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Assessing the natural interest of the landscapes of Andorra, a mountain country under contrasted land use changes

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Abstract.- In this paper, we present a method for analysing the landscape, using the example of Andorra, through assessing the interest of the CORINE units recognised. The starting point was a map of habitats previously drawn at the 1:25,000 scale, on infrared orthoimages. It includes some 3,000 polygons, identified by 103 legend units based on the CORINE habitats. Diversity, naturalness, endemicity, rarity and other attributes of each habitat were evaluated *a priori* and then combined with site features (analysed through the GIS *ArcInfo*) to yield a global evaluation for each legend unit. This enabled us to produce a map showing a few levels of natural interest in the landscape of Andorra and to draw the attention to main tendencies of change, which are, when compared with similar neighbouring Pyrenean valleys, not so affected by human activity.

Key words : habitats - Andorra - Pyrenees - GIS - natural interest.

Résumé.- Au cours de ce travail, en prenant comme exemple la principauté d'Andorre, nous exposons une méthode qui permet l'analyse du paysage grâce à l'évaluation patrimoniale des unités identifiées. Nous avons utilisé comme base une carte des habitats CORINE préalablement dressée à l'échelle 1:25 000 sur ortho-images infrarouge. Cette carte contient environ 3 000 polygones, classés selon 130 unités basées sur les habitats CORINE. Nous avons évalué la diversité, le degré d'artificialisation, d'endémicité, de rareté, etc., de chaque habitat *a priori*, puis nous avons combiné ces aspects avec les paramètres locaux (analysés avec le SIG *ArcInfo*) dans le but d'obtenir une évaluation globale de chaque unité. Ceci nous a permis d'élaborer une cartographie graduant l'intérêt naturel du paysage andorran, ainsi que de mettre en évidence les principales tendances de changement grâce à la comparaison avec certaines vallées pyrénéennes proches et similaires, mais moins anthropisées.

Mots clés : habitats - Andorre - Pyrénées - SIG - intérêt naturel.

I. INTRODUCTION

In the field of landscape planning and conservation, the habitats CORINE defined for the European Union area (ECC, 1991) have become a milestone reference in the last decade. From the management perspective, these habitat definitions are very important in providing the standardisation of a comprehensive, precise typology, useful as reference in planning documents. In fact, the CORINE biotopes, or habitats, system arose as the basis for the conservation policies in the European Union; the areas included in Natura 2000 net are based on the occurrence, quality and singularity of the most interesting habitats (European Union Habitats) in them. A noticeable aspect of the habitats system is its biological basis, which may become very precisely defined, where the lower rank units are used. For a given habitat, this allows the assumption of the « quality » indexes of the biological communities which define it, referring to items such as diversity, endemicity and resilience. As the habitat definitions are generally based on higher plant communities, a good correlation may be assumed at least with edaphic components and with those communities depending on higher plants (fungi, insects, etc.).

Although Andorra is not part of the European Union, its geographic situation has led its environmental agencies to adopt methods and bases of information similar to those of CORINE and Natura 2000 net. This practice was clearly followed by « Centre de Biodiversitat », a non-government organisation for nature study and protection in Andorra, when commissioning a habitats map of that country. Based on the CORINE biotopes and following thematic mapping procedures, we have produced a detailed map of the habitats of Andorra, which we present and briefly discuss here.

A basic use of a habitats map is a general assessment of the landscape, which represents a first information step in any land planning. The handling of the map through a geographical information system (GIS) has enabled us to evaluate the mapped units from several points of view. Then, we assessed the whole landscape, taking into account general procedures in this field (Mallarach, 1999) and following a method applied in another Pyrenean area (Carrillo *et al.*, 2003). The particular situation of Andorra has led us to compare its landscape with that of similar Pyrenean valleys, albeit not subject to such striking changes. Therefore, we have evaluated the landscape of Vallferrera and Vall de Cardós in the same way, from an existing habitat map (DMA, 1998-2003), and have discussed the most interesting differences.

II. THE STUDY AREA

Andorra is a small country, ca. 468 km^2, located in the main range of the Pyrenees (Fig. 1). It corresponds roughly to the basin of the Valira river which, together with its tributaries, runs from north to south. The relief is generally abrupt, made by fluvial valleys bearing more or less steep slopes at medium altitudes and by typical glacial geoforms at the high mountain altitudes. Substrata correspond to diverse outcrops; acidic rocks (slate and granite) are the majority, whereas calcareous materials (calcschists) are relatively rare. Altitudes range from 840 to 2,942 m a.s.l., which produce strong bioclimatic and ecologic gradients.

The landscape of Andorra shows the typical zonation of the axial Pyrenees, including four vegetation belts. The lower altitudes correspond to the Submontane belt, where the relatively warm, dry climate favours Submediterranean oak forests, box scrubs, dry pas-

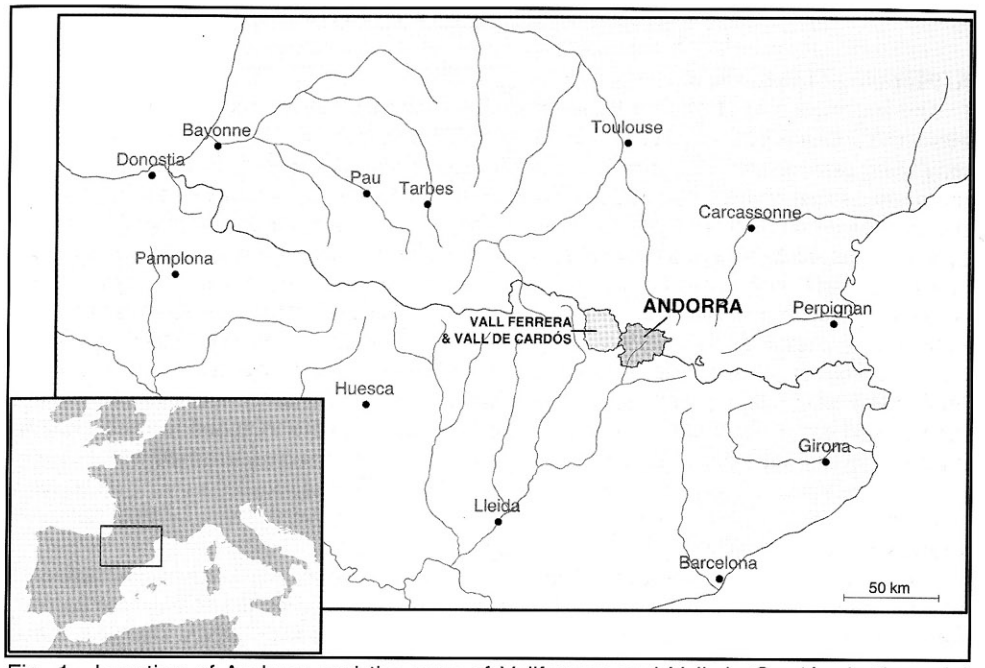

Fig. 1.- Location of Andorra and the area of Vallferrera and Vall de Cardós, in the axial Pyrenees.

Fig. 1.- Situation d'Andorre et de l'ensemble formé par Vallferrera et Vall de Cardós, dans les Pyrénées centrales.

tures and even noticeable Mediterranean units, such as sclerophyllous forests. The Montane belt is more diverse, due to its greater surface and also to topographic factors, climatic variations (from Submediterranean to Mountain Atlantic) and human impact; almost all the villages and towns, as well as fields, are included in it. Scotch pine woodlands, oak and mixed deciduous forests, pastures and mountain scrubs make most of the montane landscape. In the subalpine belt, mountain pine makes forest units on diverse substrata and aspects, accompanied by pastures and scrubs. In the alpine belt the typical short pastures occupy favourable soils, whereas communities of special sites make the most of the landscape, settling on scree, rocky areas, snow beds, lacustrine areas, etc.

The particular rules in Andorra, together with the good snow covering conditions in the high mountain of the country, have favoured a spectacular increase in trade activities and winter sports during the last decades. This has created a rapid increase of urban surfaces and infrastructures, sometimes in a rather uneven manner, which has caused drastic changes in land use.

III. MATERIAL AND METHOD

A. Mapping of the area

The starting point of this landscape study is a map of habitats based on the CORINE biotopes or habitats (ECC, 1991). This map was made from photointerpretation on infrared digital orthoimages at 1:20,000 scale (taken in 1997) and through intensive field work during the summers of 2000 and 2001. After validation of the map produced, including comparison with other cartographic sources (Folch *et al.*, 1979; Roquet *et al.*, 1997; Zwart, 1979), it was integrated as a coverage into a GIS (geographic information system) implemented on *ArcInfo*.

The legend units were taken from the list established in the cartographic project for Catalonia (Carreras & Diego, 1998; DMA, 1998-2003; Vigo & Carreras, 2003). Each unit is a main habitat in most cases (forests, fields, extensive scrubs or pastures) or a group of related habitats in the case of small surface-habitats which generally occur together. In the appendix, there is the final legend list, with the main habitats included in each unit. As mapping procedure, in each polygon up to three legend units were identified where appropriate.

B. Landscape evaluation

To assess the natural interest of the area considered, we previously evaluated each legend unit in terms of diversity, naturalness, vulnerability, etc. We have taken into account some proposals made from vegetation maps (Díaz & Fernández, 1997; Dumont, 1988; Loidi, 1994; Rameau & Bricault, 1988; Richard *et al.*, 1988; etc.), following a procedure already used in another Pyrenean area (Carrillo *et al.*, 2003). The particular interest of this method is in the use of some attributes of the legend units, which were obtained from the habitats map, through landscape analysis made by means of the GIS *ArcInfo*.

As shown in Table I, we selected 11 attributes which reflect the most outstanding aspects of each legend unit: 4 inherent attributes — naturalness, plant diversity, resilience and form of landscape covering —, 3 attributes expressing their biogeographical significance — endemicity, rarity within the Pyrenees and rarity within Andorra — and 4 other attributes produced from the GIS analysis — altitude range, exposure diversity, mean surface of the polygons and landscape density of polygons. These 4 attributes, which depend on the local landscape, give higher scores to a given unit, the more defined topography it inhabits in the area. All the attributes were ruled as corresponding indexes ranging from 1 to 4, as shown in Table I. A particular value was given for each attribute and for each legend unit, taking into account various information sources dealing with Pyrenean vegetation (Braun-Blanquet, 1948; Gruber, 1978; Folch *et al.*, 1979; Rivas-Martínez *et al.*, 1991; Carrillo & Ninot, 1992; Carreras, 1993; etc.). Where a legend unit includes more than one habitat, we gave one global value per attribute, according to the sharing of the habitats included.

All these attributes were then synthesised into a global interest value (GIV). Since we considered some of them to be a bit redundant, namely the couples f & g, h & i, and j & k, we used the formula:

$$GIV = \{a + b + c + d + e + [(f + g)/ 2] + [(h + i)/ 2] + [(j + k)/ 2]\}/8$$

This enabled us to produce a basic map of natural interest of the landscape of Andorra, in which the polygons showed the given GIV, as well as their specific vegetation contents.

Then, we introduced a threat factor, which would express the probability of disturbance of each legend unit, taking into account the singularity of the area studied. Therefore, we assumed that the most threatened landscape units in Andorra were fens, mires, alluvial forests and other systems related to superficial waters, because they always occupy reduced surfaces, which become altered by all the frequent hydrologic change. We evaluated this situation, giving to these units a coefficient of 1.5. Other units under medium threat got a coefficient of 1.2: snowbeds and chionophilous pastures (threatened by uprising ski facilities), Montane pastures (depending on traditional management), and forests typical of low, gentle slopes (vanishing due to growing urban areas). The rest of the legend units remained unchanged. The combination of GIV together with the potential threat factor gives a new value (global interest value with threat factor, GIVT), for each legend unit, ranging from 1 to 6, which may be used as the basis for a comprehensive map of interest of the landscape of Andorra.

Table I.- Attributes selected for evaluating the legend units, and values given.
Tableau I.- Attributs choisis pour évaluer les unités et valeurs qui leur ont été données.

Attributes	Values			
	1	2	3	4
a Naturalness	very low (field, ruderal vegetation, urban areas)	low (montane and subalpine pastures)	medium (degradated forests, secondary scrubs, birch forests)	high (forests and other potential communities)
b Plant diversity (species richness, combined with equitability)	very low (rocks, scree, fields)	low (calcifuge pastures, scrubs, snow beds)	medium (coniferous or oak forests, alpine pastures)	high (mixed forests, rich pastures)
c Resilience	high	medium	low	very low
d Form of landscape covering: surfaces	large, non fragmented	medium, rather fragmented	small, rather fragmented; or medium, fragmented	small, fragmented
e Endemicity (chorological interest of the unit)	very low (subcosmopolitan)	low (late-Pyrenean)	medium (Pyrenees + related mountains)	high (endemic of the Pyrenees)
f Rarity in the Pyrenees	very common	common	rare	very rare
g Rarity in Andorra	very common	common	rare	very rare
h Altitude range	high: > 900 m	medium: 600-900 m	low: 300-600 m	very low: < 300 m
i Exposure diversity*	high: 0.86-0.88	medium: 0.8-0.85	low: 0.6-0.79	very low: < 0.59
j Density of polygons (pol./100 ha)	high: 0.300-1.255	medium: 0.050-0.299	low: 0.010-0.049	very low: < 0.09
k Mean size of the polygons	large: > 50 ha	medium: 15-50 ha	small: 5-14 ha	very small: < 5 ha

* Calculated according to the diversity/uniformity index of Simpson (McGarigall & Marks, 1994).

IV RESULTS AND DISCUSSION

A. The landscape of Andorra

The map produced includes 3,340 polygons, each identified by 1, 2 or 3 legend units, with an evaluation of their sharing ratio (Ninot *et al.*, 2002). The legend is formed by 103

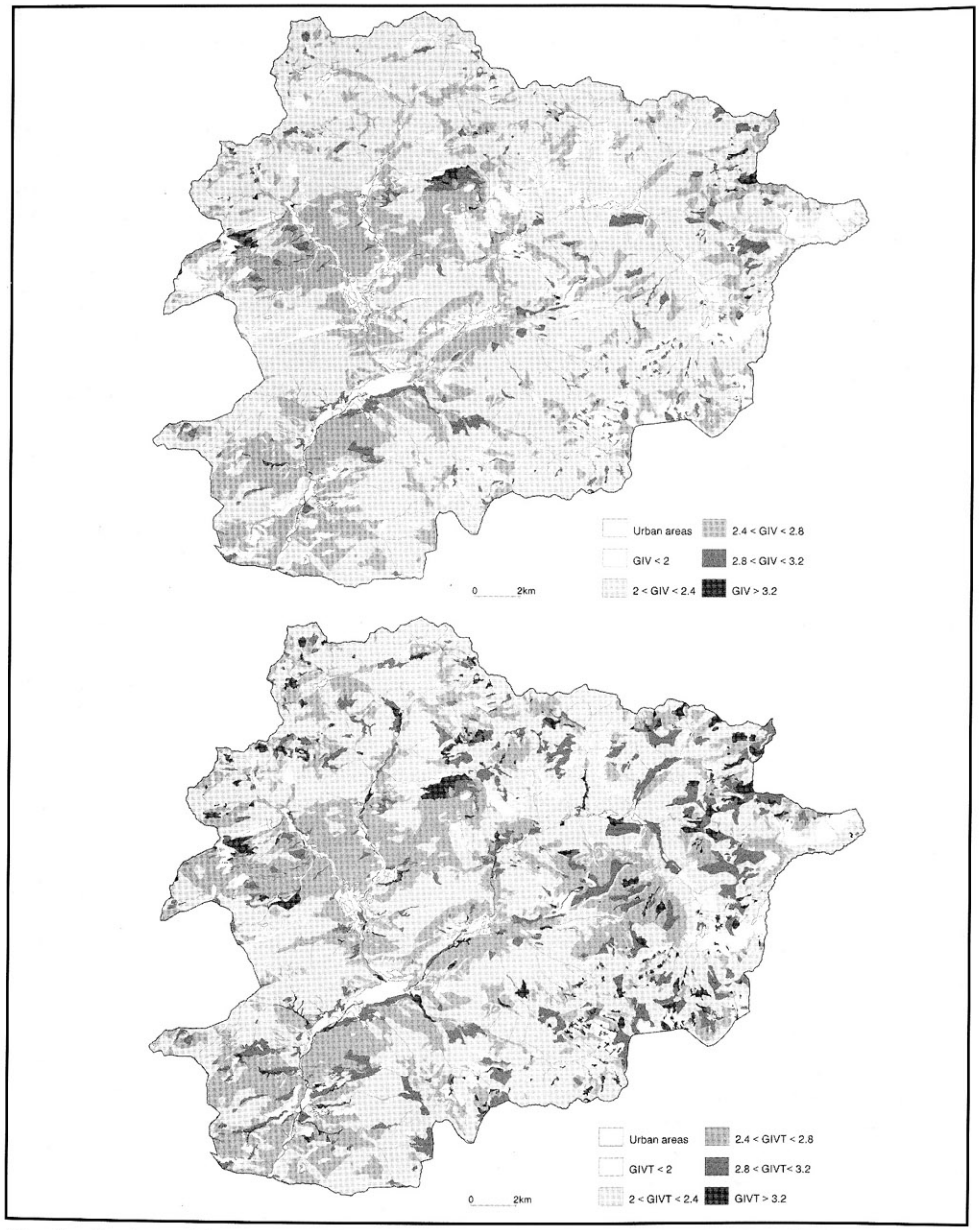

Fig. 2.- Cartographic covers of Andorra, showing the global interest value (GIV) of the habitats mapped (upper) and these indexes modified by means of the threat coefficient (GIVT) of each one (lower). More detailed version in Centre de Biodiversitat-IEA (2003).
Fig. 2.- Couvertures cartographiques d'Andorre, qui montrent la valeur globale d'intérêt (GIV) des habitats cartographiés (en haut) et ces valeurs modifiées par le coefficient probable de perturbation (GIVT) de chacun (en bas). Plus de détails *in* Centre de Biodiversitat-IEA (2003).

units, corresponding to 175 habitats (see the Appendix). Thus, the most simple polygons contain a sole legend unit which in most cases is formed by a sole habitat unit; whereas, others may contain a combination of 3 legend units, each one including a group of related habitats, which occurs in the most abrupt surfaces, or in lacustrine complexes.

The most represented habitat types in Andorra are forests, which account for 39% of the area. Since 43.4% of the country is situated above 2,200 m a.s.l. (the general altitude at which big forests stop), montane and subalpine belts are vastly forested. Among the forests, coniferous woodland (*Pinus sylvestris, P. uncinata* and *Abies alba* forests) represents more than 91% of them. The calciphugue, mesophilous *Pinus uncinata* forest (habitat 42.413) is the most extense habitat in the country (5,567 ha, 11.9% of the total surface). Grasslands and fens occupy 31.4% of Andorra and rocks and screes account for 17.3%. At low altitudes, the landscape is more diverse and fragmented, in part due to human activities. Here are concentrated the majority of urban areas and crops (which represent together 3% of the area). The remaining 9.2% correspond to scrubs and standing and running waters.

This habitats map, as well as its legend and numerical appendixes, may be consulted under digital format (Centre de Biodiversitat-IEA 2003, *http://www.sigma.ad*).

B. Territorial assessment

The values given to each legend unit and the corresponding global values are shown in the Appendix. The implementation of them on the map of habitats is expressed in the map of Figure 2, upper, where the polygons are grouped into grey intensities, according to a few levels of natural interest. This points out that higher values of interest coincide, for the larger part, with three landscape units: i) calcareous outcrops (occuring in the middle-west and in the south-west parts of the country), with a high concentration of rare, diverse and endemic habitats; ii) low altitude bottoms of the main valleys, where mixed forests, mesohygrophilous forests, and alluvial forests occur; iii) some small, sparse areas in the high mountain zone, where coincide lakes, dwarf heaths and scrubs, tall herb communities, snow-patch communities, fens, etc.

The polygons under potential threat in Andorra draw a particular pattern (not shown), in which the areas standing out correspond to the high mountain snow lasting areas, the gentle slopes at low or moderate altitudes and a system of riparian stripes. The index of potential threat produces noticeable modifications on the combined index (GIVT), shown in the lower part of Figure 2. The most evident are the rising values exhibited by some high mountain areas, where interesting habitats coincide with good snow coverage, and are thus liable to suffer from snow sports infrastructures. A similar combination occurs along the riparian areas, in which high values of GIV coincide with other types of urban pressure.

The landscape evaluation obtained may serve the public bodies of Andorra as a useful tool in basic planning. It shows the main tendencies, both of interest and of threat, which should be taken into account for management purposes, such as delimitation of preserved areas, design of infrastructures, and general land planning.

However, it should be taken into account that such evaluation is based only on the mapped habitats, *i.e.* those occupying medium sized to large surfaces. Although small sized habitats add interesting biodiversity to most landscapes, they have not been truly included here, since not mapped due to the scale used. This fact, and also several aspects not evenly related to habitats (communication infrastructures, ski resorts, even faunistic particularities at large scale) should be further incorporated into a comprehensive evaluation for any particular purpose.

Table II.- Comparison of the percentages in Andorra and in Vallferrera and Vall de Cardós of some units. Whereas the most extended show very similar percentages in both areas, the differences in land use are expressed by a few small units.
Tableau II.- Comparaison des pourcentages de certaines unités en Andorre, et à Vallferrera et à Vall de Cardós. Les unités les plus répandues montrent des pourcentages très semblables, tandis que les différences liées à la gestion du territoire sont montrées par des unités à surface réduite.

Units mapped	Andorra	Vallf. & Cardós	Ratio
Most extensive and coincident units			
Calcifuge, mesophilous *Pinus sylvestris* forests	3,192	3,092	1,032
Calcifuge, mesophilous *Pinus uncinata* forests	11,904	11,275	1,056
Rhododendron ferrugineum heaths	4,061	3,672	1,106
Siliceous mountain cliffs	5,81	5,201	1,117
Artificial units produced by human activity			
Urbanised areas with semi-natural vegetation	0,259	-	-
Quarries and similar exploitations	0,052	-	-
Reclaimed areas	0,764	-	-
Urban and industrial areas	1,598	0,099	16,141
Deciduous montane forests			
Mesohygrophilous mixed forests with *Quercus petraea*	0,023	1,423	0,016
Mesophilous *Quercus petraea* forests	0,123	3,57	0,034
Calcifuge *Quercus pubescens* forests	0,416	1,772	0,235
Alnus glutinosa forests	0,01	0,089	0,112
Mesohygrophilous *Corylus avellana* thickets	0,133	0,392	0,339
Fields and other exploited areas			
Low altitude hay meadows	0,676	2,408	0,281
Extensive herbaceous fields	1,799	0,062	29,016
Abandoned fields	0,022	0,012	1,833
Woodlands severely cleared	0,111	0,538	0,206
Xerophilous mountain forests			
Calcifuge, xerophilous *Pinus uncinata* forests	6,959	5,009	1,389
Calcifuge, xerophilous *Pinus sylvestris* forests	4,488	2,071	2,167
Secondary dry heaths and pastures			
Montane *Genista balansae* heaths	0,417	7,428	0,056
High mountain *Genista balansae* heaths	0,5	5,941	0,084
Calcifuge, semi-dry grasslands with *Agrostis capillaris*	0,514	1,953	0,263

C. Some tendencies in the landscape evolution

The landscape of Andorra reflects the particular management of this country, in which urban activity and snow sports, together with allied facilities, have been on the increase for some decades. In a parallel way, traditional land use has been strongly decreasing, mainly through pasture abandonment and low forest exploitation. These tendencies and their results, although general in the Pyrenees, clearly differentiate Andorra from the neighbouring valleys, at least those on the south facing side of the range. Thus, a comparison between the landscape of these valleys and that of Andorra may be used to outline the particular tendencies of Andorra, assuming the neighbouring areas may be taken as representative of its « previous situation ».

We take as a comparison subject the area of neighbouring Vallferrera and Vall de Cardós. It accounts for 409 sq. km and is very similar to Andorra in altitude range, geomorphic structure, and vegetation units. The data were obtained from the cartography of habitats done in Catalonia (DMA 1998-2003: sheets 150 and 182). The first aspect to be commented on is the strong surface similarity between Andorra and Vallferrera and Vall de Cardós area in the most extensive units: mesophilous *Pinus uncinata* forests, mesophilous *Pinus sylvestris* forests, *Rhododendron* scrubs, and acidic high mountain rocks, occupy almost the same surface in both the areas, accounting for about 23-25% of the landscape. As for the differences evidenced by other units, their causes may be grouped into four main aspects:

i) differences in substrata composition; since no calcareous rocks occur in Vallferrera & Vall de Cardós, calcicolous units indicate a noticeable difference - about 20 calcicolous units present in Andorra and not in Vallferrera and Vall de Cardós;

ii) a different situation in the Pyrenean range of the compared areas; there is a greater presence in Andorra of eastern Pyrenean units and of Atlantic units (occurring mainly in the north-eastern part of the area, open to the Ariège); there are some units related to Central Pyrenees in Vallferrera & Vall de Cardós;

iii) methodological differences between the maps compared; due to the more detailed cartography done in Andorra, about 15 units were mapped there, such as alpine dwarf shrubs, clearings, or tall herb communities, which were not mapped in Vallferera and Vall de Cardós;

iv) different land use.

Table II shows the most interesting differences in the landscape percentages related to land use. In the particular regime of Andorra, the most direct effect on the landscape is the greater urban surfaces, which reflect from relatively small figures a great difference: the scarce 900 inhabitants of Vallferrera and Vall de Cardós are dramatically surpassed by the 70,000 of Andorra. As counterpart consequently, the deciduous forests (oak forests, mixed forests, etc.), which in these Pyrenean valleys occupy gentle, low slopes, are less extensive in Andorra, where they have, at least in part, been replaced by urban facilities. As for the cultivated areas, most of the fields in Vallferrera and Vall de Cardós are used as hay meadows, whereas the remaining fields in Andorra are mainly used for growing tobacco, not allowed by Spanish rules.

As for to mountain forests, although most of the communities show similar extension in both the areas considered, the xerophilous pine forests (both of *Pinus sylvestris* and *P. uncinata*), occupying south facing slopes, are more extensive in Andorra. Among the units able to occupy these dry aspects, some serial scrubs (*Genista balansae* heaths, etc.) are clearly more abundant in Vallferrera and Vall de Cardós. Since south facing areas have been traditionally used as pasture range in the montane and subalpine belts of the Pyrenees, this may be taken as an indication of spontaneous afforestation, which would maintain Vallferrera and Vall de Cardós in a more immature situation, since extensive pasture and occasional burning still play an important role. Forest exploitation is apparently only residual in Andorra, whereas it is still occurring in the neighbouring valleys, where there are a number of severely cut woodland areas.

Another aspect revealed is the greater surface used by snow sports in Andorra. Although not very big in terms of hectares, it should be recognised that this land use implies severe damage in alpine systems, which includes substrate moving (with subsequent low plant colonisation and irreversible loss of soil) and the introduction of allochthonous plants for reclamation.

REFERENCES

Braun-Blanquet J., 1948.- La végétation alpine des Pyrenées Orientales. *Mon. Est. Est. Pir. e Inst. Esp. Edaf. Ecol. Fisiol. Veg.*, **9**, 1-306.

Carreras J., 1993.- Flora i vegetació de Sant Joan de l'Erm i de la vall de Santa Magdalena (Pirineus catalans). Institut d'Estudis Ilerdencs. *Col. Estudis*, **3**. Lleida, 321 p.

Carreras J. & F. Diego, 1998.- *Projecte de la cartografia dels hàbitats a Catalunya.* Dept. Medi Ambient de la Generalitat de Catalunya & Univ. Barcelona. Unpublished report.

Carrillo E., A. Ferré, G. Granier & J.M. Ninot, 2003.- Evaluación del interés natural del Parque Nacional de Aigüestortes i Estany de Sant Maurici a partir de la cartografía de hábitats CORINE. *Acta Bot. Barc.*, **49**, 357-374.

Carrillo E. & J.M. Ninot, 1992.- Flora i vegetació de les valls d'Espot i de Boí. *Arxius Sec. Cièn.*, **99** (1-2), 1-474, 1-350.

Centre de Biodiversitat-IEA, 2003.- *Mapa digital dels hàbitats d'Andorra 1:25.000.* Centre de Biodiversitat - Institut d'Estudis Andorrans (ed.), Andorra. CD-Rom & *http://www.sigma.ad.*

DMA (Departament de Medi Ambient) 1998-2003.- Cartografia d'hàbitats 1:50.000. Generalitat de Catalunya. *http://www.gencat.net/mediamb/pn/2chabitats-2.htm*

Díaz T.E. & J.A. Fernández, 1997.– Un nuevo método para la evaluación de la cubierta vegetal de un territorio. *Coll. Phytosoc.*, **27**, 727-739.

Dumont J.M., 1988.- La conception, la réalisation et l'utilisation de la carte d'évaluation biologique de la Belgique. *Coll. Phytosoc.*, **15**, 117-126.

ECC (European Communities Comission) 1991.- *CORINE biotopes manual, a method to identify and describe consistently sites of major importance for nature conservation.* Office for Official Publications of the European Communities, Luxembourg, 300 p.

Folch R. *et al.*, 1979.- *El patrimoni natural d'Andorra. Els sistemes naturals d'Andorra i llur utilització.* Ketres editora, Barcelona, 446 p.

Gruber M., 1978.- *La végétation des Pyrénées ariégeoises et catalanes occidentales.* Thèse d'État, Université Aix-Marseille III, 305 p + 60 tb.

Loidi J., 1994.- Phytosociology applied to nature conservation and land management. *In: Applied Vegetation Ecology.* Y. Song, H. Dierschke & X. Wang (eds.), Proceed 35th Symposium IAVS. Shangai, East China, Normal Univ. Press, 17-30.

Mallarach J.M., 1999.- *Criteris i mètodes d'avaluació del patrimoni natural.* Documents del Quaderns de medi ambient 2. Dept. Medi Ambient, Generalitat de Catalunya, Barcelona, 106 p.

McGarigal K. & B. Marks, 1994.- *FRAGSTATS. Spatial pattern analysis program for quantifying landscape structure.* Forest Science Department, Oregon State University.

Ninot J.M., J. Carreras, E. Carrillo & A. Ferré, 2002.- El mapa d'hàbitats d'Andorra. *Hàbitats*, **4**, 16-27.

Rameau J.C. & Ph. Bricault, 1988.- Phytosociologie et protection des milieux forestiers. Exemple des plateaux calcaires du nord-est de la France. *Coll. Phytosoc.*, **15**, 35-64.

Richard L., S. Arquillière, J.M. Dorioz, P.H. Guillot & J.P. Party, 1988.- Les groupements végétaux indicateurs de sensibilité ; application aux études d'impact en montagne. *Coll. Phytosoc.*, **15**, 127-155.

Rivas-Martínez S., J.C. Báscones, T.E. Díaz, F. Fernández-González & J. Loidi, 1991.- Vegetación del Pirineo occidental y Navarra. *Itinera Geobotanica*, **5**, 5-455.

Roquet P. *et al.*, 1997.- *Mapa forestal del Principat d'Andorra.* Govern d'Andorra, Dept. de Medi Ambient, Andorra.

Vigo J. & J. Carreras, 2003.- Los hábitats del proyecto CORINE en el ámbito territorial catalán: delimitación y cartografía. *Acta Bot. Barc.*, **49**, 401-420.

Zwart H.J., 1979.- The geology of the Central Pyrenees. *Leidse Geologische Meded.*, **50**, 1-74 + 10 maps.

Appendix. Values given to each legend unit (with the most outstanding CORINE codes specified where appropriate). a, naturalness; b, diversity; c, resilience; d, form of landscape covering; e, endemicity; f, rarity within the Pyrenees; g, rarity within Andorra; h, altitude range; i, exposure diversity; j, density of polygons; k, mean size of polygons; GIV, global interest value; t, threat coefficient; GIVT, modified GIV throught. The complete definitions of the habitats are available in *http://www.gencat.net/mediamb/pn/2habitats-llista.pdf*

Annexe. Valeurs données à chaque unité (qui est identifiée par les codes CORINE). a, degré d'artificialisation ; b, diversité ; c, résilience ; d, recouvrement dans le paysage ; e, endémicité ; f, rareté dans les Pyrénées ; g, rareté en Andorre ; h, intervalle d'altitude ; i, diversité d'exposition ; j, densité des polygones ; k, grandeur moyenne des polygones ; GIV, index de valeur globale d'intérêt ; t, coefficient de menace ; GIVT, valeur modifiée par t.

Legend units	a	b	c	d	e	f	g	h	i	j	k	GVI	t	GVIT
High mountain lakes and ponds	4	2	4	3	3	3	3	3	4	1	4	3,111	1,5	4,667
Low altitude lakes and reservoirs	4	2	4	3	2	3	3	4	4	4	2	3,111	1,5	4,667
Margins and beds of rivers, devoid of woody vegetation 24.3, 24.5)	3	1	1	3	1	2	2	3	4	3	1	2,056	1,5	3,083
Calluna vulgaris heaths (31.2261)	2	2	2	2	3	2	2	2	3	2	2	2,167	1	2,167
Dwarf heaths of *Loiseleuria procumbens* (31.411)	4	2	4	4	3	4	3	4	3	2	3	3,333	1	3,333
Dwarf heaths of *Vaccinium* spp. (31.412)	4	3	3	3	3	3	3	3	3	2	3	3,056	1	3,056
Rhododendron ferrugineum heaths (31.42)	3	2	3	1	3	2	2	2	3	1	2	2,222	1,2	2,667
Dwarf scrubs of *Juniperus nana* (31.431)	3	2	3	2	3	3	3	3	2	1	3	2,611	1	2,611
Dwarf heaths of *Empetrum hermaphroditum* (31.44)	4	2	4	4	3	4	4	4	3	4	3	3,556	1,2	4,267
Dwarf scrubs of *Arctostaphylos uva-ursi* (31.471)	3	2	2	2	3	2	3	2	3	2	2	2,389	1	2,389
Dwarf scrubs of *Dryas octopetala, Salix pyrenaica,* etc. (31.491, 31.6214)	4	3	2,5	4	3,5	3	4	2	3	2	3	3,222	1	3,222
Salix bicolor scrubs with tall herb communities (31.6215)	4	3	3	4	3	4	4	4	4	4	4	3,667	1,5	5,500
Thickets of *Prunus spinosa, Rubus* spp., etc. (31.8122, 31.82)	3	2	1	4	2	2	3	3	3	3	3	2,556	1,2	3,067
Thickets of *Amelanchier ovalis, Buxus sempervirens,* etc. (31.8123)	3	2	1	2	2	3	3	3	3	2	3	2,389	1	2,389
Montane *Genista balansae* heaths (31.84221)	2	2	1	1	4	2	2	3	3	2	1	2,056	1	2,056
High mountain *Genista balansae* heaths (31.84222)	2	2	1	2	4	2	3	3	3	2	2	2,333	1	2,333
Woodland clearings with *Rubus idaeus, Salix caprea,* etc (31.8711, 31.872)	3	2	1	3	2	2	2	3	3	3	3	2,333	1	2,333
Juniperus communis scrubs (31.881)	2	2	1	2	2	3	3	3	4	3	3	2,389	1	2,389
Mesohygrophilous *Corylus avellana* thickets (31.8C1)	3	4	3	2	2	2	3	3	2	3	2	2,667	1	2,667
Mesoxerophilous *Corylus avellana* thickets (31.8C3)	3	4	2	2	2	2	3	3	2	2	3	2,556	1	2,556
Early colonising stages of mixed deciduous trees (31.8D)	3	4	2	2	2	2	3	2	2	2	2	2,444	1	2,444
Juniperus phoenicea scrubs (32.1321)	4	2	3	3	2	3	3	3	4	3	3	2,944	1	2,944
Genista scorpius scrubs (32.4811)	2	2	1	2	1	2	3	3	3	3	3	2,111	1	2,111
Buxus sempervirens thickets (32.641)	2	2	2	1	2	1	3	2	2	2	2	1,889	1	1,889
Calcicolous, semi-dry grasslands with *Bromus erectus* (34.32611)	2	4	2	1	3	1	3	2	2	2	2	2,222	1,2	2,667
Calcicolous, very dry grasslands with *Festuca ovina* (34.332G1)	2	4	2	1	4	2	2	2	3	1	2	2,333	1,2	2,800
Calcicolous, dry grasslands with *Festuca spadicea* (34.32613)	2	4	2	3	4	3	4	4	4	4	3	3,278	1,2	3,933
Calcicolous, dry grasslands with *Astragalus catalaunicus* (34.32614)	2	4	2	2	4	3	4	4	3	4	2	3,056	1	3,056
Calcicolous, dry grasslands with *Anthyllis montana* (34.7133)	3	4	2	3	3	3	3	3	4	2	3	3,000	1	3,000
Calcifuge, semi-dry grasslands with *Agrostis capillaris* (35.122)	2	4	2	1	3	2		2	2	1	2	1,944	1,2	2,333
Calcifuge, very dry graslands of therophytes (35.21)	2	2	1	3	2	3	4	4	4	4	4	2,778	1	2,778
Calcifuge, very dry graslands of *Festuca ovina* (35.81)	2	4	2	2	4	2	3	2	3	2	2	2,611	1,2	3,133

Calcifuge snow-patch communities (36.111)	4	2	4	4	3,5	4	3	3	1	1	3	3,167	1,5	4,750
Calcicolous snow-patch communities (36.122)	4	3	3	4	3,5	3	4	3	4	3	3	3,444	1,5	5,167
Mesophilous *Nardus stricta* grasslands (36.311, 36.315)	2	2	1	1,5	3,5	1,5	1	2	1	1	2	1,722	1	1,722
Hygrophilous *Nardus stricta* grasslands (36.312)	4	2	3	3	4	2	3	3	1	2	3	2,833	1,2	3,400
Dense *Festuca eskia* grasslands (36.314)	4	2	2	1	4	2	2	3	1	1	1	2,222	1,2	2,667
Festuca paniculata grasslands (36.3311)	3	4	2	3	3	2	3	2	3	2	2	2,722	1	2,722
Open, striped *Festuca eskia* grasslands (36.332)	4	2	2	1	4	1	1	1	3	1	2	2,056	1	2,056
Carex curvula short grasslands (36.341)	4	3	4	4	3,5	3	4	3	1	2	3	3,333	1,2	4,000
Festuca airoides short grasslands (36.343)	4	3	3,5	3	4	2	1	3	1	1	1	2,611	1,2	3,133
Dense, calcicolous grasslands with *Trifolium thalii* (36.4142)	4	3	4	3	4	2	4	3	3	3	2	3,278	1,2	3,933
Kobresia myosuroides short grasslands (36.422)	4	3	4	3	4	3	4	3	2	2	3	3,333	1,2	4,000
Open, striped *Festuca gautieri* grasslands (36.434)	4	3	2	2	4	1	2	3	3	2	1	2,500	1	2,500
Montane humid, tall grasslands (37.1, 37.2, 37.3)	3	3	3	4	2	3	3	3	4	3	3	3,056	1,5	4,583
Subalpine, hygrophilous tall herb communities (37.83)	4	2	3	4	3,5	3	3	4	2	3	4	3,222	1	3,222
Subalpine, nitrophilous tall herb communities (37.88)	1	1	1	4	3	2	3	3	3	3	4	2,389	1,2	2,867
Low altitude hay meadows (38.23)	1	4	2	3	1	1	2	3	1	2	2	2,000	1,5	3,000
Montane and Subalpine hay meadows (38.3, 36.51)	1	4	2	3	3	2	3	3	1	2	1	2,389	1,5	3,583
Fraxinus excelsior forests (41.33)	4	4	2	3	3	1	2	3	1	2	3	2,611	1,5	3,917
Mixed forests of ravines and slopes (41.44)	4	4	3	4	4	4	4	4	3	4	1	3,667	1,5	5,500
Mesophilous *Quercus petraea* forests (41.5611)	4	3	2	2	3	2	3	3	4	2	3	2,778	1	2,778
Mesohygrophilous mixed forests with *Quercus petraea* (41.5612)	4	3	2	2	4	3	4	2	3	3	3	3,056	1	3,056
Calcicolous *Quercus pubescens* forests (41.7131)	4	3	2	2	2	2	4	3	2	3	3	2,722	1	2,722
Calcifuge *Quercus pubescens* forests (41.7132)	4	4	3	2	3	2	3	3	3	2	1	2,833	1	2,833
Secondary *Betula pendula* forests (41.B332)	3	3	2	1	4	2	2	2	3	1	2	2,333	1	2,333
Mesohygrophilous *Betula* spp. forests with tall herb communities (41.B333)	4	3	3	3	4	4	4	4	4	4	3	3,611	1	3,611
Populus tremula forests (41.D3, 41.D4)	3	2	1	3	3	3	3	3	4	3	3	2,722	1	2,722
Abies alba forests with *Pyrola chlorantha* (42.113, 42.132)	4	3	3	1,5	4	3	4	3	4	3	2	3,167	1	3,167
Abies alba forests with *Rhododendron ferrugineum* (42.1331)	4	2	3	2	4	4	4	3	4	3	1	3,167	1	3,167
Calcifuge, mesophilous *Pinus uncinata* forests (42.413)	4	2	3	1	4	1	1	2	3	1	1	2,167	1	2,167
Calcifuge, xerophilous *Pinus uncinata* forests (42.4241)	4	2	3	1	4	2	1	3	2	1	1	2,278	1	2,278
Calcicolous, xerophilous *Pinus uncinata* forests (42.4242)	4	2	3	2	4	2	3	3	2	2	1	2,667	1	2,667
Calcicolous, mesophilous *Pinus uncinata* forests (42.425)	4	3	3	2	4	3	3	3	3	2	2	3,000	1	3,000
Pinus uncinata stands devoid of forest understorey (42.43)	1	1	1	1	1	3	4	4	2	3	2	1,944	1	1,944
Calcicolous, mesophilous *Pinus sylvestris* forests (42.561)	4	3	3	1	4	2	3	3	2	2	1	2,667	1	2,667
Calcifuge, mesophilous *Pinus sylvestris* forests (42.562)	4	3	3	1	4	2	2	2	3	1	1	2,500	1	2,500
Calcicolous, xerophilous *Pinus sylvestris* forests (42.5921)	4	3	3	1	4	2	2	2	2	1	1	2,444	1	2,444
Neutrobasophilous, mesophilous *Pinus sylvestris* forests (42.5922)	4	3	3	1	3	2	3	3	3	2	1	2,611	1	2,611
Calcifuge, xerophilous *Pinus sylvestris* forests (42.5B11)	4	2	3	1	4	2	1	2	2	1	1	2,222	1	2,222
Pinus sylvestris stands devoid of forest understorey (42.5E)	1	1	2	1	1	1	4	4	3	4	2	1,944	1	1,944
Mixed *Abies alba* and *Pinus uncinata* forests (42.B1)	4	3	3	2	4	2	2	3	3	2	1	2,722	1	2,722
Mixed *Abies alba* and *Pinus sylvestris* forests (42.B2)	4	3	2	2	4	2	2	3	4	2	1	2,667	1	2,667
Mixed *Pinus sylvestris* and *Pinus nigra* subsp. *salzmannii* forests (42.B3)	4	3	1	2	2	2	4	4	3	4	2	2,722	1	2,722
Other mixed coniferous forests (42.B5)	4	3	1	2	1	3	4	4	4	4	3	2,833	1	2,833

Calcicolous mixed *Quercus pubescens* and *Pinus sylvestris* forests (43.7131)	3	3	2	2	2	2	3	4	4	4	3	2,722	1	2,722
Calcifuge mixed *Quercus pubescens* and *Pinus sylvestris* forests (43.7132)	3	3	2	2	2	2	3	3	3	3	2	2,500	1	2,500
Other mixed forests of deciduous and coniferous trees (43.H)	3	3	2	2	1	2	3	3	2	2	2	2,278	1	2,278
Willow thickets and allied communities (44.124, 24.224)	4	3	2	3	2	3	3	3	3	3	3	2,889	1,5	4,333
Alnus glutinosa forests (44.3431)	4	4	2	4	4	3	4	3	2	4	4	3,500	1,5	5,250
Mixed *Quercus rotundifolia* and *Q.* xcerrioides or *Q. pubescens* forests (45.3416)	4	3	2	2	3	3	3	4	2	3	2	2,833	1	2,833
Quercus rotundifolia sclerophyllous forests (45.3415)	4	2	2	2	4	2	2	3	3	2	1	2,500	1	2,500
Mixed *Quercus rotundifolia* and *Pinus sylvestris* forests (45.3417)	4	2	2	2	3	2	3	3	3	3	1	2,556	1	2,556
Alcaline fens with *Carex davalliana* (54.24)	4	3	3	4	4	4	4	4	4	4	4	3,778	1,5	5,667
Acidophilous fens with *Carex fusca* (54.424, 54.452)	4	2	3,7	4	4	3	3	3	1	1	4	3,133	1,5	4,700
Pinus uncinata bog forests (44.A3)	4	3	4	4	3	4	4	3	3	4	3	3,611	1,5	5,417
Siliceous montane screes (61.12)	4	1	2	2	1	3	3	2	1	2	2	2,167	1	2,167
Siliceous high mountain screes (61.33, 61.37)	4	1	3	2	3	2	1	1	1	1	2	2,056	1	2,056
Calcareous high mountain screes (61.341)	4	2	3	2	4	2	3	2	2	2	2	2,667	1	2,667
Calcareous badlands with sparse vegetation (61.51)	4	1	2	3	1	3	4	4	4	4	4	2,889	1	2,889
Calcareous mountain cliffs (62.12)	4	2	4	3	4	2	3	1	2	1	3	2,833	1	2,833
Siliceous mountain cliffs (62.211)	4	1	2	3	3	2	2	1	1	1	2	2,167	1	2,167
Flat outcrops with sparse communities (62.3, 36.2)	4	2	3	4	2	4	4	3	3	3	3	3,222	1	3,222
Extensive herbaceous fields (82.3)	1	2	1	2	1	1	2	2	1	1	2	1,444	1,2	1,733
Populus sp. plantations (83.321)	2	1	2	2	1	4	4	4	3	4	3	2,556	1	2,556
Urban and industrial areas (86)	-	-	-	-	-	-	-	2	1	1	2	-	1	-
Urbanised areas with semi-natural vegetation	-	-	-	-	-	-	-	2	1	2	2	-	1	-
Quarries and similar exploitations (86.4)	1	1	1	4	1	3	4	2	3	3	3	2,278	1	2,278
Reclaimed areas (86.7)	1	1	2	2	1	3	2	2	2	2	1	1,722	1	1,722
Abandoned fields (87.1)	1	2	1	2	1	2	3	4	2	3	3	2,000	1	2,000
Woodlands severely cleared	3	3	2	4	1	2	4	4	4	4	1	2,833	1	2,833
Woodlands recently burnt	2	3	2	3	1	3	4	4	3	4	3	2,778	1	2,778
Woodlands recently destroyed by avalanches	3	3	2	3	1	3	3	3	3	3	2	2,611	1	2,611

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