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MAPA DE CALIDAD DEL PAISAJE DE ESPAÑA

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RESUMEN

Actualmente, el proceso de evaluación del paisaje está reconocido como una herramienta para la evaluación del medioambiente potente e interdisciplinar. Proporciona una base para percibir una zona de estudio como un sistema de unidades territoriales interrelacionadas con características ambientales específicas. El desarrollo y aplicación de diferentes métodos de valoración del paisaje en diferentes territorios ha provocado que existan mapas de valoración del paisaje en numerosas regiones y países. En España, se han realizado estudios a nivel regional. Sin embargo, a nivel nacional, el paisaje ha sido descrito cualitativamente y no de forma cuantitativa. El objetivo de este trabajo es elaborar un mapa de calidad del paisaje a escala nacional, lo cual permite introducir esta variable, junto con información relativa a vegetación, geología, suelo, etc., en el proceso de planificación. El trabajo se completa con la validación del mapa mediante su comparación con la zonas protegidas.

Palabras clave: Evaluación del paisaje, cartografía, SIG.

MAPPING LANDSCAPE QUALITY IN SPAIN

ABSTRACT

The process of landscape evaluation is currently recognised as a powerful, interdisciplinary, environmental research tool. It provides a basis for perceiving a study area as a system of inter-related territorial units with specific environmental characteristics. The development and application of different methods to different territories has advanced landscape mapping to the point that widely accepted maps now exist for many regions and countries. In Spain, a number of published landscape maps have been made at the regional level. At the national level, the landscape has been mapped descriptively, but no landscape quality maps exist. The aim of this work was to produce a national landscape quality map which would allow this variable, along with information on vegetation, geology and soils, etc., to be integrated into the planning process. The work also tackles the validation of this map through a comparison with maps previously produced for protected areas.

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Keywords: Landscape classification, cartography, GIS.

LE PLAN DE QUALITE DU PAYSAGE EN ESPAGNE

RÉSUMÉ

Actuellement, le processus d'évaluation du paysage est reconnu comme un outil puissant et interdisciplinaire pour évaluer l'environnement. Il donne la possibilité de percevoir une aire d'étude comme un système d'unités territoriales interconnectées, aux caractéristiques environnementales spéciphiques. Le développement et l'application de méthodes différentes de valorisation du paysage aux différents territoires a favorisé la production de planes de valorisation du paysage dans de nombreuses régions et pays. En Espagne, on a réalisé des études au niveau régional. Cependant, au niveau national le paysage a été décrit qualitativement et pas encore par des méthodes quantitatives. L'objectif de ce travail est d'élaborer un plan de qualité du paysage à l'échelle nationale, qui va nous permettre d'introduire cette variable, avec les renseignements relatifs à la végétation, la géologie, le sol etc, dans le processus de planification. Le travail sera complété par la validation du plan à travers une comparaison avec les aires protégées.

Mots clé: Évaluation du paysage, cartographie, SIG.

1. INTRODUCTION

The process of landscape evaluation is currently recognised as a powerful, interdisciplinary, environmental research tool. It provides a basis for perceiving a study area as a system of inter-related territorial units with specific environmental characteristics. The attention given to natural geoecosytem and socioeconomic data, and the relationship between these, provides an ideal framework for territorial sampling as part of evaluation work, mapmaking and environmental modelling, Milanova et al. (1993).

Over the years, the term "landscape" has been used with many different meanings, including Nature, territory, geographical area, the environment, a system of systems, habitat, backdrop, everyday environment, and the surrounding area. One of the most important is 'the subject of landscape ecology', Turner (2005a, 2005b) (a subdiscipline of ecology that examines the patterns, processes and changes in landscapes), Turner (1989). But above all, and in all cases, landscape is an external manifestation, an indicator image or key reflecting the processes (natural and anthropic) that take place within a territory. As a source of information, landscape requires interpretation. Man establishes his relationship with the landscape as a perceiver of information, which can either be analysed scientifically or experienced emotionally, Otero & Ramos (2002). However, the absence of a clear concept of landscape, plus the difficulty in reducing the amount of information it provides to manageable quantities, have led to the recent development of methods for its analysis.

Landscape quality is difficult to define. Although there is no consensus within the scientific community, several meanings have been proposed. From a landscape management point of view, the concept of quality refers to diversity, coherence and continuity, Kuiper (1998). Arraiza et al. (2004) assume that quality is related to the visual characteristics of the landscape. Lee et al. (1999) and others define quality as the ecological value of the landscape. Otero et al. (2006) consider the term quality to refer to the concept of naturalness; in this context, a landscape has a high quality value when human no influence is visible.

The large number of features making up landscapes have given rise to many different approaches to their study, some of which are complementary. In general, however, these systems classify landscape from two major standpoints: the human landscape (mainly used in Europe), Blankson & Green (1991) and Green et al. (1996), and the biological landscape, Christian & Steward (1953), De Agar et al. (1995), Bailey (1996) and Bernert et al. (1997), which combines information on climate, soils, vegetation and landform into observable and definable units of terrain, Omernik (1987). The methods employed vary from visual analysis, using elements such as "scene", to quantitative techniques employing different sets of variables, Benefield & Bunce (1982), Blankson & Green, (1991), Host et al. (1996) and Bernert et al. (1997). These methods are not entirely objective since the variables taken into account have to be selected, but they are less subjective than visual methods, Fairbanks & Benn (2000). However, these two major landscape classification systems have a common basis - the reality of the territory.

1.1 Features of Different Landscape Evaluation Methodologies

The two major approaches to landscape classification are represented by a number of methodologies incorporating different philosophies. The problem of the aesthetic evaluation of the landscape is multidisciplinary. Experts in philosophy, landscape architecture, engineering, psychology, biology and territorial planning have all attempted such evaluations, but always from very different points of view, Cañas & Otero (1993), Gussow (1979), Carlson (1977), Ribe (1982), Carlson (1984) and Dearden (1987). The greatest philosophical and methodological divisions occur between those who defend a more reductionist and quantitative-objective approach (quantitative focus), and those who maintain that standard positivist techniques cannot be used to describe such holistic concepts as landscape aesthetics.

The focus based on the possession of attributes encompasses a number of physical, artistic and psychological descriptors. Physical descriptors were used in landscape evaluations by Daniel & Boster (1976), Ramos et al. (1976), Schauman (1979), Civco (1979), Blanco & Otero (1980) and Schaumann (1986). Among those who have used artistic descriptors, Tetlow (1979) and Litton (1982) stand out. Finally, Russell & Pratt (1980), Kaplan & Hebert (1987) and Kaplan (1988) employed psychological descriptors. Zube et al. (1982) proposed a model combining both major approaches to landscape evaluation.

1.2 Landscape Mapping

The development and application of the above methods to different territories has advanced landscape mapping to the point where widely accepted maps now exist for different regions and countries. The classic work in this area was performed by Mori (1977), De Veer & Burrough (1978), Burrough & De Veer (1984), Alfrey & Daniels (1990) and others. More recent authors include Saxebøl (1998), Fairbanks & Benn (2000), Clout (2000), Canters et al (2002), Apan et al. (2002), Petrooshina (2003) and Chust et al. (2004).

In Spain, a number of landscape maps have been published at the regional level, Gómez (1999), Aramburu & Escribano (2003), or as web pages (www.euskadi.net/vima_mapas, ww.juntadeandalucia.es/obraspublicasytransporte, and www.madrid.org). At the national level, the landscape has been mapped descriptively, but no landscape quality maps exist that might allow this variable to be integrated into planning tasks (e.g., the assessment of plans and programmes, strategic environmental assessment [SEA], environmental impact assessment

[EIA], strategic planning, conservation, etc.).

Landscape character assessment also helps to address the objectives of sustainable development (effective environmental protection and prudent natural resource use). The Countryside Agency (2002) (www.ccnetwork.org.uk) reports it can help to:

- identify the environmental and cultural features of a locality;
- monitor change in the environment;
- understand a location's sensitivity to development and change;
- set the conditions for development and change.

In relation to development and planning, landscape character assessment can help to decide policies in development plans, inform on the siting and design of particular types of development, assess land availability for a range of uses (including new developments), provide information for the environmental assessment of plans, policies and individual development proposals. In relation to land management it can help to provide information on programmes for environmental enhancement, to target agro-environmental schemes, and to contribute to wider environmental initiatives such as Local Agenda 21.

2. AIMS

The main aim of this work was to deign a methodology based on a GIS platform that would allow the production of a national landscape quality map, which could be integrated with other variables into the planning process. A further aim was to compare the landscape quality values obtained with those of ecological quality in maps including Natura 2000 protected areas.

3. LANDSCAPE CLASSIFICATION CRITERIA

In this study, the starting point was the digital version of the *Atlas de los Paisajes de España* (Atlas of Spanish Landscapes), Mata & Sanz (2003). This work (scale 1:4,000,000), which recognises 24 large landscape associations, is divided into 51 separate maps (scale 1:200,000) showing different landscape groups (subdivisions of these landscape associations) within their respective areas. However, this work is descriptive: it provides no appraisal of the *quality* of these landscapes. The primary objective of the present work was to provide such an appraisal, thus affording the necessary data for the production of a landscape quality map for the entire country.

To develop a useful landscape classification, it is necessary to have a set of criteria upon which to base the classification, Brabyn (1996). The classification criterion used in this study deals with the manner in which a set of characteristic features present in each of the landscape units has served to define their extension. The selection of these characteristics - relief, altitude, position/influence, land use and population nucleus of the study area, which have been widely used, Otero et al. (2006) - was based on the classic works of Schuurmans & Van Shie (1978), Smith (1976), de Veer & Burrough (1978), Kerstra (1974), Weddle (1973), Steinitz (1979) and Lovejoy (1973):

Types of relief

- Complex or massive (large volumes and a diversity of forms)
- With large, rounded volumes
- Mountain and valleys
- Mountains and rocky areas
- Mountain ranges
- Mesetas
- Rolling countryside (low, rolling hills, small valleys and depressions)
- Wide valleys
- Narrow valleys
- Plains
- Coastline

Types of Altitude

- Very high, >2000 m
- High, 1600-2000 m
- Moderate, 1200-1600 m
- Medium, 800-1200 m
- Low, 400-800 m
- Very low, <400 m

Type of position / influence

- Oceanic
- Mediterranean
- Atlantic/sub-Atlantic
- Maritime (coastal area)
- Insulated from external influences

Types of land use

- Forest (trees)
- Forest (shrubs)
- Agricultural
- Stock raising

Types of population nucleus

- Extensive, concentrated urban settlements
- Small, concentrated settlements
- Small, disperse urban settlements
- Urbano-industrial settlements
- Utbano-touristic settlements

4. CLASSIFICATION PROCESS

The landscape associations and groups were then evaluated by a panel of ten experts (landscape specialists, engineers and biologists). This process took place in two stages:

Stage 1: the 24 landscape associations were assigned a value on a scale of 1 – 10 (a direct and discrete scale of 10 equidistant classes sufficient to cover all landscape association qualities), where 1 = low quality and 10 = excellent quality

Stage 2: each landscape group was assigned a value on a scale of 0 to 3 (with intervals of one third) in order to qualify the assessment of the different associations (given their great spatial variability). The reason for choosing these scales was two-fold: to allow the classification and ordination of the landscapes, and to allow their mathematical analysis. Voogd (1983) and Eastman et al. (1993) describe the characteristics of the different types of scale normally used in these evaluation processes.

The final value of each landscape group is given by the expression:

$$V_F = V_A \pm [(V_A \times V_g)/30]$$

Where

V_F = is the final value for the landscape

V_A = is the association value

V_g = is the value of the group within the association

Thus, the absolute value assigned to each association is qualified by the value of each landscape group, such that, in the most favourable scenario V_F would increase by one point (one class) on the 1-10 scale. In the worst case scenario it would fall by one point.

Table 1 shows the landscape values for the different landscape associations and groups of mainland Spain.

5. RESULTS AND DISCUSSION

Decisions had to be made on the following cartographical features: the scale to be used, the datum required, the software and projection best tailored to the case study, Bach et al. (2005).

In principle, the quality of the cartographical analysis improves as the scale increases. Since landscapes are characterised by having very diffuse limits, great temporal stability and as occupying large territories, a scale of 1:200,000 was deemed adequate for characterising the territorial variability of the landscape at the national level.

The datum used was that established for Europe: datum ETRS89. Eurogeographics, the authority commissioned with harmonizing and preparing guidelines for maps of EU member states, recommends ETRS89 as the European standard, European Commission (1999, 2000). The same authority provides the datum transformation parameters to be used for each country in the region if harmonisation with sufficient precision at small and medium scales is to be achieved.

With respect to the software used for the cartographical analysis, the following features were taken into account:

- the capacity to perform all the analyses required
- the technical capacity to perform such analyses with relatively large scale maps (i.e., with the smallest processing limitations possible).

Analyses were performed with several commercial programs produced by the Environmental Systems Research Institute (ESRI). The SIG Arc/Info program was finally chosen.

Finally, based on reports in other studies, Mancebo el al. (2005), both the UTM Zone 30 Extended and the LAEA were understood as valid projection options, the former being ideal for distance analyses, the latter for area analyses. A disadvantage of the UTM system is that precision is gradually as one travels away from the centre of the projection, i.e., for the analysis of countries larger than Spain or for the simultaneous examination of several countries, this projection is insufficiently precise. However, the LAEA projection is designed for the whole of Europe. Again, the greatest errors appear the farther away from the centre of the projection (central Europe). Since Spain is on the edge of this map, the precision for this area is poorer than that which might be expected from an analysis of Europe as a whole.

From a cartographical point of view, the main result of this work is the landscape quality map for mainland Spain and the Balearic Islands (Figure 1). Table 2 numerically shows the distribution of the different landscape quality classes; Figure 2 shows the histogram for these data.

6. VALIDATION

As a complement to the study, and as a means of validating the results, this map was compared to a map of the wild and/or protected areas of Spain (Figure 3). The landscape quality of some of these areas, e.g., National Parks and Protected Landscapes etc., is supposedly greater than that of non-protected areas, and indeed greater than that of other protected areas not particularly renowned for their landscapes.

The coherence between the landscape quality and the protected areas map was examined and found to be very good. Table 3 shows the mean landscape quality values obtained for the different types of protected area.

Figures 4 and 5 show the percentage area of Protected Landscapes and National Parks belonging to each quality class.

7. CONCLUSIONS

The average landscape quality for Mainland Spain as a whole was 4.94. The landscape quality map assigned the Protected Landscapes and National Parks (areas *a priori* assumed to be of greater landscape quality) significantly higher quality ratings than the non-protected areas of the country. These ratings were also higher than those assigned to protected areas not particularly renowned for their landscapes (e.g., Areas of Community Interest or Special Areas for the Protection of Birds).

The proposed methodology was found to be valid for producing landscape quality maps at the national scale, allowing this variable to be integrated with other environmental information in planning processes. In fact, the map produced has already been used in the strategic environmental evaluation associated with the Spanish *Plan Estratégico de Infraestructuras y Transporte 2000-2020* (Spanish Strategic Plan for Infracstructures and Transport 2000-2020), and is available at http:\\topografia.montes.upm.es.

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Table 1: Values of the different landscape associations and landscape groups of mainland Spain

Landscape Associations	Atlas Code	Landscape Group	Landscape Value
Northern mountainous massifs	1	Mountainous massifs of Galicia, Asturias and León	8.33
	2	Cantabrian mountainous massifs	8.33
	3	Pyrenean mountainous massifs	8.67
	4	Mountainous massifs of Mediterranean Catalonia	8.00
Mountainous massifs of the interior	5	Massifs and high mountain ranges of the Central System	7.17
	6	Mountainous massifs of the Iberian Range	6.83
Massifs of the Betic ranges	7	Mountainous massifs of the Betic Range	7.33
	8	Mountainous massifs and high mountain ranges of the Sub-Betic-Prebetic area	7.00
Atlantic and sub-Atlantic mountains and mountain ranges	9	Hill country of Galicia and the Asturias-León divide	8.83
	10	Highlands and mountain ranges of Galicia, Zamora and León	8.83
	11	Mountain ranges and the eastern open plains of the Cantabrian Range	8.50
	20	Littoral and prelittoral Cantabrian-Atlantic mountain ranges	9.17
	23	Mountain ranges and valleys of the Cantabrian Range	9.50
Pyrenean ranges	12	Pyrenean mountain ranges	9.50
	24	Pyrenean mountain ranges and valleys	9.50
Mediterranean and Continental mountains and mountain ranges	13	Prelittoral mountain ranges of Catalonia and Castellón	6.67
	14	Iberian mountain ranges	6.67
	15	Central System mountain ranges	7.00
	16	Betic mountain ranges	7.00
	17	Mountain range of the *Montes de Toledo* and *Las Villuercas*	6.33
	18	Quartzite mountain ranges of the Extremaduran peniplane	6.33
	19	Mediterranean mountain ranges showing signs of volcanism	6.00
	21	Coastal mountain ranges of Catalonia and Valencia	6.00
	22	Betic littoral and sublittoral mountain ranges	6.33
Mountain ranges, slopes and valleys of Andalusia, the Levant and Extremadura	25	Quartzite mountain ranges and valleys of Extremadura	5.83
	26	Betic mountain ranges and valleys	6.17
	27	Mountain ranges and valleys of the *Sierra Morena*	6.17
	34	Mountainsides and valleys of the *Sierra Morena* to the Guadalquivir	5.50
	35	Mountainsides, slopes and rolling hills of Andévalo	5.50
Atlantic and sub-Atlantic hills	28	Galician hills	6.00

	29	Hills and valleys of the Basque Country, of the *Condado de Treviño*, and the Navarrese Pyrenees	6.00
	32	Sides and bottoms of the Miño and Ulla valleys	6.00
Slopes, rolling land and flatland North of the Sierra Morena and the Sub-Betic border	30	Hillsides and plains of the *Sierra Morena*	5.00
	31	Hillsides and rolling hills of the Sub-Betic border	5.00
Slopes, rolling land and flatland North of the Sierra Morena and the Sub-Betic border	33	Slopes of the central Catalonian depression	5.00
	36	Depressions of Galicia and León	5.00
	37	Depressions of the Basque Country, Navarre and the Cantabrian Range	5.00
	38	Catalonian depressions and basins	5.00
	39	Depressions of the Soria-Burgos corridor	4.00
	40	Troughs of the Central System and its borders	4.67
	41	Murcia basins	2.67
	42	Hollows and depressions of the Betic area and Alicante	4.00
Corridors	43	Corridors of the Cantabrian Range and Pyrenees	5.17
	44	Castellón corridors	4.50
	45	Corridors and depressions of the Betic area	4.83
	46	Corridors and valleys between the Castile-La Mancha mountains	4.50
	47	Valleys and corridors between the mountains of the Betic area	4.83
Peniplanes and piedmonts	48	Sourthwestern peniplanes	6.50
	49	Peniplanes of Salamanca and Zamora and the *Montes de León* piedmont	6.17
	50	Piedmont of the Central System and the *Montes de Toledo*	5.83
Open countryside	51	Open countryside of the Northern Meseta	2.50
	52	Open countryside of the Ebro Depression	2.50
	53	Open countryside of the Southern Meseta	2.50
	54	Open countryside of Andalusia	2.50
Fertile lowlands and riversides	55	Fertile lowlands of the Douro Basin	5.17
	56	Fertile lowlands and irrigated lands of the Ebro Basin	5.50
	57	Fertile lowlands of the Tagus and Guadiana Basins	5.17
	58	Fertile lowlands of the River Segura	4.50
	59	Fertile lowlands of the Rivers Guadalquivir, Genil and Guadalete	4.83
	73	The *Vega del Ebro* between Alforque and Móra de Ebro	5.17
Interior plains	60	Plains of Castile	1.50
	61	Plains and glacis areas of the Ebro Depression	1.50
	62	Plains of the Southern Meseta and its borders	1.50
	63	Plains of the Andalusian interior	2.17
Coastal peninsular plains	64	Coastal and prelittoral plains and glacis areas	4.83
Valleys	65	Galician Valleys	6.33

	66	Cantabran V-shaped valleys	6.67
	67	Asturian V-shaped valleys	6.67
	68	V-shaped valleys of Palencia and Léon	6.00
	69	Pyrenean valleys	7.00
	70	V-shaped valleys of Soria and La Rioja	6.00
	71	Industrial valleys of the Basque Country	4.00
	72	Valleys of the North of Burgos	6.67
Mooreland and mesas	74	Calcareous moorlands of Castile-León	2.50
	75	Detritic moorlands of Castile-León	2.50
	76	Aragonese mesas	2.50
	77	Moorlands and open plains of the Southern Meseta	2.50
	78	Detritic moorlands of the Southern Meseta	2.50
Butter and open plains	79	Buttes of the Iberian range	1.50
	80	Open plains of the Iberian range	1.50
Passes, gorges and canyons	81	Box valleys	7.83
	82	Cantabrian mountain passes	8.17
	83	Upper Ebro canyons and mountain passes	8.17
	84	Gorges and valleys of the Portuguese frontier	7.83
	85	Ravines and gorges of the Levant and Iberian Ranges	7.67
Ria inlets and coastal flats of the Atlantic-Cantabrian Sea	87	The Rías Altas, hills and valleys of the Galician coastal area	7.50
	88	Large Galician ria inlets (Rías Bajas) and surrounding hills	6.83
	89	Ria inlets and bays of the Cantabrian and Atlantic coasts	7.17
	90	Coastal areas, hills and valleys of the Cantabrian coast	7.17
	91	Cantabrian coastal flats	6.83
Mediterranean and southern Atlantic marshes, deltas and sands	92	Deltas and associated river flats	6.83
	93	Coastal dunes of the Doñana area	7.17
	94	Andalusian marshes	7.17
Large cities and their metropolitan areas	86	Large cities and their metropolitan areas	0.50

Table 2 Distribution of landscape quality classes

Value	Frequency (thousand ha)	Percentage (%)
1	299.771	0.61
2	6338.464	12.84
3	10264.150	20.79
4	1153.584	2.34
5	6090.710	12.34
6	5491.129	11.12
7	12589.419	25.50
8	2194.620	4.45
9	3065.531	6.21
10	1881.256	3.81
	49368.638	100.00

Table 3: Average landscape quality values for each type of protected area

Protected Area	Average Quality
Protected Landscape	8.04
National Park	7.34
Natural Park	6.61
Regional Park	6.16
Natural Area	6.05
Area of National Interest	7.42
Special Areas for the Protection of Birds	5.68
Areas of Community Interest	4.94
RAMSAR	5.91
Biosphere Reserve	4.63

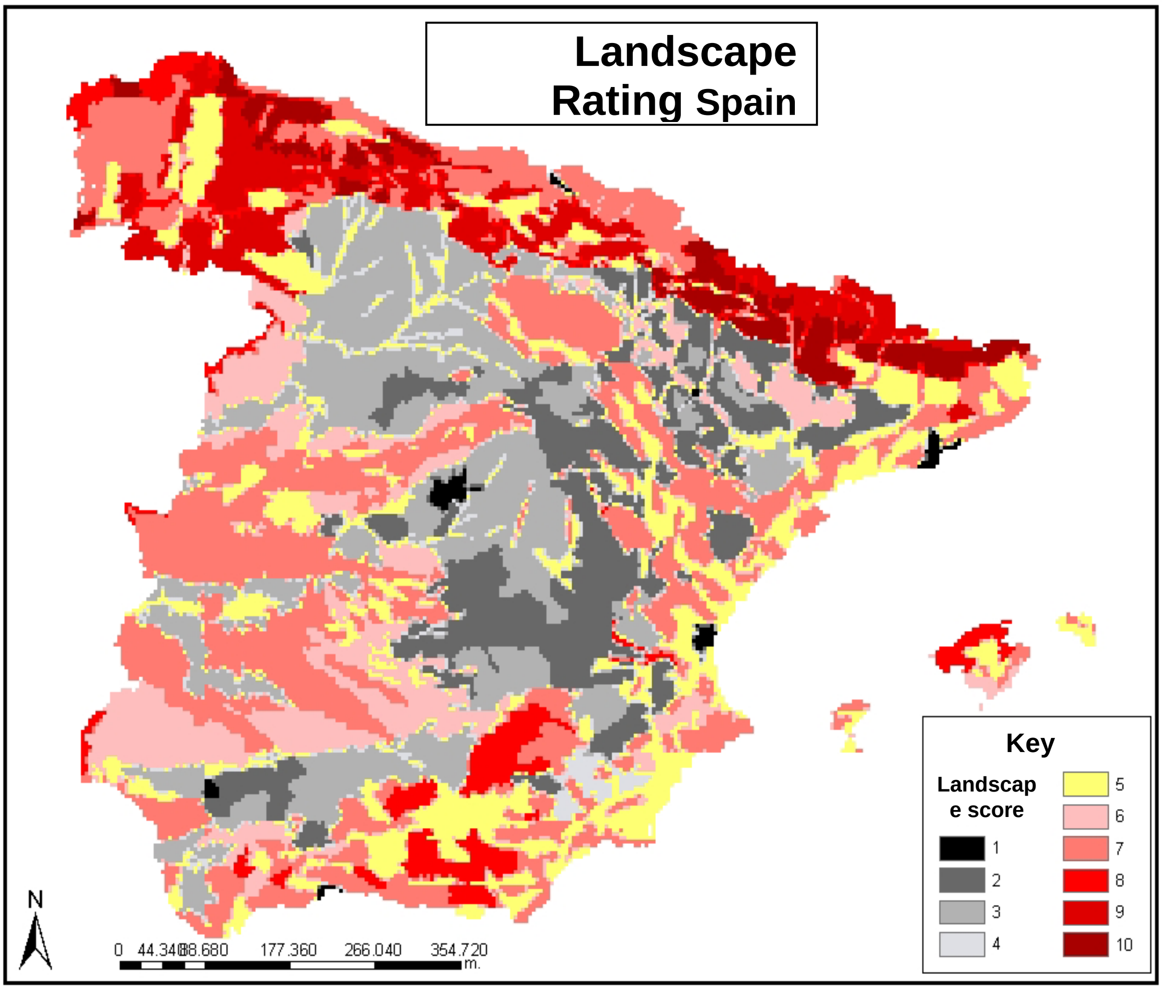

Figure 1: A landscape quality map of mainland Spain and the Balearic Islands.

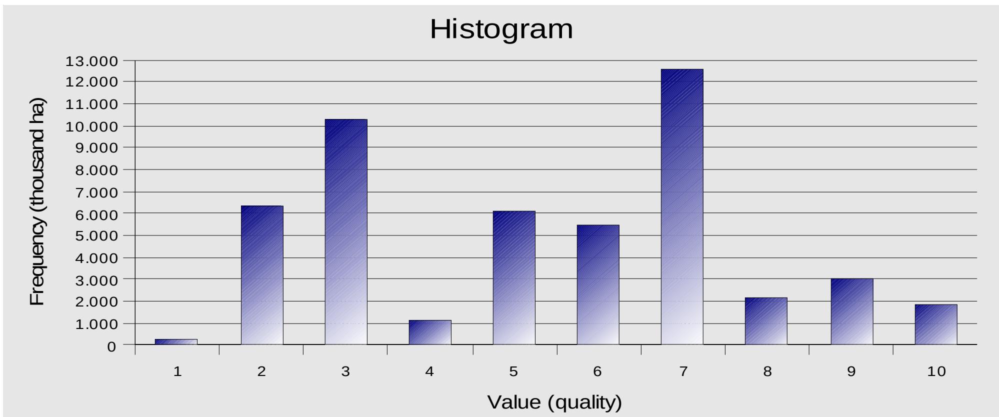

Figure 2: Histogram for the different landscape quality classes

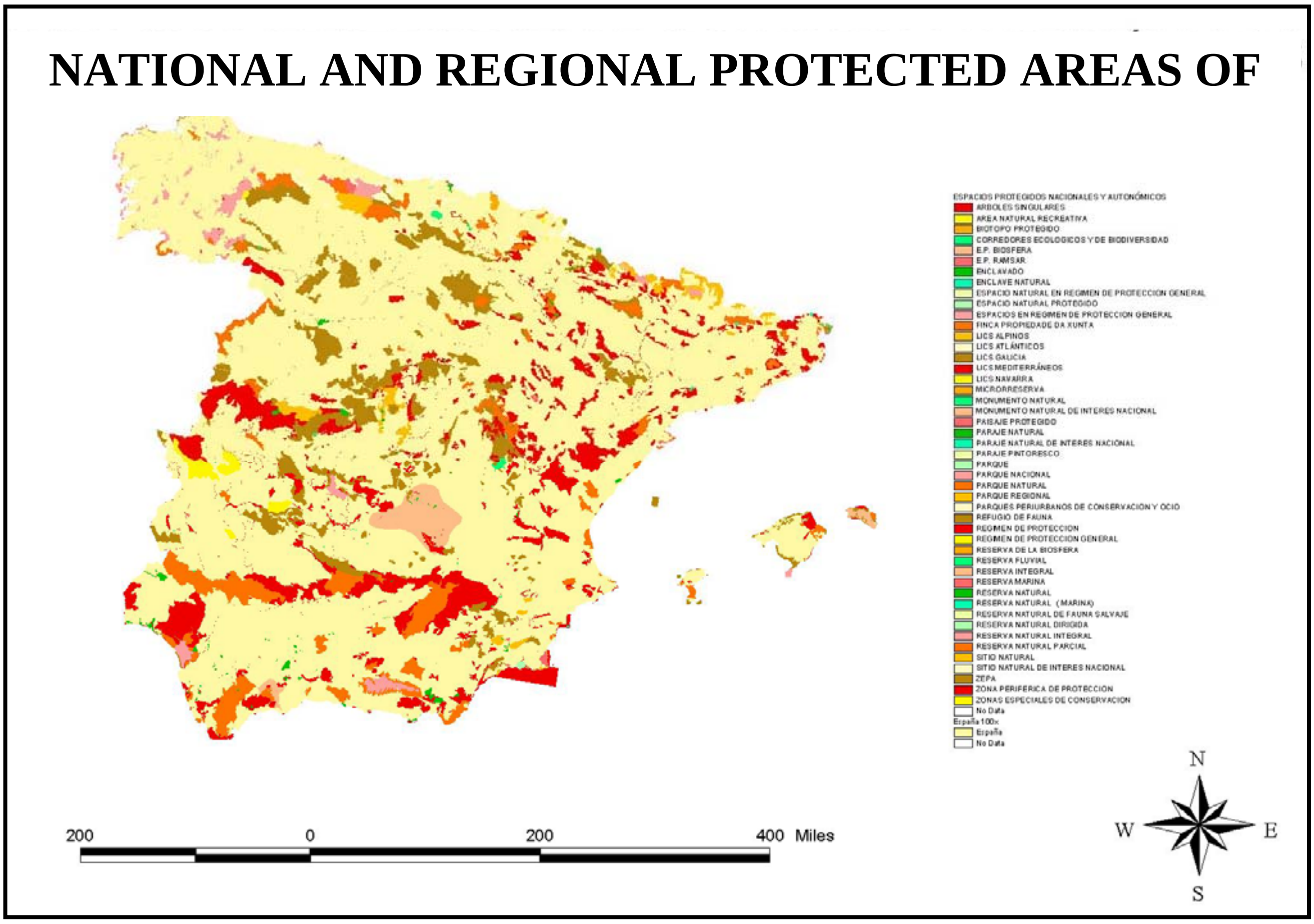

Figure 3: Map showing the protected areas of Spain

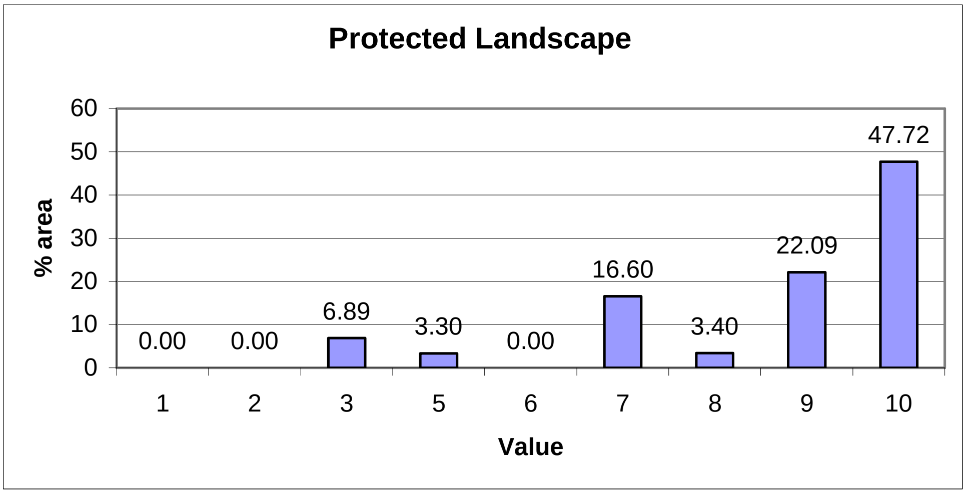

Figure 4: Percentage area of Protected Landscapes belonging to each landscape quality class.

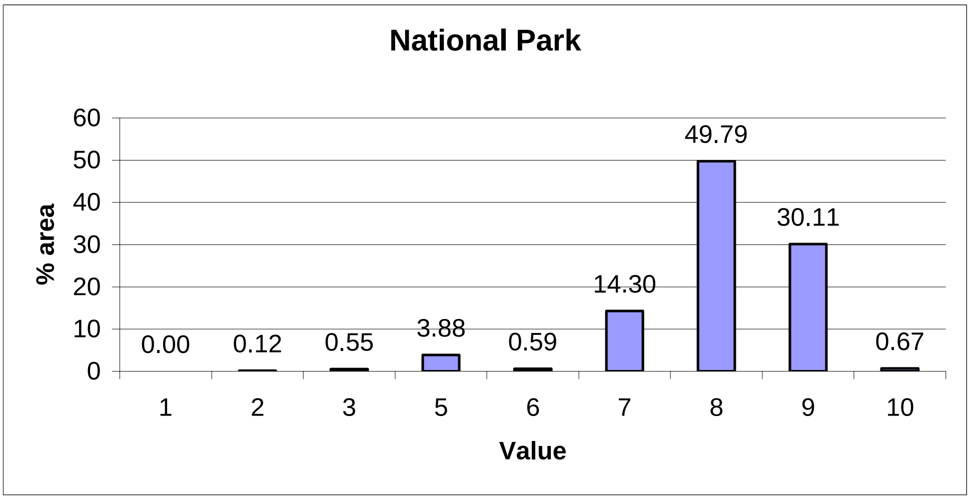

Figure 5: Percentage area of National Parks belonging to each landscape quality class.

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