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European framework for surveillance and monitoring of habitats: a methodological approach for Spain*

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Abstract

There is a well defined policy requirement for a practical and reproducible procedure for surveillance and monitoring of habitats in Spain that can subsequently be fitted into a European framework. Any such procedure also needs to incorporate records of the Spanish habitat classification.

A procedure is described that will satisfy those requirements and has been field tested both in Spain and in Europe. Rigorous rules and training are required; otherwise changes from baseline records cannot reliably be separated from background noise. The procedure uses the classical plant life forms long used in biogeography and is based on their statistical relationship with the environment. This relationship has been validated statistically and the procedure has also been tested in the field in all European environmental zones and widely in Spain. 130 General Habitat Categories are defined and these are enhanced in the field by recording environmental, site and management qualities to produce a flexible database that can then be interrogated. The rules for mapping the habitats mean that they can be used for descriptive purposes or for monitoring. In conjunction with stratification and subsequent sampling, national estimates of stock and change can then be produced.

Finally, based on the previous experience of *SISPARES*, a methodological scheme is proposed for adapting the approach to Spain. The proposal will allow links to be made between European scale surveillance and monitoring to those already obtained for Spain.

Key words: field recording, stratification, biodiversity, life forms, BIOHAB, SISPARES.

Resumen

Estructura europea para la supervisión y el seguimiento de hábitats: aproximación metodológica para España

Existen en España políticas bien definidas que demandan procedimientos prácticos y reproducibles para llevar a cabo la supervisión y seguimiento de los hábitats, de modo que subsecuentemente puedan ajustarse al marco Europeo. Cualquier procedimiento de estas características necesita poder incorporar datos registrados de la clasificación española de hábitats.

Aquí se describe un procedimiento que satisface dichos requisitos y que ha sido probado tanto en España como en el resto de Europa. El método exige reglas rigurosas y entrenamiento de campo; si no los cambios en los registros básicos no se podrán separar de manera fiable de los errores subjetivos cometidos durante la toma de datos. El procedimiento utiliza las clásicas formas de vida, ampliamente utilizadas en estudios biogeográficos y está basado en sus relaciones con el medio ambiente. Esta relación ha sido validada estadísticamente y el procedimiento ha sido probado en el campo en todas las zonas ambientales de Europa.

En España, se han definido 130 Categorías Generales de Hábitats y se han verificado en el campo mediante el registro de atributos ambientales, estacionales y de manejo, de forma que puedan ser incluidas en una base de datos suficientemente flexible. Las directrices para la cartografía de hábitats posibilitan su uso descriptivo y permiten su seguimiento. Al mismo tiempo, con la estratificación y subsecuente muestreo, es posible hacer estimaciones nacionales de existencias y de cambios.

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Finalmente, basados en las experiencias previas de SISPARES, se propone un esquema metodológico para adaptar BIOHAB a España. La propuesta permitirá conectar los resultados a escala Europea de supervisión y seguimiento con los obtenidos a escala española.

Palabras clave: toma de datos en campo, estratificación, biodiversidad, formas de vida, BIOHAB, SISPARES.

Introduction

The Policy Background

Since the Rio Convention in Biological Diversity signed by 150 governments in 1992, there have been a series of policy initiatives relating to biodiversity. A full review of these is beyond the scope of the present paper, which primarily concerns the habitat level of the biodiversity hierarchy. The methodology is designed to record habitats in the field at the landscape level: Provided the expertise is available, landscape features and habitats can be recorded on the same field visit.

In Europe the legal framework for the protection of habitats has been provided by the Habitats Directive of 1991. Within Annex 1 of this Directive a list of habitats was provided, derived from the CORINE Biotope project initiated in 1986 that reported in 1991 (Commission of the European Committees) within which certain priority habitats were identified for legal protection. The Directive has been subsequently augmented by other initiatives, such as the Gothenburg Commitment by the EU, that biodiversity decline should be halted by 2010 and the Killarney Declaration of the Malahide Conference in 2004 regarding nature conservation. Within these initiatives the requirement for monitoring is frequently identified, but as yet it has not been carried out consistently around member States, although many countries have their own programmes.

Over recent years the NATURA 2000 series of sites has been set up as the major initiative to maintain habitats and associated biodiversity. The selection of these sites is primarily based on ANNEX 1 Habitats but also reflect national priorities. In Spain the sites cover 25% of the country, so an integrated procedure, as described below involving stratification is essential. The information available on the current status and extent of habitats is fragmentary, and there is a real need for establishing the ecological bases for the management of those habitats included in the Directive 92/43.

Therefore, currently not only is consistent data not available to answer these requirements, but there is also lack of a repeatable and transmissible procedure. The procedure described in the present paper fills this gap and is based on the BioHab project of the EU Fifth Framework programme. Whilst the core of the procedure concerns rules and instructions for consistent field recording, it is essential that they are linked to a spatial framework for the whole of Europe. Such a framework is therefore integral to the methodology as it provides a means to extend the detailed samples needed to assess habitats in the field, to European and national estimates. A summary of the framework is also therefore provided that can be linked to the existing national monitoring scheme for habitats using air photos, as described by Elena-Rosselló (2003). The temporal dimension is added by describing the monitoring procedure.

Concepts and Objectives

For a fully understanding of the present paper, it is critical to introduce the concept of habitat; Habitat is considered as «a land entity with sufficient spatial dimension to provide the ecological conditions required by a given set of organisms». An arbitrary level was taken reflecting a compromise between organisms of different size and at a convenient scale of recording. Consequently, habitats are necessarily linked to the biological concept of species. According to Hutchinson's niche and Shelford's tolerance concepts, habitat is the real expression of the ideal ecological conditions where a species can live, and may be considered as a site with niche's values for a given species.

The BIOHAB project developed and used the following working definition of habitat: «*An element of land that can be consistently defined spatially in the field in order to define the principal environments in which organisms live*».

With such a practical definition, there are significant differences in the characteristics of habitats for plant and animal species: A habitat for a plant species is a recognisable ecosystem, which can be defined exclusively by using vegetation structure and the associated soil and climate conditions. Such conditions may not be enough for animal species, because of the differences in scale between for example, birds and carabid beetles. The habitat definition for heterotrophic species needs flora as it main ecosystem component. Accordingly, habitat definition and further detection in the field has to be predominantly based on vegetation science.

Field recording has been at the core of Ecology since its inception as a recognisable science. The development of vegetation science has been mainly descriptive and based on the selection of homogenous stands of vegetation, usually relatively undisturbed (Braun-Blanquet, 1928; Rivas Martinez, 1987). Such works were not designed for long-term monitoring, but it is essential to include their classes in any integrated programme.

In the 1980's, habitat mapping progressively became a separate exercise from recording vegetation alone because strategic conservation priorities did not necessarily require the distinction between vegetation associations. For example, the small biotope project in Denmark (Agger and Brandt,1998) monitored changes in small landscape patches in intensively farmed landscapes, with minimal relationships with vegetation. An examination of the development of the Countryside Survey in the UK (Haines-Young *et al.,* 2000) has also showed that, whilst it initially concentrated on vegetation in 1978, by 2000 on 19 Broad Habitats were used for integrating the reporting of change.

In Spain, habitat classification has been recently developed from phytosociological associations (Morillo Fernandez, 2003). At the landscape level, i.e. recognising that habitat need to be seen as interrelated patches, Elena-Rosselló (2003) has developed the largest national program in Europe for detecting changes in habitats from aerial photos. Inevitably further detail is required for some habitats such as grassland to include sufficient information on biodiversity.

The BIOHAB project (Bunce *et al.,* 2005) established that all the available pan European classifications used many terms that were not clearly defined (e.g. montane and sub-mediterranean) and they could not therefore be used consistently in the field. Hence the Biohab approach has adopted traditional scientific principles in developing General Habitat Categories to be used for survey and monitoring.

The present paper first describes those BIOHAB principles and the validation process accompanying them. The environmental framework for relating the necessary detailed sample to the whole population is then described. The recording system is then summarised by giving the principal rules and the method of using qualifiers to convey information on drivers and descriptive information, as well as links to other classifications. Additional details on structure are also given to provide better links between in situ data and remote sensed information.

Finally, a methodological scheme is proposed to adapt the BIOHAB approach for use in Spain. The proposal will allow linking European surveillance and monitoring with information obtained in Spain.

Principles of the BIOHAB procedures

The BIOHAB initiative was developed for a European window as shown in Figure 1. The strategic dimension of a surveillance and monitoring system poses important dimensional constraints at continental, subcontinental or regional levels. Full coverage of field survey is not economically feasible and statistical stratification has therefore to be used as described below. In addition, habitat definition has to be done consistently throughout the continent, in order to minimise artefacts that could arise from subjective field recording.

According to previous experience: e.g. Bunce *et al.* (1996a) and Elena-Rosselló (1997), a three step methodological framework was established:

1. Development of an environmental stratification of the study area.
2. Extraction of stratified samples.
3. Development of a field survey procedure.

The European environmental classification used in BIOHAB

An essential part of BIOHAB has been the construction of an environmental stratification of Europe, including Northern Africa and Turkey (Metzer *et al.,* 2005). This classification system has been derived from statistical analysis of climatic, location and altitude data at a 1 km square level of resolution. So far, this classification has been the base line for assessment of the environmental impact of climate change. 13 environmental Zones have been established, linked hierarchically to 84 environmental strata (Fig. 1).

The classification of Europe could also be used to select samples in Spain, due to its sub-continental dimension. However, because the selection of sites already used for landscape monitoring (Elena-Rosselló, 2002) was based on a parallel statistical methodology,

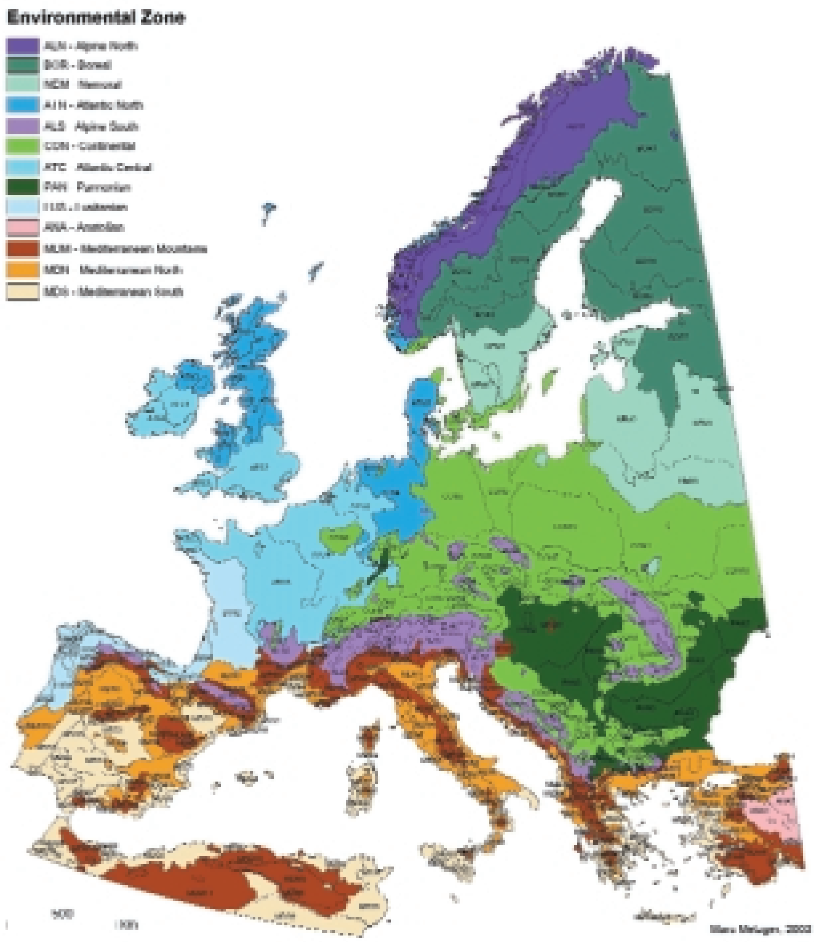


Figure 1. Land Classification of Europe developed by Metzger *et al.* (2005) is the base for BIOHAB sampling stratification system.

they can also be used as basis for selection of a Spanish series of sites, which would be further strengthened by the collection of supporting field information (e.g. vegetation or birds). This procedure would have the major advantage that the field survey could be directly linked to historical change. Furthermore, because satellite imagery could also be obtained from the sites, a fully integrated system could be developed combining the strengths of all three types of data.

A stratification system for surveillance and monitoring

Surveillance is considered as recording a habitat at given point of time, whereas monitoring is repeating the records over a time series.

The majority of ecological survey is descriptive and covers only the former category and is not sufficiently rigorous to be repeated. The rules described in the present paper are necessary to define sufficiently accurate boundaries for monitoring to be carried out, otherwise real change can not be separated from background noise. However, they can also be used to coordinate diverse existing data and to link these to phytosociological associations.

The need for detailed records precludes complete coverage, hence sampling becomes essential. The procedures described by Bunce *et al.* (1996a,b) for Great Britain and Bolaños *et al.* (2001) for Spain have been developed for these objectives and are based on the production of statistically derived environmental strata based on environmental variables. Because of the regression relationship between the environment and habitats, the strata can be sampled for assessing the resources. Furthermore, because they are relatively stable, can also be used for subsequent repetition, to detect change. It is necessary to use the same sites in order to restrict the variation between sampling dates and to facilitate the recording of actual change. The procedures developed for detecting changes from air photos are also suitable, as described by Elena-Rosselló (2003) for detecting change between boundaries drawn in the field. Because the relationship between the samples and the whole domain is known, population estimates of stock and change can then be made, with associated estimates of statistical error. A worked example is given by Haines-Young *et al.* (2000).

BIOHAB has proposed the use of the European Stratification (Metzger *et al.,* 2005) to derive a minimum of about 1,400 environmental sample 1 km squares required for surveillance and monitoring of habitats as defined in section 3 below to an acceptable statistical accuracy according to previous experience in Great Britain (Bunce *et al.,* 1996a) and for the European stratification (Jongman *et al.,* 2006). Existing data from objectively located samples will also be used where possible.

Such a sampling design enables data from the sample km squares to be integrated across Europe at the stratum level. The mean figures from the strata can then be extrapolated to the whole of Europe using standard statistical procedures. Because the stratification system holds information from all 1 km squares in Europe, it can then be used to display the spatial distribution of any available parameter either from each km square (e.g. altitude or estimates of habitat extent) or from the records made in the environmental strata. If the field data were available, then they could also be linked to the CORINE land cover map to develop show the distribution of the main habitats in Europe or Spain [PEENHAB Project (Mucher *et al.,* 2003)].

For monitoring purposes, it is statistically essential to return to the same sites to record changes. This is the procedure followed in all the major monitoring initiatives in Europe. Therefore it is required to establish a permanent sample network, and a clear habitat definition. The first would be provided by the described European Stratification. The second is supplied by General Habitat Categories specifically designed to be recorded consistently, as describe in the next section.

Principles of the BIOHAB field survey procedure

Habitat categories based on life forms

Plant life forms were first identified as valuable in the BIOHAB project because they were able to provide field rules to separate grassland, scrub and forest categories within previous classifications, especially EUNIS (Moss and Davis, 2002). However, during the project it became clear that life forms provide a means of transcending species and enabling consistent recordings of all habitats to be undertaken.

The use of life forms has the major advantage that, at the lowest level, species do not have to be identified. Of course, if more detailed information on other aspects of biodiversity is required, then further data is essential. Consequently, the full recording procedure includes the life form option, as well as recording other habitat classifications. Whilst life forms are the core of the approach, a progressive series of qualifiers is attached to the recording units involving environment, management and other habitat classifications.

A further essential reason for using life forms is that many animal species (e.g. birds and butterflies), respond to habitat structure rather than to individual species. Thus scrub vegetation has distinctive forms that have different species assemblage, depending on the biogeographical location of the sites.

Another important advantage of using plant life forms is the possibility of making comparisons between different continental regions where the floras have vicarious species. Data on life forms from Spain could thus be linked to other Mediterranean regions e.g. in the western USA, Chile, South Africa and Australia, so that the impacts of factors, such as climate change, could be related to the Spanish situation.

It was therefore decided to use life forms as the sole criteria for determining the primary General Habitat Categories (GHC's) so that they can be recorded directly in the field but are also sufficiently general to be used to link existing datasets which have been collected for monitoring. The lifeforms adopted were those of Raunkiaer and are based on the height above ground of the overwintering buds.

Various floras were consulted, especially Pignatti (1982), to determine at what level to treat life forms because some recent floras give highly detailed categories. However, as Raunkiaer (1934) originally emphasised, the more detailed breakdown of life forms, lose the strong relationship with climate. Eventually, it was decided to use 16 life forms (see Fig. 2) with the height ranges taken from more recent literature e.g. Castri *et al.* (1981); Quetzel and Barbero (1982).

Further details and examples of the species are given in Bunce *et al.* (2005). It is also recognised that some species are sufficiently plastic to adapt to several ha-

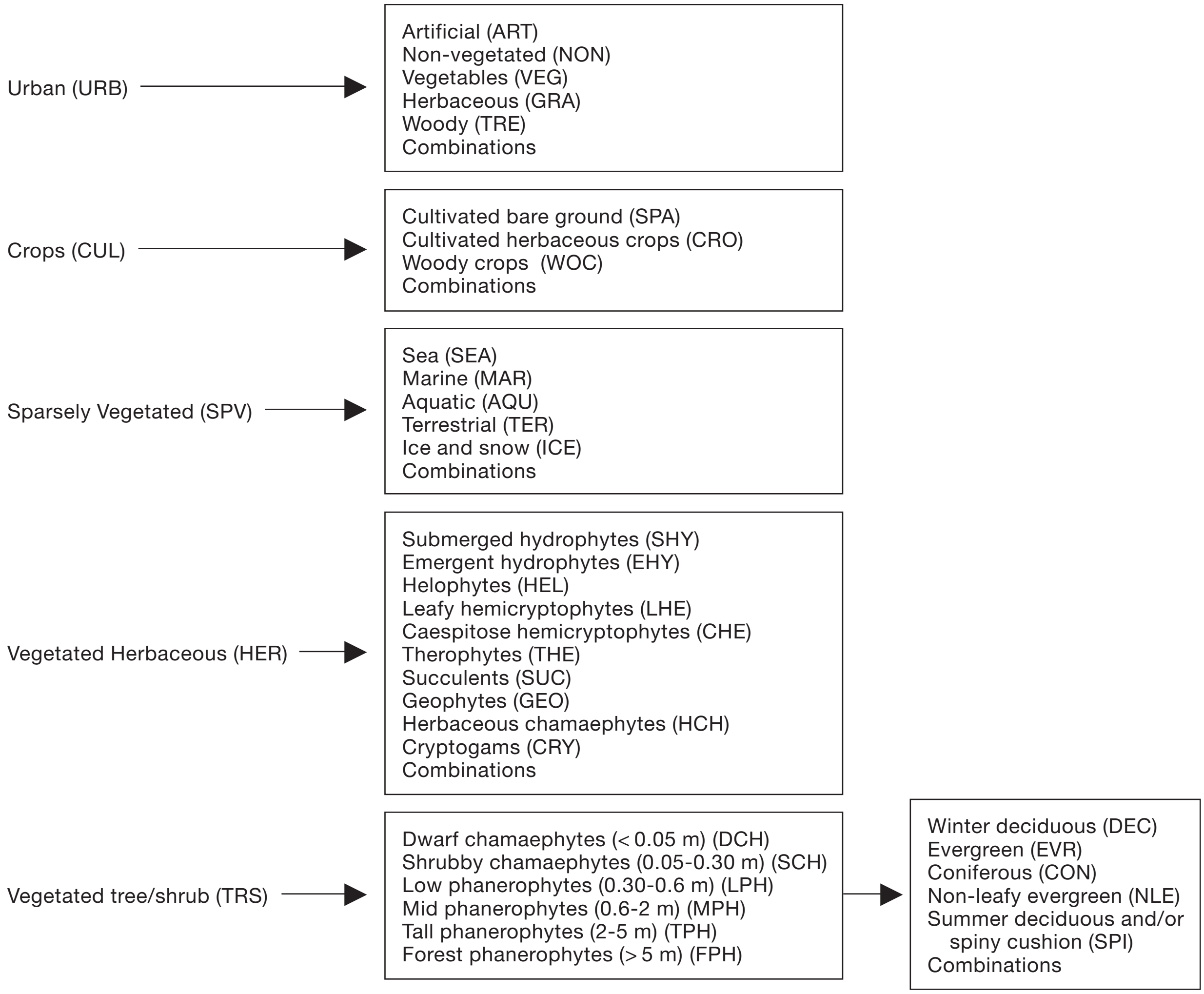


Figure 2. Diagrammatic representation of the BIOHAB key (Bunce *et al.,* 2005): 16 life forms were adopted for defining herbaceous and ligneous vegetation types.

bitats, e.g. *Ranunculus aquatilis*: In this case, the environmental conditions present at the site, as described by Bunce *et al.* (2005), should be used to determine whether it is in aquatic or waterlogged conditions.

Another aspect of plasticity relates to woody species which respond to a range of environmental and management pressures, especially in Southern countries as Spain with such a wide range of both environments and management regimes. These species can occur in lower than optimum height categories because:

— They have been heavily grazed e.g. grassland between trees in *dehesas*.

— They have been burnt e.g. in the widespread wildfires that occur in Spain.

— They are regenerating e.g. in abandoned agricultural land, where *matorral* is replacing grassland.

— They are in highly exposed environments e.g. on sea cliffs.

The first three categories are transitional and shifts can take place according to changes in the external pressures e.g. fire or felling. The fourth is a climax state. The only way to provide consistent data is to record the actual heights of the tree and shrub cover in the field.

Land associated with built structures and routes of communication (termed urban in a broad sense) and crops cannot be defined solely in terms of life forms as they are primarily land uses. However, for practical reasons it is essential that such land is separated from other land covers e.g. grassland or forest. Hence these two categories have been defined in detail (see Bunce *et al.,* 2005) and together with bare land are taken out at the first level of the hierarchy (Fig. 2). However, divisions within both the former categories are made on life forms, albeit above the full level of 16. These are termed super categories. A major problem whether in habitat classifications or multivariate analysis is the determination of the number of classes. In some habitat classifications e.g. Morillo Fernández (2003) there are almost 1,000 classes and in EUNIS there are 350 at level three. It was therefore decided that below the first tier of five super-categories all possible combinations of life forms should be included, even although some will be rare. This procedure has provided a statistical rule for determining the number of GHC's and results in 130 covering the pan-European region, of which over 90% are in Spain because of its wide range of geographical variation. The principal reason behind the GHC's is that they enable the primary decision on the habitat categories to be made in the field and the rules and instructions also make them appropriate for monitoring. A worked example of monitoring national change using a similar level of categories of habitats is given by Bolaños *et al.* (2001). These categories could be linked to more detailed field data by carrying out sampling of representative sites to provide links to more detailed categories e.g. grassland into calcareous and acidic subdivisions.

Sample Units and Size

One of the main problems in determining the number of samples is that a given habitat often occurs at different scales in contrasting landscapes. The recording procedure therefore needs to reflect such heterogeneity. In the present paper, it is recognised that the optimum size of the sampling unit depends on the objective of the study as discussed by Bunce *et al.* (1996a). However, air photo interpretation is often more efficient in larger units, for example in Bolaños *et al.* (2001) 4×4 kilometre units were used. Field testing in four landscapes near Madrid and in Almería has indicated that a 1 km square unit was a good compromise between the level of detail required for field survey and the production of spatial data, but the relationship to longer units requires further study.

In terms of the General Habitat Categories where a given category is in an optimum situation for its occurrence, it will occur extensively e.g. spiny cushion and summer deciduous species in south-east Spain. Elsewhere in southern Europe, except in Greece, it may occur as small patches but not elsewhere in the continent. This complexity means that for any initial survey, the strategy has to be at a constant scale to enable comparison of relative extent to be made. Rare habitats, whose distribution is often known, can be targeted, either objectively using known parameters (e.g. coastline), or according to rules developed by local experts (e.g. *Ziziphus lotus* scrub in Almería). In the latter case, statistical estimates of extent can only be made locally, but at least rare habitats can be identified and monitored using a standard procedure.

In this respect, there are three levels of sampling in relation to Spain:

1. The contribution of Spain to European resources.
2. The contribution of Natura 2000 sites to Spanish resources.
3. The occurrence of rare habitats within individual Natura 2000 sites.

The number of samples in Spain would increase progressively in Spain throughout these three levels.

Field rules and their process of validation

It was considered essential that the rules should be tested rigorously in a variety of situations. Previous experience of practical workshops organised by the International Association for Landscape Ecology (IALE) had already shown the limitation of mapping theoretical classifications in the field, especially where intergrades were concerned.

Initially, field rules were developed from previous experience, especially from the UK Countryside Survey (Barr e*t al.,* 1998) and from field excursions in Europe. These rules were discussed in several workshops and decisions built into the rule framework. They were also progressively modified by field testing in diverse field locations, eventually extending from Almeria in South-East Spain to inside the Arctic Circle in Northern Norway.

The main location for the testing between 1999 and 2004 was however around El Tiemblo near Madrid. Within 30 kilometre squares the landscape varied from open fields to vineyards and forests, to open mountains. These studies ensured that the structure of the classes was appropriate for Mediterranean conditions, because previously the majority of habitat mapping had been done in Northern Europe.

The instructions were developed following a six stage process, and the field procedure described below was the result of this development. The six stages were:

1. Development of initial rules.
2. Discussions of the rules in workshops.
3. Field excursions to a wide range of biogeographical locations.
4. Discussions in the field.
5. Field mapping of 1km squares.
6. Statistical tests of the underlying hypothesis.

As the use of life forms is based on a regression model the hypothesis can be tested, although it is the substance of classical biogeography e.g. Walter (1973); Box (1981) and Woodward (1987). The first test was carried out in a valley in the Picos de Europa, northern Spain, which extended from broadleaved evergreen forest at 200 m to scree, rock and sub-alpine vegetation at 2,500 m. A highly significant correlation was found between the mixtures of life forms recorded in samples and the mean altitude of environmental classes as described by Bunce *et al.* (1996). Such a correlation shows that at even local scale the model was valid.

In the second test, data had been collected on the full life form composition, within the sites visited for the validation of the field procedures throughout Europe. Correlations were found between the distribution of life forms and the principal gradient of temperature, i.e. from high to low temperatures, which is the same across the whole of Europe (Metzger *et al.,* 2005), as that found in Spain (Elena-Rosselló, 2005).

The Surveillance and Monitoring System

The General Habitat Categories (GHC's) are the primary structure of the surveillance system and are designed for recording habitats and providing links to other classifications. However, they are also applicable to Spain and can provide limits between the habitat classification of Spain and then elsewhere in Europe.

The GHC's are based mainly on Life Forms with added detailed information on environment, site, management and species composition. They are designed for consistent recording. Under such requirements, the working definition of «habitat» developed by the BIOHAB project is as follows: *«An element of land that can be consistently defined spatially in the field in order to define the principal environments in which organisms live»*. All the GHC's can be applied to linear or areal features, to simplify recording and reporting.

The use of General Habitat Categories (GHC's) in the BIOHAB Field Handbook is based on the following set of principles that have been adopted as essential for consistent recording of habitats.

— A GHC has to be determined by one field visit, or from extant data at a scale of at least 1:10,000, which must be made in an appropriate time window for a given region, i.e. either side of the period of maximum biomass.

— GHC's must be mutually exclusive and together cover the complete land surface of Europe, including water bodies.

— GHC's must be a common denominator for comparison between countries using extant data and classes in current use wherever possible.

— GHC's must be distinctive and recognisable.

— There must be explicit rules to define GHC's.

— Differences in management are recorded as qualifiers and are not in the definitions of GHC's.

— Habitats are not defined on the basis of biogeographic regions because of difficulties of maintaining consistency due to the lack of adequate definitions of the multiplicity of terms. Any biogeographical term that can be determined consistently can be attached to GHC's through database management.

— Individual species are not used to identify GHC's, because if vicarious species and differences in species behaviour in contrasting biogeographical regions. However the use of indicator species to identify environment qualifiers is useful.

The Minimum Mappable Element (MME) for an areal element is 400 m^2 with minimum dimensions of 5×80 m; if it is smaller than 5 m the element is recorded as a linear element with a Minimum Mappable Length (MML) of 30 m. Elements that do not pass the MME criteria for either areal or linear elements can be mapped and recorded as point elements or as portions of a larger element.

Areas of recognisable linear features (e.g. motorways) that qualify as areal elements can be subsequently be identified as linear elements by data base analysis, if required. Details of the practical mapping procedure are given in Bunce et al. (2005).

In order to avoid inconsistency all field surveyors should make as many decisions as possible in the field and not postpone them to the laboratory. However, database management methods can be used subsequently to extract other data, e.g. calculation of slope angles, aspect and height of cliffs.

Elements are assigned alpha codes that are the same on the map and on the corresponding recording sheet as described by Barr *et al.* (1993) and Bunce *et al.* (2005).

The total cover is estimated as from a vertical perspective and the mapping of areal elements adds to 100% of the land surface. The entire survey area must be mapped, even the small corners of the square.

Point elements are recorded if they are considered significant in the landscape context. It must be made explicit how these have been recorded, so that they can be monitored effectively.

For monitoring, the recording of the GHC's should be made in a time window inside of the period of maximum biomass, as close as possible to the height of the growing season. This window is likely to be before maximum biomass in most of Spain, but may be later in the Pyrenees. The extent of the window should be set by region, using local phenological information. Repeat surveys should be carried out at the same time. In Spain much local experience is available for the appropriate time of survey, but flexibility will be required because of annual variations.

The actual period of field training for monitoring depends on the experience of the surveyors but should be at least one week. However, if only description is required then such training is not necessary. For monitoring quality, control and assurance are also essential; determine real change can not be separated from differences between records.

Combined teams of two people, preferably with a botanist and an experienced mapper, are needed to ensure that optimal expertise is available with field training being essential.

The same recording format is to be used for areal, linear and point elements. The recording form has an alpha identifier and eight subsequent recording fields:

— The first field is for entry of the GHC.

— The second field is for entry of the environmental qualifiers and global codes, for expressing moisture regime and acidity variations between elements that otherwise may have the same GHC. Environmental conditions must be considered at a continental scale: e.g. «*dry*» in Scotland may be «*mesic*» compared with southern Spain.

— The third field is for entry of the site qualifiers to record other characteristics, e.g. geomorphology, geology, soil or archaeology, in order to express variation between elements that may have the same GHC.

— The fourth field is for entry of the management qualifiers to record managed characteristics (e.g. forest management, succession and recreation) expressing variations between elements that may have the same GHC.

— The fifth field is for entry of the detailed composition of the GHC's together with the major species and percentages.

— The sixth field is for entry of European Habitat classifications, including EUNIS and other pan-European classifications.

— The seventh field is for entry of regional or local habitat classifications.

— The eighth field is for entry of phytosociological associations, where appropriate.

All fields must have an entry in order to ensure that subsequent database management can identify that an entry has not been omitted in error. Full details of the recording procedure are given by Bunce *et al.* (2005).

A new areal or linear element is separated from adjacent or surrounding elements if any one of the following seven rules is true:

— A change in GHC.

— A change in environmental qualifier.

— A change in site qualifier.

— A change in the occurrence of point elements.

— A change in management qualifier e.g. a fence line or age of forest trees.

— A change of at least 30% in the cover of an individual species.

— A change in any other specified habitat classification e.g. the Spanish habitat classification.

It is essential to refer to the handbook to ensure consistent decision making. As emphasised above, quality control and regularly assurance are also essential to ensure reliable data. Quality control procedures involve checking field surveyors identification and mapping skills by experienced staff actually in the field.

In Spain, in comparison with many north European countries, there is still a wide range of people with good field experience, so the cost of training will probably be not so high.

The major categories

The major divisions, termed super-categories, are as follows: (full details being given in Bunce *et al.,* 2005)

1. Urban or built-up land which is defined as land functionally related to buildings or urban uses, such as recreation. It is recognised that the term is arbitrary and not based on life forms but is a land use division that is essential as major category for European statistics. The second tier in the hierarchy within urban

is based on life forms e.g. trees/scrubs. Further guidelines are given in Bunce *et al.* (2005).

2. Cultivated. Crops are mainly the result of plant breeding but may include planted native species such as walnut or hazel trees. Woody perennial crops and recently ploughed or fallow land are also included here.

3. Sparsely vegetated. Includes elements that have under 30% cover of vegetation. e.g. lakes or tidal estuaries.

4. Herbaceous. Elements that have over 30% vegetative cover of species with buds at ground level or cryptogams. This super-category is divided into nine categories e.g.: helophytes (plants that grow in waterlogged conditions) therophytes (annual plants) and cryptogams (non-saxicolous bryophytes and lichens).

5. Shrubs and trees. Most of this super-category is woody but some species do not have secondary ligneous thickening, e.g. Phagnalon and Asparagus spp. These categories are further divided by height, and by the time of leaf fall and character e.g.: summer deciduous or conifer.

The rule base identifies any element into one of the five categories, after which a further set of definitions places the element into one of the 130 General Habitat Categories. The summary list is given in Figure 2.

Qualifiers

There are five different types of qualifiers recorded in progressive columns: detailed definitions are provided by Bunce *et al.* (2005): Some modifications and additions would be required to reflect Spanish conditions.

1. Environmental and global qualifiers. These can apply to any element and are entered into the second field of the recording form. These codes include assessment of the moisture and nutrient status of the soil in the element and a series of general information such as substrate and the type of linear feature.

2. Site qualifiers. A series of site qualifiers are then recorded including factors such as geomorphologic features, historical artefacts and coastal attributes.

3. Management qualifiers. These are grouped in convenient sections (e.g. forestry and recreation) and are designed to give information about potential causes of change and can subsequently be linked to the GHC's. They include such information as ploughing, silage and forest felling.

4. Detailed life form and species composition. All life forms that cover more than 10% of the element are included here, together with the major nature species or crops that are present within the recorded life form. Instructions are given for recording the codes given for crop types.

Description of the methodological proposal for Spain

The methodological strategy developed under the Biohab project can be applied at continental as well as sub-continental scales. Spain is a good example of the potential application of the BIOHAB methods at a regional level in the European context. In bio-geographical terms, Spain has a sub-continental dimension with 500.000 kilometre squares including wide range of geo climatic gradients between the Oceanic, Mediterranean and Continental European regions.

As it has been mentioned before, our previous experience in the SISPARES (SIstema para el Seguimiento de los PAisajes Rurales ESpañoles) project was an important input for developing BIOHAB methods. SISPARES was designed for monitoring landscapes, considered in the Forman and Godron (1986) conceptual perspective. However, BIOHAB has been designed for monitoring habitats in the field and is therefore more detailed. Both initiatives shared the monitoring objective and the sampling strategy but they differ in their ecological scales. Differences and similarities among both initiatives are shown in Figure 3.

Our purpose is to coordinate the methods developed from both projects so that mutual benefits could be obtained: SISPARES results could then be used in the BIOHAB European level, and BIOHAB would provide a continental framework for coordination with other countries experiences.

Our methodological proposal requires a common environmental stratification baseline. *Clateres* (Elena-Rosselló, 1997) and the European Classification (Metzger, 2005) show a high degree of correlation, comparable to that reported by Bunce *et al.* (2002), and the strata can therefore be used for extrapolation purposes. Figure 4 shows both classification maps, where the main geographical patterns are clear visible. The table of correspondence between the strata ensures that the mutual exchange of photo and field analysis among Biohab and *SISPARES* sample networks is feasible and efficient.

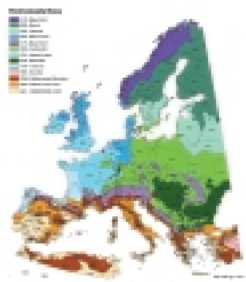
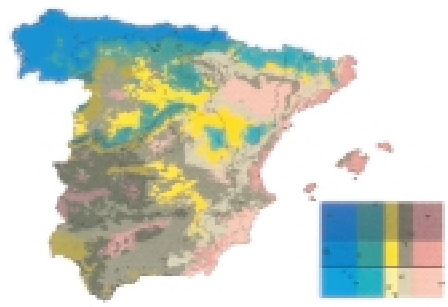
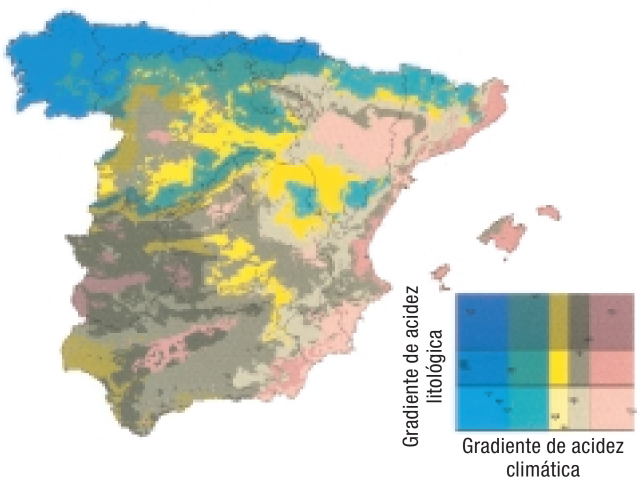
	BIOHAB	SISPARES
Land classification	 Mètzger *et al.,* 2005	 Elena-Rosselló, 1997
Sample stratification	Habitats 84 environmental strata 1,400 samples 1 km squares	Landscapes 11 environmental strata Network of 206 samples 4 × 4 km squares
Land survey	GHC detection based on life forms of areal, linear and point elements Periodical field surveys	Landscape pattern detection based on land cover of areal, linear and point elements Periodical aerial photo and field surveys
Results	Habitat type distribution and change detection	Landscape distribution and change detection

Figure 3. Description of methodological features of both BIOHAB and SISPARES projects.

Because their different conceptual aims (habitat as opposed to landscape), there is a disagreement between the size of the sample units in BIOHAB and SISPARES. Any possible coordinated method should proposed a conciliation approach, e.g. using a subdivision process of the larger SISPARES samples. However, a simple splitting of those samples will increase four times the number of samples, but it will reduce the sample environmental variability. A process that minimise these problems needs to be developed and would involve

A



B

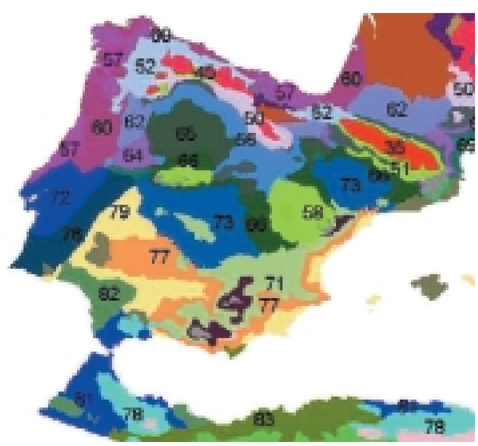


Figure 4. Land classiffications of Spain. A: *Clateres* land classification map (Elena-Rosselló, 1997). B: Europe land classification map (Metzger *et al.,* 2005).

the measure of autocorrelation between adjacent samples.

The field surveillance categories are more detailed in BIOHAB than in *SISPARES*, mainly due to its smaller scale. Habitat definition and future monitoring requires more detailed field information than Landscape evaluation. Nevertheless, the BIOHAB field survey procedure is a good baseline for coordination as it is based on Life Forms, and *SISPARES* procedure is based on plant formation criteria. *SISPARES* landscape element categories, both areal and linear, can therefore be easily translated into BIOHAB GHC's, and then be used in field surveys.

We therefore propose a methodological procedure according the following steps:

Land Classification System

Clateres land classification will be the base for the stratification sampling. From the result obtained in *SISPARES* project, we have found a high correlation among the landscape pattern and the biogeoclimatical gradients underlying the Spanish environmental structure (Ortega *et al.,* 2006). *Clateres* based strata have shown an important potential for consistently extrapolating their sample results.

Stratified Sampling Design

According to the BIOHAB surveillance guidelines, the proposal for Spain requires a 1 km square sampling unit. In order to achieve the necessary BIOHAB sampling intensity for Europe, at least 300 samples need to be selected in Spain. There are two important reasons for that: Spain is almost 10 percent of the Europe's total area. For 1,400 samples, that means that Spanish sample should be 116. However, Spain shows the highest environmental diversity of Europe, so the number of Biohab samples should be at least 300.

In order to get mutual benefit from the *SISPARES* and BIOHAB initiatives, we propose to use the *SISPARES* landscape samples. Therefore, 206 BIOHAB samples will be located in the central 1 Km square of each SISPARES sample. The remaining 100 samples will be selected using the contingency table in order to avoid possible under-representation of some European classes. The result from this system will balance sample representation at both Spanish and European levels.

Field Surveillance

Field surveys have to be carried out following the guidelines established in the «Handbook for Surveillance and Monitoring of European Habitats» (Bunce *et al.,* 2005), already translated into the Spanish. The existing information from the past surveys carried out in *SISPARES* for 1956, 1983 and 1998 can be readily adapted throughout the conversion of the Land Use and Cover Types (LUCT) of the landscape patches into General Habitat Categories. Future surveys will be carried out in the 300 samples following accurately the BIOHAB guidelines.

We have to emphasize that field surveillance requires a previous aerial photo interpretation that produces a preliminary draft map of the landscape pattern by recognizing areal, linear and point landscape elements. Such a draft map together with the land information obtained from a Digital Terrain Model will make the field works more efficient. Consequently, time in the field will be mainly devoted to identify GHC's and the completion of the recording sheets.

Integration of Results

Survey information will be incorporated into a GIS database using both European and Spanish land classification systems. That strategy will allow a dual integration of the results. On one hand, the results will be part of the European scale habitat surveillance and monitoring system, and they will be integrated into the continental models. On the other hand, future surveys will continue being part of the *SISPARES* system, allowing the monitoring of the Spanish rural landscapes.

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