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# THE USE OF NATURAL RESOURCES AND ENVIRONMENTAL CHANGE

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## INTRODUCTION

Spain is characterized by a great diversity of natural ecosystems and a range of cultural landscapes created by human occupation over thousands of years. Recent decades have witnessed changes in the processes of production and other changes of a social, demographic, political and cultural nature. These transformations have had a growing impact on an environment that offers a complex picture of interaction between the diversity of a natural milieu undergoing bioclimatic change and the customs of a long-established society in which the tertiary sector is taking an ever firmer hold. For this reason, the current dynamic of many natural processes, the workings of numerous ecosystems and the particular features of certain environmental problems cannot be understood without an evaluation of the direct or indirect interventions of the human groups that have occupied Spanish soil (MATEU, 1993: ALONSO, 1995).

Since 1984, the Ministry for Public Works, Transport and the Environment (MOPTMA) has published annual reports on the environmental situation in Spain (MOPTMA, 1994). Some autonomous governments also bring out periodical reports on the regions and territories under their jurisdiction. These documents, in conjunction with analyses by the EU and worldwide organizations, provide a range of essential information concerning Spain's environmental problems. Recent years have seen the consolidation of scientific research into these problems, run by specialist groups. The involvement of Spanish geographers in theoretical and practical environmental studies of varying scope is also increasing. Ecologist groups conduct other environmental studies, principally of the aspects that receive less attention from public organizations.

## 1. PRINCIPLE ENVIRONMENTAL IMPACTS

In recent decades, the cultural impact on the natural system has risen spectacularly. Some authors suggest that it is this activity, rather than an environmental change, that is causing a worldwide transformation, measurable in terms of loss of biodiversity, climatic change and imbalances in the water regime. The growth of the world's population, the mass application of powerful technologies and the increasing exploitation of natural resources generate horizontal flows of matter and energy, and the interdependence of ecosystems ever further afield. This global context (GORE, 1993) provides the background for the environmental situation in Spain.

Due to its combination of temperate and semiarid subtropical areas, Spain is characterized by greater environmental diversity than other European countries. In recent years environmental management in Spain has been provided with legal and economic instruments for protecting areas of great ecological value, while environmental awareness has taken root in many sectors of the population (COSTA, 1985; HARO, 1986; JIMÉNEZ, 1992). Undoubtedly, Spain's entry to the European Union has boosted the transfer of technologies that will contribute to the recovery of natural systems or, at least, help to minimize the damage to them.

In general, reports on the state of the environment in Spain stress the consequences of the main effects of human activity (pollution, alteration of natural processes and geochemical cycles, waste, soil loss, destruction of vegetation) and pay little attention to their natural and social causes. Only fuller diagnoses can help to reduce the high environmental cost of the development of the tertiary sector over the past decades, and implement the advantages that its growth could provide. Attention needs to be paid to the environmental and territorial impact of cities and large urban areas, of areas in advanced stages of depopulation and tourist areas, the ecological cost of the new infrastructures and the growing demand for natural and landscape resources. The impact of the mobility of an advanced society, the dynamic and scope of the regeneration of ecosystems, and the effect of the network of protected areas are also factors whose importance needs to be evaluated.

Obviously, from both a territorial and temporal perspective, Spain's environmental situation is a vast subject. This article will focus on a number of specific natural resources — water, air, soil, and vegetation — in an attempt to offer an analysis of the state of the environment, recording the increase in pollution, the degradation of natural resources and the transformation of natural milieus.

## 2. THE PRESSURE ON WATER RESOURCES

Water is central to the dynamic of natural ecosystems and is an essential element of human activity (MATEU, 1984). The hydrological situation in Spain is characterized by huge regional and seasonal variations between available resources and demand (RUIZ, 1993). The quantity and quality of the resource also merit attention from the environmental perspective. For this reason, here we will make a distinction between subsoil waters, surface waters, and coastal waters, even though they all form part of the same cycle.

In recent decades there has been a marked increase in the construction of hydraulic installations in Spain, aiming to harness and supply water for urban and industrial needs,

irrigated areas and hydroelectric production (GIL OLCINA, 1986). Progress has also been made on the construction of water purifiers. These installations increase the water resources available in the face of the limits imposed by the climate, and demand (NADAL, 1993).

### 2.1. Surface waters

The average annual discharge from Spanish rivers is estimated at around 113,000 $Hm^3$, of which 94,000 $Hm^3$ correspond to direct runoff and the rest to base flow. However, these figures conceal considerable annual variations; in some dry years discharge does not reach 40,000 $Hm^3$. Furthermore, the unit resources (in $m^3km^{-2}$) — 25% of which flow into the Mediterranean and 75% into the Atlantic — differ greatly; the Cantabria river flow is fifteen times greater than that of the Segura basin. Although Spain is conventionally considered a dry country, its surface hydrology is complex, and characterized by river flows that differ widely according to area and time of year.

Spain has a surplus of water resources with which to meet current and future demand. Hydraulic planning — incorporating regulation, distribution, drainage and treatment — is an integrated element of general planning and aims to provide resources for cities, irrigation and hydroelectric production. Spain has had a sustained hydraulic policy, with the participation of large hydroelectric companies, throughout the twentieth century (GIL OLCINA and MORALES GIL, 1995). Spanish dams can store more than 50,000 $Hm^3$ (equivalent to almost half the average annual discharge of the rivers) and this water plays a central role in hydrological management. At the same time, hundreds of kilometres of distribution channels have been built, and the transfer of resources to drier regions has begun, although this policy has met with some resistance.

In spite of this, there are still periodic droughts — and structural droughts as well — in some regions of the country. There are also floods. The National Hydrological Plan, after some ten years of preparation, has still not been approved. This plan will regulate the management of this resource, of such crucial importance to society and the country's ecosystems in the coming decades. In some regions, water shortages may curb economic growth. Hydraulic planning in the future cannot be treated in isolation from other parameters such as the internationalization of the Spanish economy, and must place special emphasis on policies of modernization, renovation and recycling of small scale hydraulic systems as well as large installations.

The main consumers of surface waters are the irrigated areas (more than 2.2 million hectares) and urban and industrial areas. Consumption has increased in line with processes of agricultural mechanization, urban development and industrialization (various authors, 1991). These uses also affect the quality of the water if the natural capacity of water purification is exceeded.

The highest levels of river pollution are caused by emissions in urban, industrial and mining areas (high levels of chlorates, phosphates and organic material, etc.) (OTERO, 1992), uncontrolled discharges, runoff and percolation from intensive agricultural or stock-breeding areas (fertilizers, pesticides, herbicides, liquid manure, etc.). The authorities have taken action to control river pollution and have recently set up an automatic system (known as SAICA) offering information on water quality. In addition, the Ministry for Public Works has drawn up an ambitious national purification plan, (MOPT, 1993a). These steps aim to

respond to recent changes in consumption (1175 $m^3$ inhab.$^{-1}$year$^{-1}$ in Spain, compared with 231 in the UK and 725 in France), to remedy the lack of basic infrastructure during the process of urban development and industrialization, and to cope with the high consumption of fertilizers, pesticides, and herbicides.

### 2.2. Subsoil waters

Hydrogeological studies conducted throughout the twentieth century have offered valuable information about the characteristics and the functioning of aquifer systems: subsoil waters are now included in hydraulic planning (NAVARRO et al., 1989). Currently, around half a million wells harness some 5,500 $Hm^3$ year$^{-1}$. At the beginning of the 1990s, subsoil waters supplied 12.4 million inhabitants, or 37% of the population, and irrigated almost a million hectares (around 30% of the total irrigated area).

For this reason, aquifer systems have become valuable natural resources. However, overexploitation can affect the quantity of available subsoil waters, and pollution can affect the quality. The aquifer systems in Spain vary greatly from region to region, as does the human pressure on them and indeed their role in the management of the water supply. Subsoil waters make up almost the entire water supply in some areas, while in others they are merely a complement to the reserves provided by surface waters (various authors, 1991).

Some aquifers are overexploited; the average annual volume of water obtained exceeds the systems' capacity for natural replenishment. The failure to remedy this imbalance has led to the total or partial desiccation of humid areas, subsidence and changes in the water regime of rivers, and the progressive deterioration of water quality due to marine intrusion, salinization). This overexploitation is especially serious in areas of intense demand due to agriculture, urban development or tourism, and represents a threat to the growth of dynamic areas and the preservation of the natural heritage.

Excessive pumping brought down the piezometric level by more than 25m in areas near the Tablas de Daimiel between 1974 and 1987 (various authors, 1987). The drought that lasted from 1992 to 1995 has aggravated the situation. Similar, even more disastrous processes have been recorded in other areas (RICO, 1994). The overexploitation of aquifer systems has transformed the water regime of numerous inland marsh areas, endangering one of the most distinctive features of the peninsula's biodiversity, and the base flow of many rivers. Many coastal aquifer systems have also lost their equilibrium due to massive extractions, and marine intrusions (salinization) may disrupt sustained use in the future.

The pollution of aquifer systems — by direct entry to the saturated area or by diffuse seepage from the non-saturated area — reflects the complex, slow dispersion of waste produced by livestock, urban and industrial (REBOLLO, 1994). In the last twenty years diffuse quantities of nitrogen from fertilizers have increased in the aquifer systems on the edge of irrigated areas. Urban refuse dumps, mining activities and petrochemical and metallurgic waste also affect water quality.

### 2.3. Coastal waters

Some sectors of the Spanish coastline — especially those near ports, or near industrial areas and tourist resorts — register high levels of water pollution due to discharges from the

land or by dumping at sea. Investment in water purifying plants and marine outlets over recent years has brought about a substantial improvement in many coastal areas. Nonetheless, the density of sea traffic carrying petroleum, chemical products and nuclear waste heightens the risk of accidents such as the Urquiola (1976), Andros Patria (1978), or the Mar Egeo (1993) and high concentrations of dissolved hydrocarbons due to tank cleaning. Heavy metals and other toxic products have been detected on the coastline near large industrial complexes.

## 3. THE ENVIRONMENTAL COMPLEXITY OF AIR POLLUTION

The lower layers of the atmosphere carry out an essential function in conserving energy balances on the earth's surface. Emissions into the atmosphere can cause damage to people and to the natural system, and can modify the energy balance (climatic change). In recent years, emerging changes in the composition of the atmosphere have generated research worldwide in order to assess the magnitude of the alterations in the lower layers of the atmosphere. Spanish scientists are involved in this research and the Spanish Environmental Policy Board, in cooperation with the National Institute of Meteorology, has set up the CORINE-AIRE network (MOPTMA, 1993).

Air pollution — due to natural causes, or due to human activity — represents a complex environmental problem. The dynamics of other natural subsystems (the ocean, continental ecosystems, the hydrological cycle, energy contributions, etc.) are all factors in its diagnosis. Short, medium and long-term atmospheric changes trigger complex responses in the rest of the natural system. The low layers of the atmosphere are a decisive natural resource at global level. Here we will only consider a number of regional and local aspects.

Atmospheric pollution occurs when the capacity of fluid dispersion is exceeded due to the persistence of subsiding atmospheric situations or the microclimatic conditions of the environment. The main foci of pollution — located in cities and large industrial complexes — emit primary pollutants directly into the atmosphere, which may then produce secondary pollutants due to chemical and photochemical reactions in the atmosphere. The presence of both types of pollutants has increased over recent decades in line with the processes of urban development and industrialization.

Factories and vehicles generate a range of primary emissions, the most important of which are sulphur oxides (50%), suspended particles (40%), nitrogen oxides and carbon monoxide. Urban regions, large chemical industrial trading estates and thermal energy installations are the main sources of air pollution (SANZ, 1991). Among the consequences of this pollution are secondary pollutants derived from photochemical reactions in the air which increase the acidification of the environment, as sulphur oxides and atmospheric nitrogen return to ground level in the form of acids. The precipitation of these acids can be in dry form (near the source of emission) or as acid rain (Da CRUZ, 1989).

The atmosphere also takes up degraded forms of energy (noise, ionizing radiation, etc.). In recent decades, there has been a notable increase in environmental noise, especially in large urban nuclei, due to the mechanization of a large part of the production process and the growth in the number of vehicles. Noise is one of the most tiresome urban pollutants and even has a physical impact — for example, on areas near airports.

The natural tendencies of climatic change can be affected by the greenhouse effect,

which has evolved in the last centuries due to growing atmospheric pollution. Indeed, in this time span there has been a worldwide increase in temperature, and modifications in the water regime. At regional level, the tendencies are not fully established; in the case of Spain, the subject is of vital interest due to the extension of semiarid environments, ecosystems that are highly susceptible to thermal and hydrological changes.

The city is another example of human impact on the climate. Recent research into urban heat islands and Spanish cities indicate that the normal differences in heat in relation to areas outside the city and rural areas increase on summer nights, with calm or slight winds and clear skies (anticyclone) (LÓPEZ GÓMEZ, 1993). The horizontal shape of the heat island depends on the morphological characteristics of the particular cities (the density of buildings, parks, the urban relief, and the surrounding area (proximity to the sea, mountains, horticultural areas, etc.) (MOPT, 1993b).

## 4. EROSION AND SOIL CONTAMINATION

The soil, a subsystem that is vital to life on the planet, is the site of the generation of the majority of nutrients, and of fundamental ecological processes. Due to its position as a filter in the cycles of matter and energy, many types of contamination affect the soil and alter natural processes (BRAVO et al., 1995). Dry and wet precipitation wash the atmosphere of harmful elements which are then deposited in the soil. The use of products that protect crops has increased greatly, especially in the production of vegetables and fruit. The consumption of over a million tons of fertilizer and 50,000 million pesetas spent annually on pesticides has raised the levels of contamination of the soil. The abuse of pesticides and fertilizers and the disposal of waste cause considerable damage to the soil and may even make it toxic (EDMONDO, 1990). The concentration of these products at all stages of the trophic chains may have extremely serious effects.

Soil erosion is a natural process that acts in synchrony with the formation of the soil layer when the ecosystem is stable. Drastic changes in climate and human activity may lead to accelerated soil erosion, causing the erosion rate to rise above the regeneration rate. Accelerated soil erosion is the result of the transport and sedimentation of large quantities of fertile soil, triggering a cycle of environmental degradation which begins with the loss of vegetation and ends with the exhaustion of the soil, the silting of marshes and the flooding of valleys. These accelerated processes are typical of semiarid areas such as the Iberian Peninsula, and begin with the alteration of the vegetation cover (THORNES, 1976: LÓPEZ BERMÚDEZ & ALBADALEJO, 1990; SALA et al., 1991).

In Spain, a large part of the soil has suffered processes of degradation due to ancient agricultural practices (ranging from tree felling and burning to irrigation), excessive grazing, and large scale ploughing. In recent decades this tendency has shown few signs of changing. In the forties and fifties, due to the official policy of self-sufficiency, ploughing contributed to eliminating natural vegetation. The mass exodus from rural areas in the sixties and seventies left fields unprotected (boundary walls were neglected, and drainage networks gradually deteriorated, etc.) and soils structurally altered by agricultural practices which removed the vegetation cover. In the eighties and nineties the use of chemical pesticides and fertilizers has introduced toxic components and caused a gradual impoverishment of the natural nutrients. According to ICONA (the Spanish organization for environmental conser-

vation and exploitation), in 43.8% of the country surface water erosion is above the limits accepted worldwide; erosion is intense in 18.1% of the territory. Erosion rates are higher in the more arid areas, where soil regeneration and formation is slower.

Desertification is a process of progressive degradation which destroys the soil's productive potential. The manifestation of this loss of productive capacity is the physical, chemical and biological degradation of the soil and the alteration of the vegetation cover. Processes such as salinization, structure degradation, loss of organic material, alteration of the water regime, etc. are clear indices of desertification. The World Conference on Desertification held in Nairobi (1977) under the auspices of the UN declared a large part of south-east Spain to be a high-risk area. Recurrent forest fires, contaminated water, the use of agricultural practices based on chemical fertilizers and pesticides have impoverished the soil. All this has led to a deterioration of the water balance and an increase in the rate of erosion, and in turn an increase in the risk of desertification (ARAUJO et al., 1992).

## 5. THE VEGETATION COVER

Natural vegetation is highly sensitive to the direct and indirect interventions of human society and presents a great diversity which expresses the complexity of the natural system in Spain. Nonetheless, urban development, factory installations, holiday homes and large infrastructures have disrupted areas of vegetation. For its part, agriculture — the most destructive of the various forms of human activity — has led the centuries-old process of retreat of Spanish forests. Since the end of the fifties, there has been an accelerated process of abandonment of marginal lands (RODRÍGUEZ & LASANTA, 1992), which are colonized by the most opportunistic vegetation, typically extremely combustible.

Spain's forestry policy over a large part of the twentieth century has had a considerable effect on the country's hill areas. From the end of the forties until the beginning of the eighties, 3.8 million hectares were reforested (3 million hectares by the State). The largest projects were carried out in three areas: the southern half of the peninsula, the north-west, and the Aragonese Pyrenees. These projects aimed to make the country self-sufficient in wood, to correct the hydrological and forestry balance of river headwaters, and to create jobs. Conifers make up eighty-four percent of the reforestation, and deciduous trees the other sixteen percent; in the reforested area the composition and structure of the vegetation cover has been replaced, mainly by fire-resistant species.

At the same time, there have been radical changes in population patterns; traditional practices in the management of mountain areas have been abandoned, and holiday homes have proliferated. All this means that centuries-old ways of managing mountain areas have gone for ever. The measures that have replaced them have in some cases proved to be inappropriate, and in others have been merely attempts to respond to the problems of a particular area. They have a high environmental cost.

Over the last two decades, the surface area affected by forest fire in Spain has been greater than in any other Mediterranean state. The various factors involved in these fires call for a thorough study of the structural causes. Indeed, a set of factors — humidity, wind, temperature, topography, etc.) favour or limit the advance of fires. Perhaps the summer plant and atmospheric water deficit is the highest risk factor affecting specific vegetation communities (brushwood, grazing land, thickets, conifer forests, etc.), in particular those resulting

from the abandonment of marginal lands or from the repopulation of other lands with pyrophytes.

The Mediterranean coastline is the area that has suffered most from forest fires, both in terms of number and surface affected, due to the increase in biomass in abandoned crop fields over recent years. The frequency and extension of fires in Galicia suggest that more specific factors are involved. Among immediate causes, practically all fires are the result of human activity, deliberate or negligent.

Among the environmental costs of fires in recent decades the reduction in the surface area of forests and the increase in the extent of bare soil stand out. Public authorities are closely involved in restoring the forest cover, building paths and firebreaks, and repopulating. At the same time, expensive fire prevention bodies and firefighting services have been set up. In any case, the environmental policies for mountain areas should not overlook certain practices of the old Mediterranean societies in their attempts to manage what is a crucial resource to environmental stability.

## SUMMARY

It is not easy to offer a summary of the environmental situation in Spain at the end of the twentieth century. In recent decades, urban, economic and technological growth has disrupted the age-old relationship between society and its natural surroundings, as new patterns of interactions between human groups and the natural system have sprung up. This is a critical moment in which the abandonment of vast areas coincides with urban, agricultural and industrial massification. In this respect, the current state of the environment reflects a profound transformation, the extent of which Spanish society does not always recognize.

Broadly speaking, the environmental transformation is pulling in opposite directions. On the one hand are the activities that lead to the loss of biodiversity, the acceleration of natural processes and the degradation of the natural system. On the other, are the activities that aim to protect - and even to increase - the stability and diversity of the natural system. Obviously this is an oversimplification, which fails to take into account regional variations. Among the most representative territorial and social processes, we should mention:

a) the increase in urbanization has intensified horizontal flows of concentration and dispersion of natural resources. Metropolitan areas represent the top of a complex pyramid made up by networks of material and energy supply (water, petroleum, hydroelectricity, consumer goods, etc.) which do not always possess the necessary infrastructure (water purifying facilities, for example, or refuse disposal systems) or which generate phenomena such as urban heat islands. Urban pollution, caused by inefficient methods of dispersion, leads inevitably to the degradation of the natural system.
b) the reorganization of rural milieus also has a negative impact on diversity. On the one hand, the complete or partial abandonment of landscapes shaped by human occupation over centuries accelerates the dynamics of natural processes, leading to fires, the neglect of old boundary walls, and soil erosion. On the other, new agricultural methods (which employ far fewer workers) use powerful technologies which accelerate the processes of degradation. The overexploitation of aquifer systems, and the

use of new fertilizers and pesticides are examples. In addition, many rural areas are being remodelled as leisure areas for city-dwellers, a process which increases the pressure on landscapes of unusual beauty and leads to the loss of established rural structures.

c) the protection of natural areas, with the wide range of laws, takes on a new dimension in Spain's current environmental situation. For years, the conservation of threatened species and the segregation of areas of special biological or geological interest were priority measures. During the eighties, the autonomous regions declared many areas to be protected, but their classifications did not always show a great internal consistency.

It seems that we have reached a point where we should reassess the objectives of protectionism in the context of the environmental transformation in which we live. The preservation of areas as ecological islands surrounded by urban or rural areas undergoing constant processes of degradation - is, and will continue to be, an essential task. It will also be fraught with difficulties. An integrated conservation plan is of paramount importance, because the ecosystems are organized in a territorial continuum in a state of accelerated transformation (various authors, 1989).

## BIBLIOGRAPHY


ALONSO, J. (1995): *Una tierra abierta. Materiales para una historia ecológica de España.* Madrid, Compañía literaria.

ARAUJO, J., BARCELÓ, N. y SERRA, R. (1992): Erosión y desertificación en España. En L.R. BROWN (Ed.) *La situación del mundo en 1992*, 375-399, Madrid, Ed. Apostrofe.

BRAVO, C., del VAL, A., LÓPEZ, J.J. (1995): La insostenible situación de los residuos en España. En L.R. BROWN (Ed.) *La situación del mundo, 1995*, 383-420, Madrid, Ed. EMECE.

COSTA, P. (1985): *Hacia la destrucción ecológica de España.* Barcelona, Ed. Grijalbo.

Da CRUZ, H. (1989); *Lluvia ácida. Impacto ambiental de las grandes instalaciones de combustión.* Madrid, Ed. Miraguano.

EDMONDO, P. (1990): *Els pesticides i el medi ambient.* Valencia, Universitat de València.

GIL OLCINA, A. (1988): *Demanda y Economía del agua en España.* Alicante. Instituto de Geografía. Universidad de Alicante.

GIL OLCINA, A. y MORALES GIL, A. (1995): *La planificación hidráulica en España.* Alicante, Fundación Caja del Mediterráneo.

GORE, A. (1993): *Earth in a Balance. Ecology and the human spirit.* Nueva York, PLUME.

HARO, J. (1986): *Calidad y conservación del medio ambiente.* Madrid, Ed. Cincel.

JIMÉNEZ, L.M. (1992); *Medio ambiente y desarrollo alternativo (Gestión racional de los recursos para una sociedad perdurable).* Madrid, Ed. IEPALA.

LÓPEZ BERMÚDEZ, F. y ALBADALEJO, J. (1990): Factores ambientales de la degradación del suelo en el área mediterránea. En ALBADALEJO, J., STOCKING, M.A. y DÍAZ, E. (Eds.): *Degradación y regeneración del suelo en condiciones ambientales mediterráneas*, 15-45, Murcia, CSIC-CEBAS.

LÓPEZ GÓMEZ, A. et al., (1993): *El clima de las ciudades españolas.* Madrid, Cátedra.

MATEU, J.F. (1984): El problema medioambiental de las aguas continentales. En *Geografía y Medio Ambiente,* 133-182, Madrid, MOPU.

MATEU, J.F. (1993): Riesgos naturales y protección del medio ambiente. En R. MÉNDEZ y MOLINERO, F. (Eds.): *Geografía de España*, 254-321, Barcelona, Ed. Ariel.

MOPT (1993a): *Protección de las aguas*. Madrid. MOPT.

MOPT (1993b): *El clima urbano. Teledetección de la isla de calor de Madrid.* Madrid, MOPT.

MOPTMA (1993): *Estaciones y redes de vigilancia de la contaminación atmosférica en España. Descripción técnica y gráfica.* Madrid, DGPA-MOPTMA.

MOPTMA (1994): *Medio ambiente en España 1993*. Madrid, DGPA-MOPTMA.

NADAL, E. (1993): *Introducción al análisis de la planificación hidrológica.* Madrid. MOPT.

NAVARRO, A. *et al.*, (1989): *Las aguas subterráneas en España. Estudio de síntesis.* Madrid, Instituto Tecnológico y Geominero.

OTERO, L.R. (1992): *Residuos sólidos urbanos*. Madrid. MOPT.

REBOLLO, L.F. (1994): *Análisis y evolución de la contaminación de las aguas subterráneas*. Madrid, Asociación de Hidrogeólogos, Grupo Español.

RICO, A. (1994): *Sobreexplotación de aguas subterráneas y cambios agrarios en el Alto y Medio Vinalopó (Alicante)*. Alicante. Instituto Universitario de Geografía. Universidad de Alicante.

RODRÍGUEZ, J. y LASANTA, T. (1992): Los bancales abandonados en la montaña mediterránea: una revisión bibliográfica. *Pirineos*, 139, 105-123.

RUIZ, J.M. (1993): La situación de los recursos hídricos en España, 1992. En L.R. BROWN (Ed.): *La situación en el mundo*, 1993. Madrid, Ed. Apóstrofe.

SALA, M., RUBIO, J.L. y GARCÍA-RUIZ, J.M. (1991): *Soil Erosion Studies in Spain.* Logroño, Ed. Geoforma.

SANZ, J.M. (1991): *La contaminación atmosférica.* Madrid, MOPT.

THORNES, J.B. (1976): *Semi-arid erosion systems: case studies from Spain.* Londres, London School of Economics.

VV.AA. (1987): *Seminario sobre bases científicas para la protección de los humedales en España.* Madrid, Real Academia de Ciencias Exactas, Físicas y Naturales.

VV.AA. (1989): *Supervivencia de los espacios naturales.* Madrid, MAPA.

VV.AA. (1991): *El agua en España.* Madrid, Instituto de Ingeniería de España.