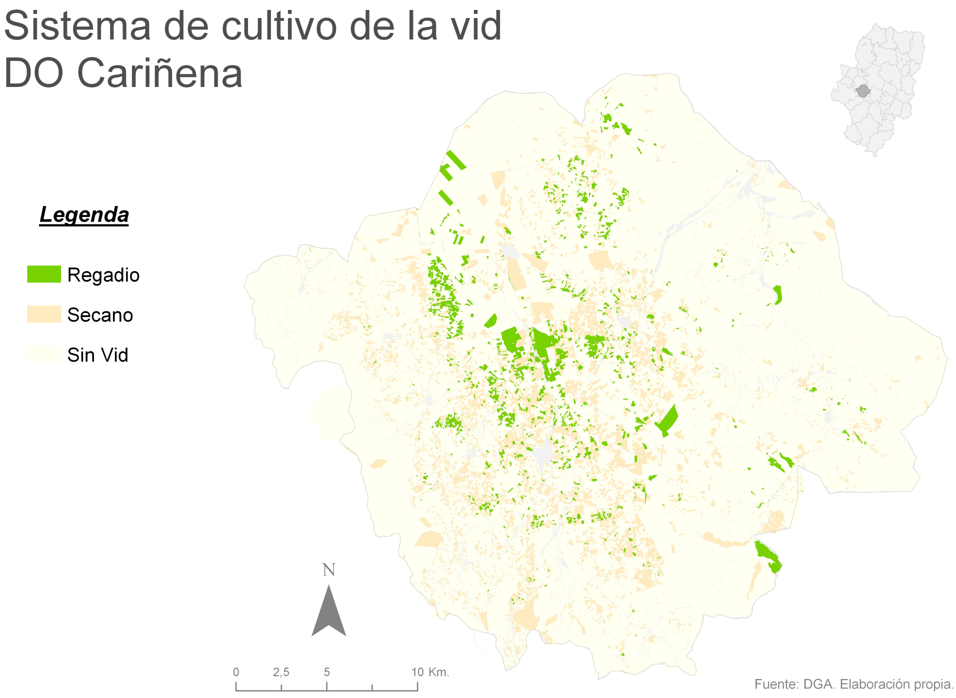
MAP 19



MAP 20



MAP 21



Sistema de cultivo de la vid
DO Cariñena
Legenda
Regadio
Secano
Sin Vid
N
0
2,5
5
10 Km.
Fuente: DGA. Elaboración propia.

CHAPTER 2. THE TERROIR

2.1. Terroir Study. Characterisation of the viticultural and oenological potential of the Cariñena Protected Designation of Origin terroirs.

A winegrowing terroir is a group of agricultural plots. It must be located in the same region, on the same type of soil, coincide from the geological and orographic point of view, have the same microclimate, use the same wine cultivation techniques in identical condition at its vineyards. These conditions, which define a soil, contribute to giving it a unique character, an identity to the grapes and the wine produced. In short, the terroir can be defined as an interaction between a soil, meteorological conditions, a vine and the human hand, the environmental characteristics and the elements of the humanised landscape.

The oldest designation in Aragon, the Cariñena Protected Designation of Origin, wishes to have a better understanding of its winegrowing terroirs. They are dispersed over an extensive surface area of 14,110 hectares of vineyards with a wide diversity of soils, climate areas and varieties. To do so, the PDO began a 5-year study in 2018 of the different terroirs that make it up and the wines produced.

The objectives of this study by the Cariñena PDO are many and ambitious: It is about maintaining, recovering and improving the vine growing and wine production heritage of the Cariñena PDO and developing the technical communication on this subject.

According to studies performed by the Groupe ICV from 2018 to 2022 in the Cariñena PDO, the following table describes the types of soil associated with each terroir unit.

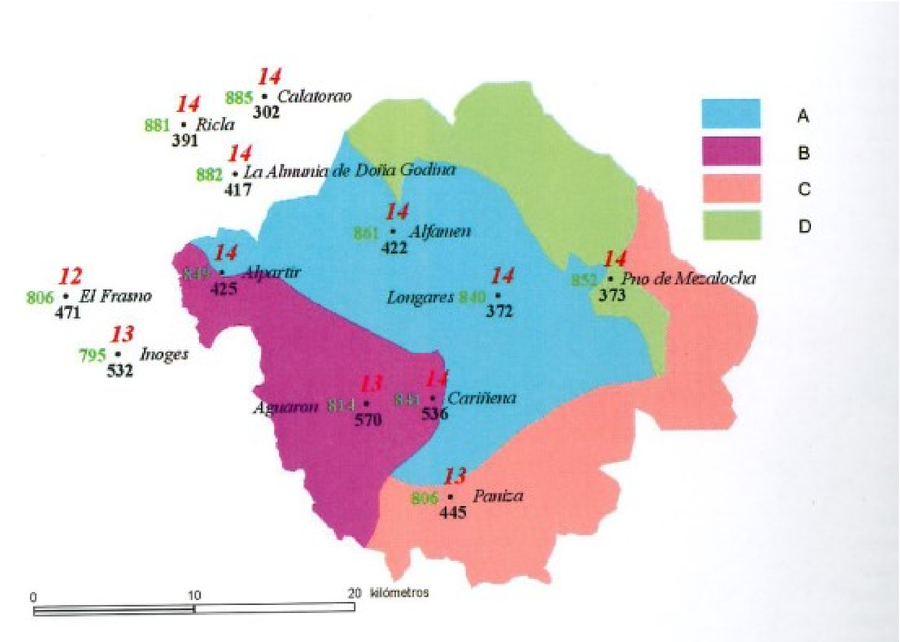
Terroir Unit	**Soil Type**
Unit 1: Recent alluvial soils	Fluvisol / Cambisol, Alfisol
Unit 2: Soil from gravelly terraces	Alfisol
Unit 3: Oxidised reddish soils from terraces	Alfisol
Unit 4: Soil from hillsides and slopes	Alfisol
Unit 5: Limestone plateaux soils	Calcisol, Inceptisol, Alfisol
Unit 6: Hillside soils	Inceptisol, Alfisol

Tab. 1. 1st classification of the terroir units for the Cariñena PDO according to the WRB classification

With the available data, on altitude and climatic zone, the largest zones are characterised by:

- Zone A (cf Graph. 3): Classic continental Mediterranean climate, larger surface area (65%), municipalities of Longares, Cariñena (Eastern part), Alfamén, Tosos.

- Zone B (cf Graph. 4): Transitional continental Mediterranean climate with increased moisture (20% of the surface area); municipalities of Alpartir, Aguarón, Cosuenda, Cariñena (western part).
- Zone C (cf Graph. 5): Semi-dry continental Mediterranean climate (10% of the surface); towns of Paniza, Villanueva de Huerva.
- Zone D (cf Graph. 6): Semi-arid continental Mediterranean climate (5% of the surface); towns of Mezalocha and Muel.



Map. Climate areas of the Cariñena PDO (Scale 1:150,000)

Finally, in 2022, we will be able to rate the classification defined by unit in Table 2:

Terroir Unit	**Average Altitude (m)**	**Climate area**
Unit 1: Recent alluvial soils	521	A & D
Unit 2: Soil from gravelly terraces	548	A & D
Unit 3: Oxidised reddish soils from terraces	667	A
Unit 4: Soil from hillsides and slopes	709	B & C
Unit 5: Limestone plateaux soils	576	A, B, C & D
Unit 6: Hillside soils	745	B & C

Tab. 2. Summary classification of the units according to average values of the altitude and climate area (in red: units studied)

2.1.1 Environmental characteristics: Flora and fauna

Those characteristic of the environment in the designation region can be found.
In the field, the effect between landscape and human activity can be seen easily. Agriculture occupies most of the land with vine, almond and olive plantations.
The typical vegetation is Mediterranean, with garrigue landscapes, scrubland and at times woods. In the units studied, some Mediterranean plants could be observed:

- In unit 1, 2, 3 & 5, a landscape deeply modified by human activity; on the boundaries and ditches, around the vineyards and roads, typical weeds can be observed (rosemary, thyme), bushes (rockrose or cistus, mastic) and few trees (almonds, holm oaks) (cf. photos 1 to 2).

- In unit 4 & 6, the landscape is also modified by human activity, except the slopes and areas where it is not possible to plant due to the presence of source rock (litho soil): trees (pine and holm oak) and bushes (mastic), which are more or less typical of more acidic soils, can be observed; the boundaries of the vineyards present a much more complex flora with various weeds (cf. photos 3, 4, 5 & 6).

Photos 1 & 2. On the left, type of vegetation of Units 4 & 6 (San Cristóbal Convent, Alpartir): garrigue of trees and bushes; on the right, type of vegetation of units 1, 2, 3 & 5 with a garrigue of bushes and olive and almond plantations (Aguarón).

Photos 3 and 4. Some common weeds of Zone 2: alliaceae and hedge mustard (Diplotaxis)

Photos 5 and 6. Fauna and flora of Zone 4: grass and many other weeds on the edge of the vines and birds, observed during visits to the plots.

To gain a better understanding of the flora and fauna of each area, the specific study or the private study available in the bibliography of Aragon is interesting. Plants indicative of each unit have been identified, bearing in mind the climate zone.

In the terroir study, information will be added on this issue as the plots are visited.

2.1.2. Humanised landscape elements

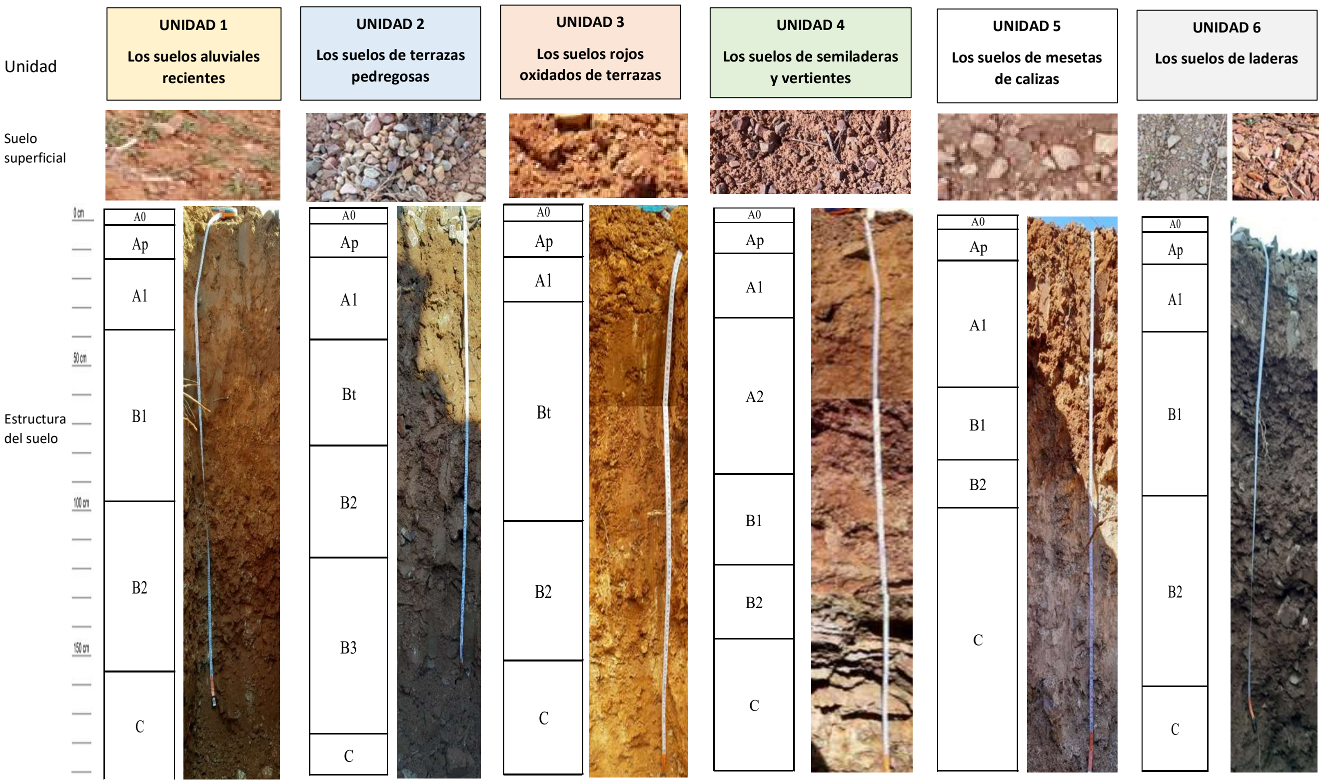
Human influence on the landscape can be seen, such as vine, almond or olive agriculture. To plant and cultivate, the soil needed to be prepared and the stones that are ever present in the landscape of the Cariñera DO had to be removed.

Local stones have been used to build walls and agricultural huts that are permanently in use today. It is easy to observe, for example, huts with quartzite or sandstone pebbles in Unit 4 (cf. Photo 7) or limestone in Unit 5 (cf. Photo 8).

Photos 7 and 8. Examples of agricultural huts with local stones: Almonacid de la Sierra to the left (Unit 4), Cariñena to the right (Unit 5).

Once the characterisation of the viticultural and oenological potential of the Cariñena Protected Designation of Origin terroirs has been studied, it is concluded in the modelling of the typical profiles of the six terroir units.

PERFILES TÍPICOS DE LAS SEIS UNIDADES DE TERROIR DE LA DOP CARIÑENA



TYPICAL PROFILES OF THE SIX TERROIR UNITS OF THE CARIÑENA PDO