

Mediterranean grasslands: ecological observations related to the climate of the past 55 years

Hernández A. J.¹ and Pastor J.²

¹Dpto. Ecología, Universidad de Alcalá, Madrid, Spain.

²Centro Ciencias Medioambientales, CSIC, Madrid, Spain.

Abstract

This evaluation was designed to gain insight into the ecological behaviour of herbaceous plant species growing in Mediterranean grasslands according to temperature and rainfall variations recorded over the past 55 years. Our evaluation included 100 sites in the central Iberian Peninsula differing in terms of land use, but lying on the same substrate in the same climatic region. We report the initial results for species acting as indicators of marked soil aridity and species representing the sites with less rainfall. Also discussed are observations, which together with these data provide knowledge on the responses shown by plant distribution to global warming in a semi-arid Mediterranean setting.

Keywords: precipitation, land use, plant indicators of soil aridity.

Introduction

The real consequences of rapid climate change, such as those currently taking place, are not well known with regard to localized effects. It is foreseen that these potential effects will be considerable and substantially irreversible and will no doubt represent a threat to the country. The Iberian Peninsula is a transition boundary region separating contrasting climatic domains. Given the scarce and irregular nature of the rainfall, the abundant solar energy and elevated albedo, water and energy cycles show very particular characteristics. Under these conditions vegetation is scarce and provides the soil with little protection or organic matter. The natural habitats looked at – herbaceous formations, stony habitats and sclerophilic Mediterranean woods – are listed in “Natural Habits of Interest within the European Community” and have been the subject of recent conservation studies.

Materials and methods

Study area: The landscape of the central Iberian Peninsula is mainly formed by a climax vegetation of terminal associations of the *Quercus rotundifolia* mesomediterranean series. Past vegetation only persists in regions where the excessive slope or private interests have impeded reclamation of the land. We are faced with a landscape of agricultural dry lands: fields of cereal interspersed with those left fallow, abandoned crops, vineyards, olive plantations and areas given over to grazing in oak wood clearings (Hernández *et al.* 1994).

Several ecosystems of the Iberian Peninsula's southern submeseta were considered by means of 100 sampling points corresponding to different soil uses following the abandonment of cereal cultivation: 50 livestock rearing and hunting grazing systems stabilized to a greater or lesser degree; 25 fallow systems subjected either to traditional management or intensely automated agriculture; 25 old fields. All these systems are found on the same arkosic substratum and represented most of the main soil types of the study area. These sampling points have their corresponding phytoecological inventories (based on random sampling of 1 m² plots) and soil analysis data. Several experimental plots were established to represent the different situations in which the plant communities referred to are found, in terms of soil use and climate variation. These plots were set up in the experimental farm “La Higuera”, Toledo (40° 04' latitude and 450 m altitude). The ecological and climatic characteristics (Table 1) of this farm, representative of the studied territory, are such that it provides, to a large degree, ideal scenarios for the study of relationships occurring between climate, land use and plant.

Table 1. Monthly rainfall values recorded on the experimental farm over the period.

Rainfall 1949-2004	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Mean ^{55 years}	53.7	49.0	41.1	48.0	43.8	26.4	8.2	9.1	31.5	51.5	58.8	64.5	488.7
St.dev.	44.2	40.1	30.5	29.8	30.2	30.0	10.2	12.4	29.0	48.0	48.0	50.0	132.3

The ecological behaviour of 245 species was examined in relation to several environmental factors: 15 climatic and edaphoclimatic, 36 edaphic, 18 biotic and 2 soil management. Next, the 174 most frequently occurring species that also/alternatively showed most balanced ecological behaviour with respect to the environmental descriptors were selected. The methods employed for this analysis included the calculation of "species-environmental factors mutual information" and that of "corrected characters and indices profiles".

Results and discussion

Ecological behaviour of the species.- Among the 10 factors of greatest ecological significance for the species were: rainfall, soil moisture and greatest or least insolation received by the plot. Other factors that also showed importance were soil use, type of plant formation, species diversity of the community, soil pH and the proportions of OM and total N.

Table 2. Representative species of dry localities.

Species representing the sites with less rainfall			
Anagallis arvensis	Calendula arvensis	Daucus carota	Lactuca serriola
Andryala integrifolia	Cynosurus echinatus	Desmazeria rigida	Lathyrus angulatus
Atractyllis cancellata	Carduus tenuiflorus	Echium vulgare	Lolium rigidum
Avena sterilis	Centaurea ornata	Vulpia hispánica	Lotus conimbricensis
Bromus diandrus	Convolvulus arvensis	Galium tricornutum	Sonchus tenerrimus
Species acting as indicators of marked soil aridity			
Aegilops geniculata	Astragalus stella	Echinops strigosus	Tolpis barbata
Brachypodium dystachion	Coronilla scorpioides	Hedypnois cretica	Linum strictum
Bromus diandrus	Trifolium angustifolium	Helichrysum stoechas	Myosostis discolor
Bromus scoparius	Trifolium scabrum	Tolpis barbata	Neatostema apulum
Bromus tectorum	Trifolium stellatum	Arenaria leptoclados	Paronychia argentea
Coynephorus fasciculatus	Trigonella polyceratia	Diploaxis catholica	Plantago afra
Lamarckia aurea	Andriala integrifolia	Diploaxis virgata	Plantago albicans
Vulpia ciliata	Atractyllis cancellata	Echium vulgare	Silene colorata
Vulpia hispanica	Centaurea melitensis	Herniaria hirsuta	Silene inaperta
Vulpia myuros	Centaurea ornata	Jasione crispa	Velezia rigida

It was observed (Table 2) that 20 species showed a preference for areas of least precipitation (mean <500 mm per year) and 15 for areas in which greatest precipitation values were recorded (500-700 mm). Sixteen species showed an intermediate preference and the remainder were indifferent to this variable within the range examined. Analysis of the effects of this rainfall on the frequency and abundance of 42 of the most significantly affected species, revealed the following ecological behaviour patterns: 28 species showed similar behaviour in terms of frequency and abundance; in 7 species both these

characteristics were enhanced with increasing rainfall; and in a further 7, they were also enhanced with increasing rainfall but showed a subsequent fall. In another 10 species, frequency and abundance were independent of rainfall and in another 4 species, these characteristics showed a reduction with increasing rainfall. Only in 3 species was this type of behaviour antagonistic; while frequency increased with rainfall, abundance was reduced. Finally, the remaining species showed other types of behaviour with respect to the precipitation factor. The different degree of insolation received by each plot gave rise highly particular responses: 53 species showed a clear preference for "sun and shade" locations, while only 12 and 14 respectively preferred sites with full sunshine or shade.

Loss of definition of plant communities. The start of the rainy season is very sudden and depends on unpredictable meteorological events. In favourable years, the drought usually commences towards the second half of April or even later. However, in dry years, it may start much earlier with the arrival of dry, warm winds. The effects of drought may also be enhanced by spatial variability of the micro relief, the shade of the oaks and bushes and the fact most sp. show great intraspecific flexibility in their phenological behaviour. These changing factors give rise to "patterns", or mosaics of plant populations in different states of maturity and desiccation. The status of the seed bank of these ecosystems is directly linked to the annual fertility of the adult plants. If seed renewal is interrupted for a year such as may occur during prolonged drought, impoverishment of the seed bank could reach significant proportions and threaten the stability of the population in terms of reproducibility. Most areas occupied by pasture land are suffering a phytoclimatic change for the worse through a process that is fairly regular. For the studied region, meteorological data recorded between the years 1949 and 1968 indicate that there were 9 more humid years, 7 comparable years and only 3 drier years than mean values corresponding to the last 50 years. However, in the 20 consecutive years (1969 to 1988), there were 8 relatively wet years, 6 normal and 5 dry. And over the last decade (1989-1998), there have only been 3 wet years, and 2 normal and 5 dry (Hernández et al., 2005). The situation may be summarized in any case as a generalized increase in the duration and intensity of aridity and a reduction, also generalized, in annual rainfall, with a certain increase nevertheless in summer rainfall. There is consequently, a danger of a stepwise decline or decay of the plant communities of the region. This has already been confirmed in the case of the "majadales", or *Poa bulbosa* and subclover communities, whose species have been the subject of previous investigations centring on the effects of environmental factors (Pastor and Martín 1984, Pastor et al., 1994). Over the last years these communities have become scarcer and their floristic composition less typical (Hernández et al. 1994) than observed in the recent past (Pastor and Martín, 1984). Further, over the last few years we have observed that increased yearly temperatures negatively affect plants accelerating their development and reducing the time available for seed dispersal.

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