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# Vegetation Science and the implementation of the Habitat Directive in Spain: up-to-now experiences and further development to provide tools for management

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**Abstract**

One decade and a half after being proclaimed, the Habitat Directive has been largely implemented in most of the EU member states under various approaches and with different degrees of intensity. The high contribution to European biodiversity provided by the Spanish territories, along with extensive mountainous areas with low population densities and the engagement in safeguarding biological and ecological patrimony exhibited by a large part of the society and its governments have led to the design of a vast Natura-2000 network in Spain. At present, it includes 23.6% of the national territories which represent 24.7% of total EU network and the proportion of Annex I habitats types incorporated to protected areas embody 30.22% when referred to the total existing in the country. Under these circumstances, naturalistic evaluation appears as an important task for vegetation scientists and some criteria and scales are commented. In this sense undertaking the development of Payment for Environmental Services (PES) schemes, where landowners collaborating to environmental welfare will be rewarded with money, becomes a viable contrivance to political managers.

Key words: Habitat Directive, management tools, naturalistic evaluation, payment for environmental services, phytosociology, vegetation science.

**Resumen**

*La ciencia de la vegetación y la implementación de la Directiva Hábitat en España: La experiencia hasta el momento y el desarrollo cara al futuro con la elaboración de herramientas para la gestión.* Después de una década y media de haberse promulgado, la Directiva Hábitat ha sido extensivamente aplicada en la mayor parte de los estados miembros de la Unión Europea usando diversos procedimientos y con distintos grados de intensidad. La elevada contribución de los territorios españoles a la biodiversidad europea, propiciada por las extensas áreas montañosas con baja densidad de población que acogen y el compromiso de salvaguardar el patrimonio biológico y ecológico de una gran parte de la sociedad española y de su gobierno, ha conducido a la designación de una vasta red Natura-2000 en España. En este momento incluye el 23% del territorio nacional que representa el 24.7% del total de la red de la UE y abarca el 30.22% de los tipos de hábitat del Anexo I que hay en la totalidad del país. En estas circunstancias, la evaluación naturalística se presenta como una tarea de la mayor importancia para los especialistas en vegetación, y para ello se comentan una serie de escalas para aplicar a los tipos de vegetación existentes. En este contexto, se considera el principio del Pago por Servicios Ambientales, con la propuesta de un método, en el que los propietarios rurales que colaboren en la conservación con las administraciones competentes, serán remunerados económicamente, de modo que este sistema se convierta en una eficaz herramienta de gestión.

Palabras clave: ciencia de la vegetación, Directiva Hábitat, evaluación naturalística, fitosociología, herramientas de gestión, pago por servicios ambientales.

## Applying the Habitats Directive in Spain

As it was explained in a previous work (Loidi, 1999) the Habitats Directive (94/93/ECC) was largely conceived within a phytosociological framing, which resulted in a description of habitats based mostly upon vegetation types. This implied using vegetation types as defined in phytosociology as the basic units for the habitats inventory which, tacitly, have required global cartography at 1:50,000 scale of the whole country (Rivas-Martinez *et al*., 1994). Advantages obtained from having done a complete survey of habitats in every a national territory of the EU are multiple:

- A realistic idea about actual extension of a given type of habitat at the moment the survey is performed.
- Accurate location of places and areas covered by the different habitat types.
- Evaluation of the proportion of each habitat type submitted to protection when implementing the Natura-2000 network, identifying the empty areas and those locations in which new protected areas need to be proposed.

In this sense, concerning Spain, the Natura-2000 network includes 1381 Sites of Community Importance (SCI) in 2007 (Fig. 1).

A total surface of 11,911,211 Has is covered, which situates Spain as the main contributor to European Natura-2000 network, this extension representing 24.7% of the 48,263,859 Has of EU countryside linked to the network: ~ 1/4 of EU Natura-2000 network resides in Spain. This means that 23.6% of the national territory has been incorporated to this protection scheme, Spain becoming the second country of the EU in such terms only exceeded by Slovenia with 31.4%. (http://ec.europa.eu/environment/nature).

Once a complete inventory of habitat types has been performed, essential information can be extracted since it becomes possible to estimate the proportion of total existing resources of each habitat type ascribed to the N-2000 network. An example is given in Fig. 2.

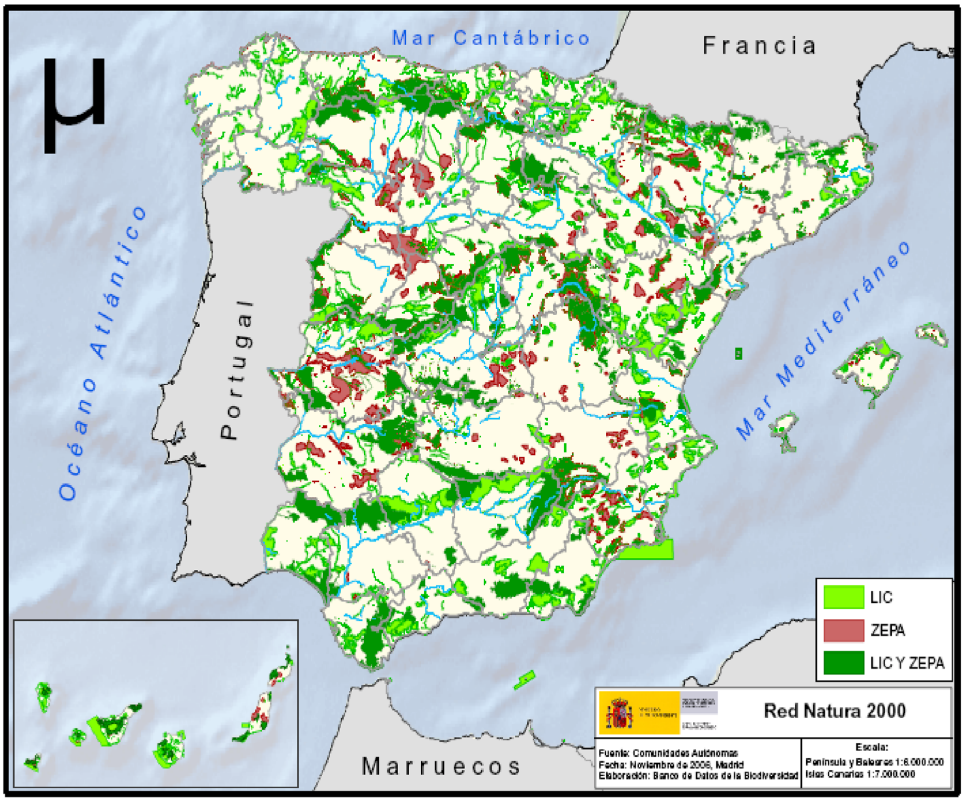


Fig. 1 - The Natura - 2000 network in Spain (http://www.mma.es/portal/secciones/biodiversidad)

| Code | Habitat type | Total area for Spain | N-2000 Network ES | % |
|---|---|---|---|---|
| 1120 | ***Posidonia* beds (*Posidonion oceanicae*) (*)** | **3.06604** | **1.30713** | **42.63** |
| 1240 | **Vegetated sea cliffs of the Mediterranean coast with endemic *Limonium* ssp.** | **19.11484** | **6.72984** | **35.10** |
| 2130 | **Fixed coastal dunes with herbaceous vegetation ("grey dunes") (*)** | **35.76322** | **16.82405** | **47.70** |
| 4040 | **Dry Atlantic coastal heaths with *Erica vagans* (*)** | **56.34819** | **22.76593** | **40.40** |
| 3150 | **Natural eutrophic lakes with Magnopotamion or Hydrocharition – type vegetation** | **74.69709** | **230.29355** | **32.44** |
| 3250 | **Cnstantly flowing Mediterranean rivers with *Glaucium flavum*** | **69.8293** | **23.0827** | **33.05** |
| 1520 | **Iberian gypsum vegetation (*Gypsophiletalia*) (*)** | **2119.765** | **646.8167** | **30.51** |
| 4030 | **European dry heaths** | **18214.83813** | **5636.77197** | **30.95** |
| 5330 | **Termo-Mediterranean and pre-desert scrub** | **13868.97** | **3565.025** | **25.70** |
| 5120 | **Mountain *Cytisus purgans* formations** | **2771.1947** | **1156.81516** | **41.74** |
| 6160 | **Oro-Iberian *Festuca indigesta* grasslands** | **735.73267** | **354.72324** | **48.21** |
| 6230 | **Species-rich *Nardus* grasslands, on siliceous substrates in mountain areas (and submountain areas in Continental Europe) (*)** | **1134.564** | **452.1137** | **39.67** |
| 9120 | **Atlantic acidophilous beech forests with Ilex and sometimos also taxus in the shrublayer (*Quercion robori-petraeae* or *Ilici-Fagenion*)** | **3176.39723** | **1343.35601** | **42.29** |
| 9340 | ***Quercus ilex* and *Quercus rotundifolia* forests** | **19866.25777** | **5633.33399** | **28.35** |
| 9520 | ***Abies pinsapo* forests** | **21.84651** | **10.89202** | **49.86** |
| 9360 | **Macaronesian laurel forests (*Laurus, Ocotea*) (*)** | **58.21709** | **28.51737** | **48.97** |
| 9370 | **Palm groves of *Phoenix* (*)** | **8.86577** | **3.13908** | **35.40** |
| 9550 | **Canarian endemic pine forests** | **604.3287** | **300.1388** | **49.66** |
| | **All types** | **183755.1** | **55536.91** | **30.22** |

Fig. 2 - Table showing the existing surfaces (in Ha) of several habitat types compared with the amount of them included in the N – 2000 network in Spain. Light blue indicates coastal habitats, dark blue humid and aquatic habitats, yellow scrub and shrubland habitat, light green high mountain habitat, red forests and lilac Canary Islands habitat (Courtesy of Elena Bermejo, TRAGSA)

Several habitat classes are included and comparisons are made between its total coverage for Spain and the surface under protection by Natura-2000 network. Habitats have been classified into five categories: coastal, aquatic and humid, scrubs, high mountain forests and Canarian (Macaronesian). Percentages show that protected areas remain over 25% approaching 50% for some habitats. High scores are obtained for the Canarian, mountains and coastal habitats, whilst lower values are found for the scrubs. Forest rank among the highest within the rare endemic types and lower in the commonest Holm-oak formations.

In a broad sense, we can consider that results for the whole process (cartography, proposals of SCI, etc) have been adequate, some balance having been reached: a large share of all the habitat types in Annex I have been integrated (~30%) while distribution of protected areas are even in terms of habitat type. Summarizing, 23.6% of national territories belong to the network and, furthermore, about 30.22% of any given habitat type is subject to conservation in terms of Annex I (as well as many others not included in this list).

**Naturalistic evaluation**

An important service rendered by this large-scale habitat mapping of vegetation types is the possibility of being used as a basic document for a naturalistic evaluation. This is not a new idea (Lucas, 1973; Seibert, 1980; Loidi, 1994; Meaza & Cadiñanos, 2000) and using vegetation as the grounds for naturalistic or ecological evaluation, has been undertaken by different authors (Asensi, 1990; Kirby, 1986; Géhu & Géhu-Franck, 1980) though not strictly based on vegetation maps. Our purpose has been assessing the naturalistic value of vegetation units by means of a set of criteria described next (Loidi, 1994; Orrantia *et al*., in press):

| **1. Naturalness. N** Tries to express the degree of human influence (hemerobie) on it. Comprises two aspects: (1) the damage or transformations caused by man in plant communities and (2) how these plant communities are the result of and dependent on human activity themselves. It is expressed in terms of distance from the climax or potential natural vegetation (PNV). The highest naturalness would correspond to PNV in an undisturbed situation. | |
|---|---|
| 0 | Intensely urbanised areas, completely occupied by buildings, roads, etc. Practically no plants. |
| 1 | Peri-urban areas, surroundings of areas submitted to intense urban activities, with plant communities strongly dependent upon influence of man (high disturbance); cultivated fields. (*Polygono-Poetea annuae, Artemisietea vulgaris (pp), Galio-Urticetea, Ruderali-Secalietea (pp), Plantaginetalia, Parietarietalia*) |
| 2 | Parks, gardens, abandoned crop-fields. Pioneer therophytic vegetation. (*Onopordenea, Pegano-Salsoletea, Taeniathero-Aegilipion, Tuberarietea*) |
| 3 | Tree plantations of exotic species for timber production. |
| 4 | Grazed grasslands and meadows. *Arrhenatheretalia, Poetea bulbosae, Festuco-Brometea* (pp) |
| 5 | Natural scrub and grasslands of secondary origin. *Rosmarinetea, Festuco-Ononidetea, Cisto-Lavanduletea, Calluno-Ulicetea, Festuco-Brometea* (pp), *Sedo-Scleranthetea, Lygeo- Stipetea* |
| 6 | Shurb-mantle and fringe vegetation. *Prunetalia spinosae, Cytisetea scopario- striati, Pistacio- Rhamnetalia alaterni* (pp). |
| 7 | Cleared natural woodlands due to grazing and forested meadows (dehesas). Mixed woodlands of authoctonous and exotic trees. Combined explotation of grazing and wood extraction. |
| 8 | Young natural woodland (initial stage) mixed with mantle and other seral communities linked to the forest system such as those of *Galio-Alliaretalia, Epilobietea angustifolii, Betulo-Adenostyletea* (pp). Severe forest explotation or recent abandonment. |
| 9 | PNV and permanent vegetation submited to light exploitation. The units involved are approximately the same as in the next level. |
| 10 | Mature non exploited forest. Rock crevices and screes. Undisturbed coastal dune communities Salt marshes. High mountain climatic meadows and scrubs. Peat-bogs. *Querco-Fagetea* (pp. max), *Quercetea ilicis* (pp. Max), *Pino-Juniperetea, Vaccinio-Piceetea, Nerio- Tamaricetea, Asplenietea trichomanis, Thlaspietea rotundifolii, Ammophiletea, Spartinetea, Arthrocnemetea, Salicornietea, Crithmo- Limonietea, Juncetea trifidi, Elyno- Seslerietea, Salicetea herbaceae, Oxycocco- Sphagnetea, Scheuchzerio- Caricetea nigrae, Littorelletea, Potametea, Molinietalia* (pp). |

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| **2. Resilience. P**<br>The capability of a vegetation type to recover itself after destruction (disturbance) by natural or humanly induced causes. An inverse scale is proposed as the less replaceable plant communities are evidently more demanding of protection. | |
| 0 | No vegetation |
| 1 | Pioneer annual communities and weeds<br>*Polygono-Poetea annuae, Ruderali- Secalietea, Hellianthemetea annuae*. |
| 2 | Nitrophilous perennial vegetation.<br>*Artemisietea vulgaris, Plantaginetalia majoris*. |
| 3 | Scrub vegetation.<br>*Rosmarinetea, Calluno- Ulicetea, Cisto- Lavanduletea, Pegano- Salsoletea*. |
| 4 | Perennial grasslands and meadows.<br>*Festuco- Brometea, Molinio- Arrenatheretea, Nardetea, Lygeo- Stipetea, Festuco- Ononidetea*. |
| 5 | Azonal permanent vegetation: salt marshes, coastal dunes and cliffs, swamps, fens, riverain vegetation, etc.<br>*Arthrocnemetea, Juncetea maritimi, Ammophiletea, Potametea, Phragmitetea, Littorelletea*. |
| 6 | Mantle and edges.<br>*Prunetalia spinosae, Cytisetea scopario- striati, Pistacio- Rhamnetalia alaterni* (pp). |
| 7 | Natural forests of temperate and not too dry areas.<br>*Querco- Fagetea (pp), Querceta ilicis (pp), Nerio- Tamaricetea*. |
| 8 | Xeric-mediterranean climatic vegetation. Rock crevices and screes. Peat-bogs (if peat is partially removed).<br>*Quercetalia ilicis (pp), Pistacio Rhamnetalia alaterni (pp), Juniperion thuriferae, Asplenietea trichomanis, Thlaspietea rotundifolii, Crithmo- Limonietea, Oxycocco- Sphagnetea, Scheuchzerio- Caricetea nigrae*. |
| 9 | High mountain vegetation.<br>*Vaccinio- Piceetea, Pino- Juniperetea, Juncetea trifidi, Elynetalia, Salicetea herbaceae*. |
| 10 | Relict vegetation; no possibility of recovery by natural means after destruction. Exceptional localities, mainly belonging to 7 to 9 categories, which develop under climatically unfavourable conditions and have the character of a refuge due to topography or other circumstances. At least some of the plants have a reduced reproductive ability and the destruction of the community implies its complete or partial disappearance. |
| **3. Threat. T**<br>This parameter depends on several factors which difficult its evaluation, and which are dependent on the human socioeconomic circumstances of each country or territory. This sacle is adapted to the Iberian Peninsula in he present times | |
| 0 | No vegetation |
| 1 | Rock crevices and other inaccessible mountain sites.<br>*Crithmo- Limonietea, Asplenietea trichomanis, Elyno- Seslerietea, Juncetea trifidi, Salicetea herbaceae.* |
| 2 | Seral scrub<br>*Cisto- Lavanduletea, Rosmarinetea, Festuco- Ononidetea, Calluno- Ulicetea*. |
| 3 | Natural grasslands<br>*Festuco- Brometea, Lygeo- Stipetea, Sedo- Scleranthetea.* |
| 4 | Edges and mantles<br>*Prunetalia spinosae, Cytisetea scopario- striati, Pistacio- Rhamnetalia alaterni* (pp) |
| 5 | Grazed meadows and grasslands (retreat of ranching activity)<br>*Arrhenatheretalia, Poetalia bulbosae* |
| 6 | Oligotrophic mountain forests<br>*Ilici- Fagenion, Quercenion pyrenaicae, Vaccinio- Piceetea, Pino- Juniperetea* (pp), etc. |
| 7 | Forested meadows (dehesas) |
| 8 | Lowland and foothill forests<br>*Carpinion, Quercetalia ilicis, Quercetalia pubescentis*. |
| 9 | Salt marshes, riverine vegetation, wet places.<br>*Arthrocnemetea, Salicornietea, Juncetea maritimi, Salicetalia purpureae, Populion albae, Potametea, Phragmitetea* (pp), etc. |
| 10 | Coastal dunes, accesible mires (peat exploitation)<br>*Ammophiletea, Scheuchzerio- Caricetea nigrae* (pp), *Oxycocco- Sphagnetea* (pp). |

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| | **4. Floristic- phytocoenotic value. F**<br>The intrinsic biological value of a formation (vegetation type) is given by the different species which constitute it, the relationships between them, and the structure, more or less complex, that, as a frame work, contains them.<br>The proposal for mapped units is:<br>a. The floristic value: specific diversity<br>b. The phytosociological value: phytosociologic diversity (richness of associated or included syntaxa in the appropriate unit if there is more than one).<br>c. vegetation structural complexity<br>d. the particular relationships between organisms (individuals and populations)<br>e. the phytogeographical character: content of endemic or territorially characteristic flora and syntaxa. |
| 0 | No vegetation |
| 1 | Nitrophilous vegetation, common flora, simple structure..<br>*Polígono Poetea annuae, Artemisietea vulgaris s.l., Ruderali- secalietea.* |
| 2 | Scrub vegetation<br>*Rosmarinetea, Calluno- Ulicetea, Festuco- Ononidetea, Cisto- Lavanduletea, Pegano- Salsoletea.* |
| 3 | Grasslands and meadows. Helophytic and aquatic vegetation.<br>*Phragmitetea, Potametea, Molinietalia, Arrhenatheretalia, Festuco- Brometea, Poetea bulbosae, Lygeo- Stipetea.* |
| 4 | Littoral and inland saline vegetation<br>*Arthrocnemetea, Spartinetea, Salicornietea, Juncetea maritimi, Crithmo- Limonietea.* |
| 5 | Rock crevices and screes, coastal dune vegetation.<br>*Asplenietea trichomanis, Tlaspietea rotundifolii, Ammophiletea.* |
| 6 | Oligotrophic deciduous forests and Mediterranean woodlands, mantles and edges.<br>*Quercetalia roboris, Quercetalia ilicis, Prunetalia spinosae, Cytisetea scopario- striati.* |
| 7 | Eutrophic species-rich deciduous forests.<br>*Fagion, Quercetalia pubescentis.* |
| 8 | Orotemperate and oromediterranean climatic vegetation, high mountain forest and scrub vegetation. *Nardus* meadows.<br>*Vaccinio- Piceetea, Pino- Juniperetea, Nardetea.* |
| 9 | Criorotemperate and crioromediterranean grasslands and associated communities. Peat-bogs and mountain rivulets and ponds. Chionophylous (snow-bed) plant-communities.<br>*Juncetea trifidi, Elyno- Seslerietea, Scheuchzerio- Caricetea nigrae, Oxycocco- Sphagnetea, Montio- Cardaminetea, Salicetea herbaceae.* |
| 10 | Mesophytic and wet forests of thermic areas with a rich flora which contains rare or relictic plants and associated communities of *Galio- Alliarietalia, Trifolio- Geranienea, Montio- Cardaminetea, Adenostyletalia*, etc. Forested meadows (dehesas). *Populetalia albae, Alno- Padion, Carpinion.* |
| **5. Rarity. R**<br>Rarity of a given plant is considered within a phytogeographical context, that is, that it appears in few or few little places, and so it is necessary to have the country phytogeographically studied and the territorial units defined and mapped.<br>The average distance between the spaces in which a species or vegetation type occurs is used. | |
| 0 | 500 m or less |
| 1 | 500 to 700 m |
| 2 | 700 to 1000 m |
| 3 | 1000 to 1500m |
| 4 | 1500 to 2500 m |
| 5 | 2500 to 3500 m |
| 6 | 3500 to 5000 m |
| 7 | 5000 to 10000 m |
| 8 | 10 to 20 Km |
| 9 | 20 to 40 Km |
| 10 | 40 Km or more |
| **6. Coefficient of territorial need for ecosystem protection. E**<br>This parameter tries to emphasise ecosystems with a variable value but situated in densely populated, and thus ecologically degraded areas. This parameter is measured by means of human population density calculate in Inh/ $Km^2$ for administrative provinces. | |
| 0.5 | From 1 to 4 |
| 0.7 | 4 to 19 |

| | |
|---|---|
| 0.9 | 20 to 39 |
| 1.1 | 40 to 59 |
| 1.3 | 60 to 79 |
| 1.5 | 80 to 99 |
| 1.7 | 100 to 129 |
| 1.9 | 130 to 199 |
| 2.1 | 200 to 299 |
| 2.3 | 300 to 599 |
| 2.5 | 600 or more |
| **7. Carbon Retention. CR** Different vegetation units' role in carbon retention is assessed, by means of the amount of biomass. In the case of forests, it is taken into account the maturity degree (carbon sink). | |
| 1 | Herbaceous communities. What it is produced is rapidly transformed into $CO_2$ by farm animals. (grazzed grasslands) |
| 1.2 | Timber production in meadows. Fruit trees (orchad) |
| 1.4 | Natural scrub, short term timber production (15 years) |
| 1.6 | Medium term timber production (35-40 years) or degraded or juvenile forests |
| 2 | Natural mature forest or long term timber production (80-100 y) |
| **8. Soil Protection. S** Plant community's role on soil protection is assessed: (root system substances retention capability, soil enrichment or genesis) | |
| 0.4 | Rural areas. Recently harvested area. No vegetation cover left. |
| 0.6 | Timber plantations using severe treatment (machinery, chemicals) on steep slope |
| 0.8 | Timber plantations using severe treatment (machinery, chemicals) on moderate slope |
| 0.9 | Seral scrub |
| 1 | Grassland and, meadows |
| 1.8 | degraded woodlands, juvenile woodlands |
| 2 | Broadleaf natural woodlands. |
| **9. Protection of Hydrological Resources. H** Assesses the hydrological value of a basin and its capacity of regulation and water purification. | |
| 0.4 | Rural areas. Wrong actions in timber harvesting activities (damage to river ecosystem) |
| 0.5 | Tree plantations using machinery and chemicals close to streams. Cattle-hut close to a stream. |
| 0.8 | Tree plantations using machinery and chemicals far apart from streams |
| 0.9 | Vegetable garden and other crops |
| 1 | Meadow, grasslands and scrub |
| 1.5 | Natural forest and woodlands |
| 2 | Riparian woodland |

**Conservation Interest (IC)**

The Conservation Interest (CI) becomes the final estimation which will be used by the land manager, attributing a numerical value to a particular area. Calculations involve determining the Biological Value (B), which is obtained by adding five parameters portraying biological properties of each of the mapped vegetation types plus the rarity:

$$B = N + P + T + F + R$$

Maximal score attained in terms of B by a given vegetation type or cartographic unit (CU) appearing within the mapped area would be 50. Additional descriptors such as E, RC S and H are included as factors so that the final formulation of the Conservation Interest (CI) becomes:

$$CI = B \times E \times RC \times S \times H$$

And since maximum value of E x RC x S x H is 20, highest ecological evaluation in terms of CIU would be 1000. A this point, to estimate total value of CI for a given (i) CU we would multiply $CI_i$ by its surface of coverage ($A_i$) so that Total Conservation Interest of the unit ($TCI_i$) can be calculated as:

$$TCIi = CIi \times Ai$$

Finally, to solve global CI for an area (GI) in which various CU´s are present, we should add up every $TCI_i$, and then

$$GI = \sum TCIi$$

By this procedure, we could reach total grades for the Conservation Interest of any area, providing a detailed knowledge of its plant communities as well as accurate vegetation maps are available.

**Payment for Environmental Services**

In order to guarantee social acceptance and, moreover, a desirable involvement of local rural population in nature conservation policies, financial resources have to be spent to avoid that charges and inconveniencies of protecting valuable habitats should become a burden to land owners. Several initiatives have been taken in various countries, as in Costa Rica (Orrantia, 2004; Saenz, 2000) consisting in variable amounts of money being paid to land owners on the grounds of environmental services offered by vegetation or ecosystems appearing in their properties. Such policies are developed under the concept of Payment for Environmental Services (PES), a tool which can be used by Administration to encourage rural population to preserve and improve the quality and extension of valuable ecosystems within their lands.

It becomes evident that an assessment method of either environmental or naturalistic quality of any territory is needed, and we propose the hitherto explained Conservation Interest (CI). From the numerical values on o to 1000 scale obtained for a particular landscape, we can deduce the economic reward for the landowner. Monitoring evolution of environmental services provided along time could be performed by regularly repeated evaluations (i.e. every 2 years).

Transformation of ecological value in terms of CI units into monetary units can be achieved by the following equation (Orrantia et al in press)

$$PES = K \times GI/(1 + \ln S)$$

Where:
K: constant
GI: Accumulated IC value of the surveyed property ($\sum$ TICi x Si)
Si: Surface occupied by the i mapped unit CU ($\sum$ Si = S) in hectares
S: total surface of the property in hectares
PES: Indicator of the Payment for Environmental Services to the land owner

Hence, PES would be into direct proportion to the obtained CI values accumulated on GI and thus, also proportional to the occupied areas. So, the larger a property, the higher PES would be (large state effect). Consequently, and in order to moderate this “large state effect”, GI appears corrected by natural logarithm of total extension of the property.

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