

DYNAMICS OF PLANT COVER

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Social-economic changes, specially those related to strategies on natural resources exploitation, have conditioned huge transformations on plant cover in recent decades. To understand properly these changes we have, first of all, to know which factors have conditioned the structure, organisation and dynamics of Mediterranean vegetation. In the second place, we have to know which anthropic factors had affected landscape modelling and plant communities structure until 50 years ago. In the third place, we have to ascertain how natural resources profiting and exploitation strategies have changed, specially in relation to agrarian and forestry activities. In the fourth place, consequences of these changes at a short and long-term must be analyzed, and changes in natural processes are pointed out. At the end, there appear the answers given by human society to changes in plant landscape and their enviromental consequences in general.

Changes on plant cover dynamics are only part of the so-called global change. Changes in plant structure and dynamics are analyzed separately just to make easier our exposition, but its global perspective ought not to be forgotten, as it is a complex system with numerous inter-dependence and relations, and where any modification of just one of its components implies consequences to the whole system.

This is not a recent fact, what is new is the size of changes resulting from human activities over Earth system in the last years, as well as the consequences that could take place in a close future if present trends go on.

The study of plant cover and of plant landscape dynamic changes is relevant because of the sensitivity of plants before any impacts or perturbations. They are true bio-indicators of the global situation of natural systems and of landscape in general. Therefore, there is a need to find natural plant landscape reference elements, something that is not easy and, in many cases, only produces estimative models as there are not any real references. For a true global view of Mediterranean plant landscape and its present situation see the enclosed bibliography (Blanco, 1997; Blondel & Aronson, 1999; Braudel, 1985; Folch, 1993; Marchand, 1990; Margalef, 1989; Pugnaire & Zamora, 2000; Quezel & Medail, 2003; Ramade, 1990; Rivas Martínez, 1987; Thirgood, 1981).

I. THE MEDITERRANEAN BIO-CLIMATE

The Mediterranean bio-climate is rather well known in its larger aspects. In general, the Mediterranean region has not a homogeneous landscape because of its climatic variations. Some authors think that it is a contact or transition fringe between tropical dry climates and the cool and humid climates of temperate zones.

The Mediterranean climate is defined by the coincidence of dry and hot seasons (Figure 1). The key factor for climate differentiation is the length of the dry season, that ranges from a few months to almost the whole year. Its consequences on vegetation are evident; there are communities very similar to those living in dessert climates as well as sclerophilous forests on contact fringes next to temperate deciduous forests. Beside summer draught, we have to take into consideration other climate elements derived from sea proximity, height and geographical location, such as rains and temperature, humidity and wind. Another aspect to be taken into consideration is soil, specially the differences derived from the existence or lack of carbonates, salts or gypsums.

I.1. A benign climate

The Mediterranean climate is in general benign; it conditions the development of a rich and diverse natural plant landscape and gives profitable agrarian exploitations to human society. The mildness of the Mediterranean climate complements with relatively fertile soils, at least those over flat and level surfaces.

As already pointed out, the Mediterranean climate is defined and differentiated by the coincidence of dry and warm seasons, in Summer, in opposition to the more or less cool and

humid season, centred in Winter. The length of the dry and warm season is enough to differentiate sub-climates, from humid Mediterranean to half-arid Mediterranean.

Beside climate heterogeneity on Mediterranean land, that result in very variable situations with yearly average rains ranging from 100 to 2500 mm and average temperatures from 5° to 18°C, we have to take into account the large inter-annual variability of rains and the existence of extreme meteorological phenomena, such as heat or cold waves.

In general the Mediterranean climate enables the growth of a dense plant cover, with the exception of the lands with a draught period lasting 5-6 months. Even in that case, plant cover is outstanding but in low formations. Another thing is abrupt slopes where soils are always scarce.

I.2. A fragile landscape

Our previous considerations may be surprising in relation to present Mediterranean landscape, where low and discontinuous formations prevail, even in more or less humid sectors. On lands with a drier climate, plant cover is very poor with large surfaces with almost no plants.

It is true that plant cover on the Mediterranean area is scarce, but it is due mainly to century-long human activity. The Mediterranean climate grows a dense vegetation and some more or less thick and fertile soils over most part of the land. But this same disposition has resulted in an intensive exploitation by the different human societies that have occupied the Mediterranean lands.

The Mediterranean climate is benign, but its landscape is fragile in relation to human exploitation. The turning of the large and dense forest mass into agrarian land and pastures has activated different erosive processes. This cleared up plant cover suffers from a progressive draught process, and the loss of protecting plants makes easier soil wash out until its complete removal, which implies a reduced capacity to retain water. The result is that dry Mediterranean climatic conditions are increased for plants, specially during draughts, and reinforced by man actions. This is why nowadays the fields of thyme and other similar plants are larger than they would be without any agrarian and cattle-rising exploitations.

In regions with more humid climates or with shorter draught periods, plant cover regeneration takes place in short time. In the Mediterranean area, plant landscape regeneration is usually a slow very slow process in those sectors with long summer draughts.

Therefore, present Mediterranean plant landscape must be understood from a global point of view, taking historical human action as an essential factor in landscape generation. It must be taken into account that human action has stressed landscape contrasts and consequences derived from climatic differences.

There are many instances of landscape inversion, where at this moment the thickest forests are located on sectors that are possibly the poorest. This is the case of many mountains, where forest stands on shady and sharp slopes while crops prevail on sunny places and other flat areas, with almost no trees. At first sight, it could be thought that shady and sharp slopes have a higher ecological potential, when it is just the opposite. The richest and most fertile places are those that get more sun radiation (sunny) and where soils are thicker (plains). But those places, because they are richer, have been most intensively exploited and, consequently, have decayed the most. At present, they seem to be the poorest.

When agrarian and cattle-rising activities are abandoned, plant regeneration is much faster on sunny places and plains, specially after the first period when soil is covered by a dense plant cover which helps to catch sun radiation and to produce bio-mass. We have to keep in mind that, on a dry rocky surface, a significant part of sun radiation turns into thermal energy, which rises environmental temperature and draught, as well.

II. ANTHROPIC FACTORS CONDITIONING TRADITIONAL PLANT LANDSCAPE

Mediterranean landscape fragility is evident on human activity disorders, up to the point that present plant landscape can not be understood properly without human actions. Human impact has been effective since the first moment Man appeared (Riera, 2006).

We are not going to go back so far, unless it is to make it known. In this article we are going to present anthropic factors of two recent periods. First, impacts on plant cover until mid-20th century, a time of large social-economic and technical changes. Until that time, impacts were general and deep but limited to the technical capacity to transform land. Since mid-20th

century, human society had the technologies to make large changes in short periods of time, in a world where society was basically urban (chapter 3).

II.1. The tradicional landscape

We have to point out that when we talk about tradition we usually refer to those uses that are transfer by word of mouth from parents to children, or to costumes that come from generations. To use terms such as “traditional landscape” and “traditional activities” may be confusing, because the word traditional may result in mistakes. In this text, it refers to activities carried out before the technological development of mid-20th century, when the possibilities to transform space were much fewer than nowadays and when economy was basically for sustenance.

The knowledge of natural resources exploitation and landscape, specifically plant cover, formation has passed from parents to children until recently. The specific moment when said knowledge stopped being transferred orally has differed according the regions, but in the Spanish Mediterranean area it took place roughly during the three first decades of the second 20th-century half. However, we have to point out that since mid-19th century there were significant changes in agrarian and forestry systems and techniques, as well as in the demographic structure of rural communities, specifically where industrial centres settled, or around them.

Plant landscape derived from traditional activities have some common general features that must be pointed out.

First, it is a landscaped manipulated in its totality. There is no place where human influence has not arrived at. Flocks were over the farthest and most marginal land, and trees were cut on crags where today we think it difficult to arrive or we find too expensive for just a little tree.

Landscape was a mosaic closely related to the usage made of each tessela or plot. Each sector was exploited according to human needs and concrete uses. It was a man-made landscape and little by little, plant cover was turned into different uses. Not all of it was agrarian land; forest plots were left, even on plains, with the trees that were relevant according to human needs. An estate was a set of tesselas or plots that enable their inhabitants to survive, with woods,

pastures, crops, water points, straw lofts, barns, animal pens, cowsheds and housing. In every plot, notwithstanding its size, there was a section for family-sustaining crops, fruit trees and other trees for wood, coal, forage, tools, fences, beams, furniture, etc. Other marginal areas were reserved for pasture as well as the stubble fields in season. Water points, such as wells, springs, irrigation ditches and ponds were essential for human and cattle life.

In the small holds, this diversity of uses and covers was evident, and its exploitation was not enough to enable the family to survive. In the large estates, tesselas were larger, specially forests, and there was an excess of production that gave them some production surplus to sell or exchange it.

It is important to insist on human action on landscape, because trees were planted or grown depending on each family's needs. Therefore, it is important to be aware of those interests and needs to understand properly present landscape and its relation with climate.

Many of the plants thought to be Mediterranean traditionally were in fact introduced some centuries and even mileniums ago. Trees such as the nut pine, European hackberry, black wattle or banana, so well-integrated in present landscape, are introduced species. Some other plants may be indigeneous but their present distribution is due to human action, as in the case of the cork oak. In some other cases, they are trees widely cultivated from old and their present natural distribution is basically related to their agrarian distribution, such as the olive tree, algarroba tree or pomegranate.

It happens the same with several other bushes and herbs, that are grown for decoration or medicinal purposes.

Present distribution of many plants, then, is not due to a natural action but is the result of human activity. Some times, it is a direct intervention as with the above list of plants. However, very often they are undirect introductions, because their seeds have been carried and disseminated passively by people, animals or different goods. For instance, when cottom bales were imported, they brought seeds of many exotic plants, some of which germinated and disseminated successfully all over the Mediterranean area. Ruderal and arvens plants come mostly from them (Groves & di Castri, 1991).

Farming, cattle-raising and forestry activities have changed environmental conditions, thus, indigenous plants have also changed in their distribution and number. Shade species find it more difficult due to the reduction of forest area; however, sun species and those adjusted to drier climates have improved.

II.2. Traditional exploitations

Find below some exploitations that were more related to the formation and evolution of plant covers.

Tree felling has been the activity that has the most impact on plant cover changes. The maximum felling area depended on regions and counties. In some of them felling took place throughout the second half of the 19th century; in other places it took place in the first half of the 20th century. From the '50s there was a general decrease of farm surface, save in the sectors where irrigation was extended (Joffre et al., 1991).

The temporary or final abandonment of farming generates a change of uses and covers. Very often, the land is reforested with resinous (pines) or other fast-growing species (blue gum tree) or by poplars in alluvial plains. Other times, land is left as pasture; it is then when plant succession takes place until the potential community is consolidated.

Forests acquired a pattern through uses. There were sectors with large trees, and other areas where short and regrowth trees prevailed. In the centre-South of the Iberian peninsula the *dehesa* (rangeland) exploitation is much extended. Farming, cattle-raising and forestry are usually combined in a *dehesa*, and its landscape is commanded by large separate trees (Gutiérrez, 1992; Martín Galindo, 1966; Penco Martín, 1992; San Miguel, 1994; Valladares, 2004).

Forests were well used and they had been a source of wealth for their owners until a few years ago; they supplied wood, firewood, branches, foliage, fruits, fungi, etc. Each tree had its priority applications and many bushes and herbs had specific medicinal, decorating or food uses. According to the needs and interests of each place, some species were preferred over others.

Firewood has been one of the most relevant traditional forest exploitations and it has conditioned much forest structure. Firewood was much demanded for ovens and home uses, and it implied a systematic and intensive clearance of bushes and branches.

Charcoal making is another important forest exploitation. Charcoal meant taking energy from the woods to villages or towns, and to ovens and boat at very low transportation costs. Charcoal making has been until a few decades ago the most relevant forest activity for economy and landscape in many Mediterranean forests. It kept a low, not dense wood where regrowth trees prevailed. Charcoal making was a well-spread use until the '50s, when it started its decrease. At present it is economically important only in very reduced areas, while in most cases it is just a testimonial or even a nonexistent activity.

Present forests flora composition is the result of the preference of some species over others to obtain a better charcoal. The wood from holm oak produces an excellent-quality charcoal, and this species has been much grown in some zones; on the other hand, oak charcoal was not esteemed and, very often, the tree was uprooted. This tree selection explains, for instance, that many groves were mono-specific and that nowadays oaks are growing among holm oaks.

Forest area has varied depending on different factors. In periods with larger demographic pressures, for instance, agrarian land was increased while in wars or plagues, pressure on land diminished and large areas remained cropland for many decades and forest regenerated on its own.

III. RECENT CHANGES IN AGRARIAN AND FORESTRY ACTIVITIES

Since late 19th century and along the 20th century, changes in plant cover have taken place basically in relation to the abandonment of unproductive lands. This abandonment was encouraged by different pests that destroyed vineyards (specifically the filoxera pest), and by social-economical changes, such as the relevant urban and industrial development. The largest changes on plant cover took place, however, from the decade of 1950.

III.1. The abandonment of traditional activities

Strategies on natural resources exploitation changed radically. These changes started in different moments depending on the regions, but they were present everywhere in early '70s.

These changes derived from social-economic transformations and from the availability of powerful land-changing and long-distance goods-carrying techniques and means.

Human population was increasingly concentrating in large urban nuclei and its life style tended to become more urban and sedentary, and farther from natural spaces. Besides, market laws were conditioning natural resources exploitation. Many farms had become little or not profitable and they were left waste. Some of them have been replanted with resinous or fast-growing trees, but most of them are left uncultivated so natural dynamics are taking over them replacing pastures, that become brushwood and finally forests, depending on the soil and the climate of the area. Land waste is important, and very often total, on mountains and on little productive and un-profitable places.

A subsistence economy was not possible for the new generations, because the new society of “consumption and welfare” requires money to meet any new needs. The young people from the countryside and villages turned into the Industry or Services workers, quitting their parents' activities.

The result is the transformation of large agrarian areas on waste land, brushwood and forests. Land waste in general does not imply a cattle-raising or forestry exploitation, because they are not profitable either. A natural regeneration is just a first consequence in plant cover dynamics.

At the same time, irrigation consolidated and spread on plains, with intensive crops, basically of vegetables; while greenhouses gave yields even in cold weather. With the new irrigation techniques (dropping, spraying) bad and dry lands became highly profitable and the performance of old dry-farming crops, such as vines, olive trees and cereal fields, increased.

III.2. New exploitation of forests

A higher density of brushwood and trees and a large continuity of tree mass increase the risk of large fires. Wood fires have become the main factor that controls Mediterranean forest landscape dynamics in the last decades of the 20th century. Traditional fire prevention and extinction activities are not enough to prevent, control and end the so-called mass fires, when fires are of large dimensions. Thus, fires ravage thousands of hectares in several days, out of

control, until some favourable weather conditions, a landform or the end of the plant mass make possible ending the fire (Moreno & Oechel, 1994; Trabaud, 1998).

The alternate to this situation is forestry management, and its main purpose is to decrease the risk of fire. Forestry profitability is seen under social and ecological objects. At this moment there are not any other direct alternates for forest resources; no bio-mass exploitation is profitable enough and, in consequence, woods keep growing left to the control of fires.

On the other side, the stressing living conditions in the cities (within very close boundaries) have created the need to have leisure spaces, embodied in two new usages. Many forest areas have been turned into developed areas, as a second home for week-ends and holidays, while a large part of uncultivated mountainous land has been declared to be protected areas as natural parks, rural parks, etc. In many cases, in spite of their formal purposes of conservation of natural systems, their true hidden object is to keep leisure green areas for town inhabitants.

All of this has resulted in changes in forest- and pasture-related activities and uses. There are very few woodcutters, charcoal-makers and sheperds; in their places, there are foresters, outdoor activities monitors, tourist guides and restaurant owners. The wood is not anymore a place where firewood or wood are found, but a pleasant framework and a place to rest in. Farm houses are not anymore places that exploit the environment but restaurants, hotels, bungalows or hostels. There are no more threshing floors, but places where children play or run.

IV. RECENT PLANT LANDSCAPE TRANSFORMATIONS

Present exploitation of forestry and pasture resources implies, as already said, a larger density and continuity of woods. There are also changes in plant communities' structure, flora composition and in their working.

Present state of Mediterranean woods is complex. On one side, traditional exploitations are not profitable any more and no market changes are foreseen immediately. On the other side, natural regeneration and bio-mass production can not be stopped. The result is a forest cover that is increasing and the turning of brushwood and pasture into forests, wherever the climate allows it.

The scheme for plant succession is rather simple, in theory. Once crop land is left waste, there appear first of all some opportunist pioneering plants, that can not stand competition. Very soon, pioneers are replaced by other more competent herbs, to be replaced by other better adjusted plants. In fact, each plant set creates a situation that enables the appearance and settlement of new species, producing a new environment on which previous plants can not survive while making possible the survival of the best adjusted species.

If a pasture or a forest are left waste, the model is similar. Once human action has stopped, depending on the environment, some or other species may survive best; from a concrete situation, an evolutive dynamics is started until a potential community is settled without human help and remains in a more or less stable way. In truth, no potential community is static, but a community can become permanent with very few variations in its structure, flora composition and working (Pérez Ramos, 2006).

Figure 2 presents schematically three stages of a plant succession from the exploitation abandonment of a grove of nut pines within an area of holm oaks. The lower profile presents the nut pine grove some years after being left waste; bushes and holm oaks are not very tall. The middle profile presents the abandoned nut pine grove after a longer term; the underwood is dense with different tall bushes, among which young holm oaks are relevant. In the upper profile, holm oaks are well developed into a continuous and dense mass; under them, the underwood is scarce due to the permanent and thick shade. Up above the holm oaks there appear some surviving pines.

In a few years, landscape has gone from a mosaic with small-sized units to a polarized landscape with large and continuous units. On one side, wood mass has increased and takes over larger areas. On the other side, crop land is concentrated on those places where soil and topography enable the use of highly-mechanical means and where (both local or channelled) large amounts of water are available. Lastly, cities have grown and created large urban estates; urban space spreads at present over a large area. It is getting more imperceptible the spatial differentiation of large plant, farming and urban covers.

This would be the desired-for dynamics except for the risks it implies, especially fires, and other risks derived from bio-mass accumulation and from landscape maturity. Fires act as

controllers of natural systems but they appear in a violent manner and they often have catastrophic effects on human population. There are different strategies to prevent them, but traditional prevention strategies are not efficient in the case of mass fires that can raze thousands of hectares of dense and continuous forests. Therefore, some institutions have started some drastic measures to reduce bio-mass at a non-excessive cost.

V. REACTIONS TO CHANGES IN PLANT LANDSCAPE

Changes in plant cover and in plant communities structure and dynamics demand new actions from human society. Processes and actions in woods, brushwoods and pasture have also changed, some of them in intensity while others are new or appear very seldom. The most evident phenomenon is fires; but there are others related to alteration, erosion, water retention and animal communities control.

These changes in plant landscape must have global reactions, as changes have a large magnitude within the Mediterranean regions. Changes have to be seen from a global point of view, from a historical perspective and at the appropriate time and space scales. Plant cover has different and valuable functions, and a rational, global and consequences-informed exploitation must be found for natural resources (Valladares, 2004).

The term of global change implies a global approach to the Earth system in its totality. Plant cover plays a relevant role on atmosphere and its composition, on water cycle and on soil formation and conservation, apart from its own intrinsic value.

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Figure 1. Shade-thermic diagrams on Iberian Mediterranean climates. See draught (darker pattern) differences among the three seasons.

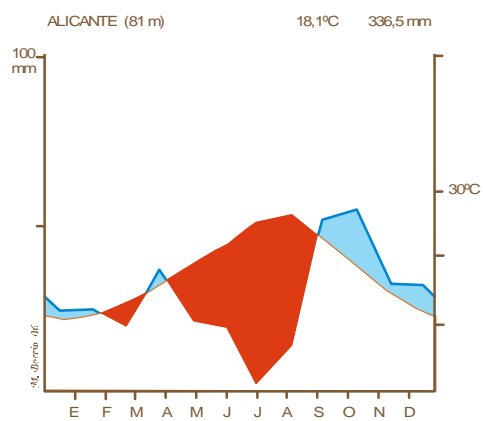
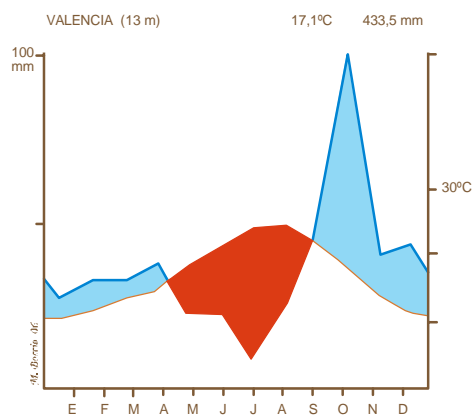
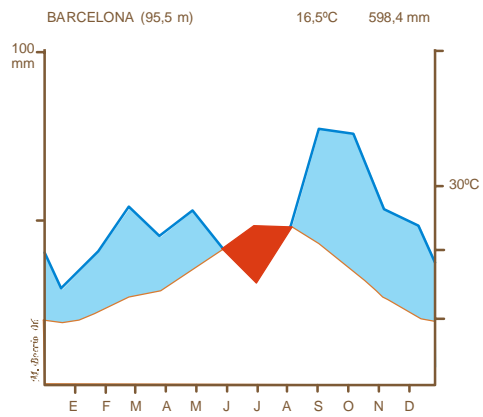


Figure 2. Scheme representation of the evolution of a nut pine grove after being left waste. See the increased density and height of holm oaks, from low isolated individuals in the lower profile till they become a dense and continuous stratum in the upper profile.

