Géomorphologie : relief, processus , environnement, 2005, n° 3, p. 197-208

Assessment of geomorphosites in natural protected areas: the Picos de Europa National Park (Spain)

Évaluation des géomorphosites dans les espaces naturels protégés : le Parc National des Picos de Europa (Espagne)

Enrique Serrano*, Juan José González-Trueba**

Abstract

The study area, located in the Cantabrian Range in northern Spain, was the first area of Spain to be declared a National Park. The landscape is characterised by glacial and karstic landforms, an elevated mountain environment with an oceanic climate, a high level of human use, and environmental changes induced by mining and tourism. The aim of this study is to develop a methodology for the assessment of geomorphosites that could be applied to natural protected areas at the local scale. It focusses on providing an inventory of geomorphosites and a natural and cultural assessment for their management. The methodology is based on the realisation of a geomorphological map in order to identify landforms, processes and reconstruct landscape evolution. Using the detailed geomorphological map as the basic document, descriptive and analytical cards were realised for each selected site. The cards include the most important features defining the unit: morphostructures, bedrock, landforms, observed dynamics, singular elements, management, past human and cultural features, natural fragility, current land uses and cultural values, and unit vulnerability. The assessment cards also specify the three assessment scoring criteria: scientific value, cultural value and use value. In this study, twenty-two geomorphosites of different sizes and categories were selected, classified and assessed. The geomorphosites are classified and compared, and potential uses are proposed according to conservation priorities.

Key words: geomorphosite assessment, geomorphic heritage, Picos de Europa National Park, Spain.

Résumé

Le Parc National des Picos de Europa, situé dans la Cordillère cantabrique dans le nord de l'Espagne, est le plus ancien parc national du pays. Le paysage est caractérisé par des formes glaciaires et karstiques dans un environnement de haute montagne humide, qui subit des conditions climatiques océaniques et des changements environnementaux induits par les activités minières et touristiques. Cette étude a pour but de développer une méthode d'évaluation des géomorphosites applicable à des espaces naturels protégés à une échelle locale. Elle vise à fournir un inventaire, ainsi qu'une évaluation naturelle et culturelle orientée vers la gestion de ces géomorphosites. La méthode est fondée sur l'élaboration d'une carte géomorphologique détaillée afin d'identifier les formes et les processus et de reconstituer l'évolution du paysage. À partir de la carte géomorphologique détaillée, des fiches descriptives et analytiques sont établies pour chacun des géomorphosites sélectionnés. Elles indiquent les caractères morphologiques les plus importants tels que la morphostructure, le substratum, les formes du relief, les dynamiques observées, les éléments singuliers, la gestion, les caractéristiques culturelles héritées ou actuelles, la fragilité naturelle, l'utilisation du sol et la vulnérabilité. Les fiches précisent aussi les trois critères d'évaluation, scientifique, culturel et d'utilisation et de gestion, pris en compte. Dans cette étude, vingt-deux géomorphosites de taille et de catégories différentes sont évalués. Ils sont ensuite classés et comparés, puis des propositions d'utilisation potentielle et de conservation sont avancées.

***Mots clés** : géomorphosites, patrimoine géomorphologique, Parc National de Picos de Europa, Espagne.*

Version française abrégée

Dans les espaces naturels protégés, les géomorphosites sont des éléments du paysage qui possèdent autant une valeur naturelle qu'une valeur économique. Ainsi, les géomorphosites constituent à la fois une ressource naturelle et une ressource touristique, culturelle, éducative, esthétique ou patrimoniale. L'évaluation des géomorphosites à

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l'échelle locale requiert une connaissance détaillée de leur valeur intrinsèque (contenu scientifique), tant qualitative que quantitative, de leur sensibilité aux changements naturels et humains, de leurs valeurs ajoutées (contenu culturel) et de la relation avec le territoire dans lequel ils s'inscrivent (Cendrero, 2000 ; Panizza, 2001 ; Panizza et Piacente, 2003 ; Reynard et Pralong, 2004). L'inventaire des géomorphosites à l'échelle locale est différent de celui mené à l'échelle régionale ou nationale, car il inclut des relations territoriales et culturelles plus importantes. Le Parc National des Picos de Europa, situé dans la Cordillère Cantabrique, au nord de 1'Espagne, est le plus ancien parc national du pays. Le paysage est caractérisé par des formes glaciaires et karstiques dans un environnement de haute montagne humide, avec des conditions climatiques océaniques. L'impact de 1'homme sur le paysage est important (mines, tourisme).

Cette étude a pour but de développer une méthode d'évaluation des géomorphosites à une échelle locale dans des espaces naturels protégés et dans un environnement de montagne. Un inventaire des sites d'intérêt géomorphologique a été effectué. Chaque site a été évalué en vue de son incorporation dans les stratégies de gestion du parc. La méthodologie appliquée au Parc National des Picos de Europa est fondée sur la cartographie géomorphologique, un outil de base permettant la localisation de l'ensemble des formes, processus et systèmes de formes, ainsi que la connaissance de l'évolution du paysage. Sur la base de la carte géomorphologique, un inventaire de tous les géomorphosites est effectué au moyen de fiches descriptives et analytiques, qui englobent les caractères morphologiques les plus importants : morphostructures, substratum, formes, dynamique, éléments singuliers, gestion, vestiges culturels, utilisation culturelle actuelle, fragilité naturelle, utilisation du sol et vulnérabilité. L'évaluation combine une objectivité scientifique maximale dans l'analyse des éléments géomorphologiques et incorpore également des valeurs ajoutées que sont la prise en considération de l'utilisation et de la gestion, soumises à une plus grande subjectivité (sociale, historique, personnelle). L'évaluation s'appuie ainsi sur trois catégories de valeurs : scientifique (valeur intrinsèque), culturelle (valeur ajoutée), ainsi qu'une valeur d'utilisation et de gestion.

Dans cette étude, vingt-deux géomorphosites ont été sélectionnés. Ils sont évalués et classés et des propositions d´utilisation potentielle sont émises en accord avec le principe de leur conservation. Du point de vue scientifique (valeur intrinsèque), six géomorphosites ont une valeur élevée, douze ont une valeur moyenne et quatre ont une faible valeur (tab. 5). Les géomorphosites dont les valeurs intrinsèques sont élevées à moyennes représentent 82 % du total, ce qui démontre la valeur géomorphologique naturelle à l'échelle régionale (Cordillère Cantabrique) et nationale du Parc National des Picos de Europa. La valeur culturelle des sites est relativement faible car elle n'est représentée que par quatre sites remarquables dans cette catégorie. Les valeurs d'utilisation et de gestion sont élevées pour 91 % des géomorphosites. Ce résultat montre le potentiel des géomorphosites du Parc National des Picos de Europa comme ressource touristique malgré la difficulté d'accès à certains sites. Enfin, on peut dégager trois groupes de géomorphosites (tab. 6) : sept sites ont une valeur globale élevée, onze ont une valeur moyenne et quatre une valeur faible, en raison de leur spécialisation thématique (cavités karstiques) ou de leur inaccessibilité. Tous les géomorphosites du Parc National ont en outre une valeur paysagère et écologique élevée.

En conclusion, la méthode proposée pour l'analyse et 1'évaluation des géomorphosites dans les espaces naturels protégés et à une échelle locale permet de dégager trois niveaux de valeurs, intrinsèque, ajoutée et d´utilisation, ainsi qu'une évaluation comparée des géomorphosites. Son utilité pour l'évaluation, la valorisation et la gestion des géomorphosites est patente.

Introduction

Geomorphosites are often important elements of Natural Protected Areas (NPAs) and may be valued both as structural and functional elements of the natural system and for their social values in relation to their location. Natural protected areas are designated as a result of a wide range of natural and cultural values that define a landscape, a natural environment, an ecosystem or a habitat. The conservation and study of the geomorphic values of NPAs may be approached from three viewpoints: as the infrastructure of habitats and ecosystems, as the landscape in general, and as an intrinsic value of the natural environment. Up to now the first view has been dominant and has resulted in a failure to consider geomorphic features as elements of value for conservation, investigation and management. In light of the second approach, geomorphosites have now been redefined in the framework of the cultural landscapes with which they are interrelated and which they affect. M. Panizza (2001) and M. Panizza and S. Piacente (2003) have indicated how three similarly interrelated factors: environment, history and philosophy or culture, must be taken in account in the study and assessment of geomorphosites. In this sense, the geomorphosites represent cultural, economic, tourist, educational and environmental resources involving a multiple assessment especially useful to NPAs. Moreover, with respect to regional or national inventories, NPAs have their own characteristics when it comes to defining geomorphosites because the interest is centred locally on their detailed territorial and cultural relationships. The protected areas in this way acquire heritage value.

The study area: the Picos de Europa National Park

The Picos de Europa was declared a National Park in 1918, the first in Spain, due to its historical, landscape and geomorphic values: limestone mountains and glacial landforms around the glacial lakes of Enol and La Ercina. In many respects it marked the starting point of the Spanish conservationist movement and has been a symbol for moun-

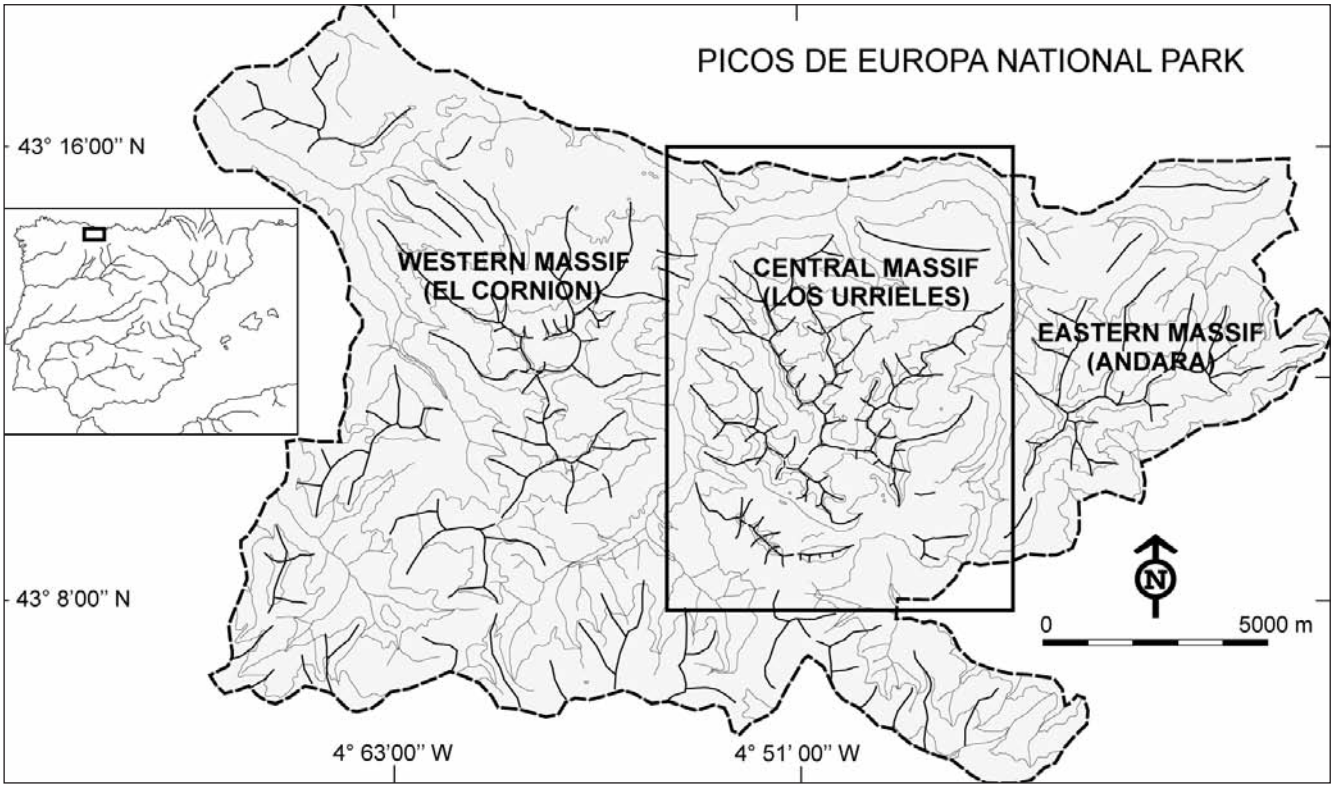


Fig. 1 – **Location of study area and hypsometric map.**

Fig 1 – ***Localisation de la région d'étude et carte hypsométrique.***

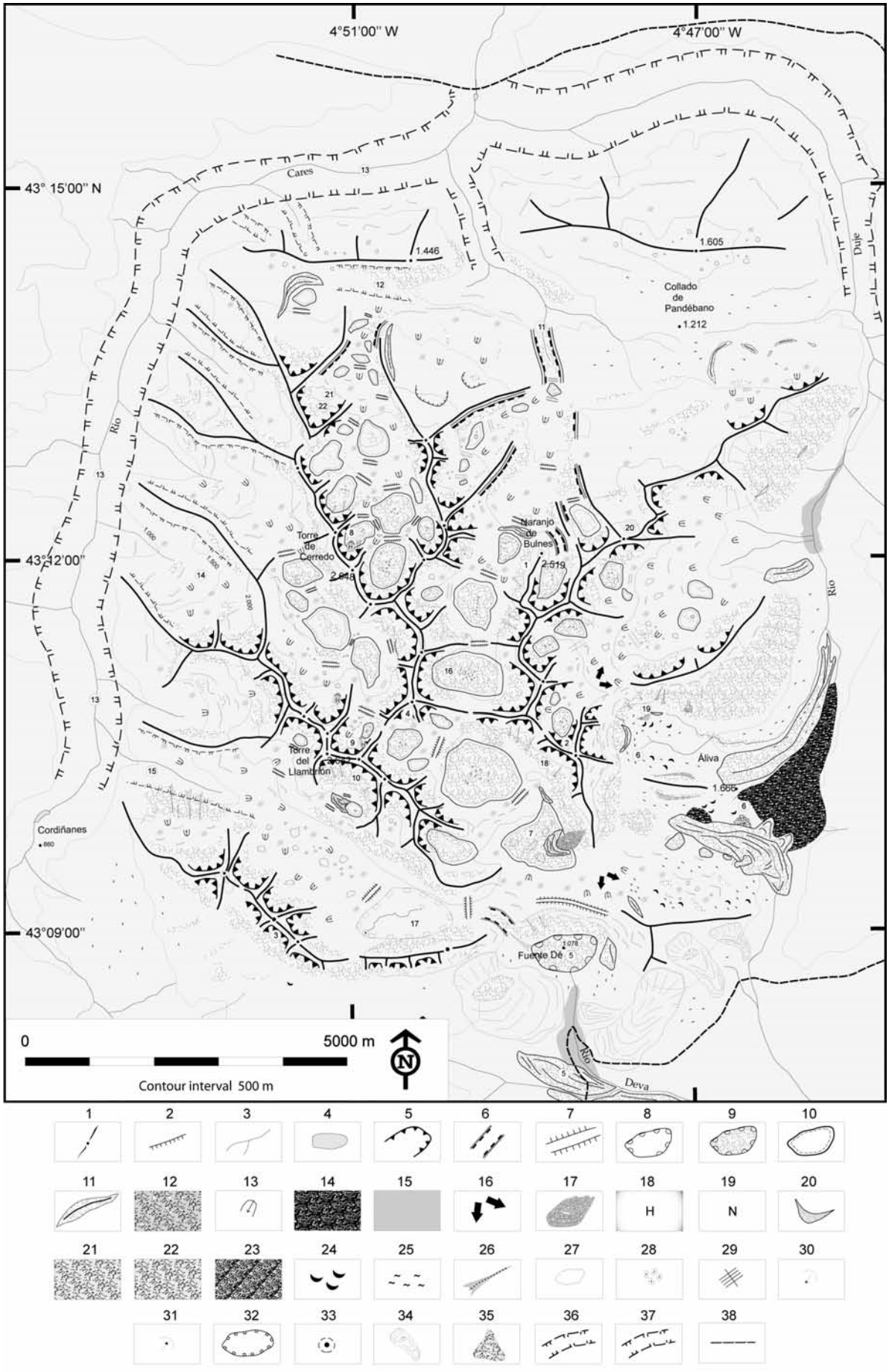
taineers since the first ascent of Naranjo de Bulnes in 1904, effectively heralded as the beginning of rock-climbing in Spain. In the Picos de Europa National Park, pioneering studies in conservation mainly assessed geomorphological aspects (Pidal and Zabala, 1918; Delgado Úbeda *et al*., 1932). The assessment of the ecosystems and species present in the Picos de Europa area formed the basis for its extension in 1995 to include the high mountain region of the three massifs of Picos de Europa. Landscape highlights are dominated by geomorphic elements over human or biotic ones, and although they are pre-eminent in the Picos de Europa National Park, they have not been introduced into either the management of the area or educational or promotional publications. They are, for instance, absent from recent nature guides describing natural landmarks and excursion itineraries.

The Picos de Europa is a limestone massif with a unique geographical identity located to the north of the Cantabrian Divide (fig. 1). It covers an area of 500 km^2 and is divided into three massifs: the Western or Cornión Massif, the Central or Urrieles Massif, and the Eastern or Ándara Massif. Environmental factors determine the organisation of the territory, but land use has profoundly transformed the natural landscape both in the valleys by agriculture and in the high areas by mining and tourism.

The relief of the Picos de Europa derives from its original geological and morphostructural characteristics, but is also the result of fluvial and torrential erosion, Quaternary glaciers, karst processes and active periglacial morphodynamics in the high mountain areas. Upper Carboniferous limestone is predominant, while sandstones, shale and quartzite conglomerate are also present to the south. The relief is defined by hogbacks facing north and fronts towards the south, forming a succession of morphostructures striking from east to west. The lithological changes result in an important morphological contrast between the calcareous massif and its surrounding valleys. Glaciers covered the massif during the Last Glacial Maximum. The most relevant and common landforms are glacial and karst, which are mutually modified. The imprint of Pleistocene glaciers is still clear and widespread, but the glacial landforms are now reworked by karst, nival and periglacial processes. The high mountain landforms have been studied by several authors since the 19th century. This work is based on more than 35 scientific papers on the geomorphology of the Picos de Europa (morphostructural, karst, glacial and periglacial studies by Spanish, French, German and British researchers) and includes our research on Quaternary and Little Ice Age glaciers and on periglacial geomorphology.

Methodology: assessment of geomorphosites in natural protected areas

Scope for the cultural assessment of geomorphic elements and sites has recently been established (Panizza, 1992; Panizza and Piacente, 2003; Piacente and Poli, 2003). Currently, the relationship between human and geomorphic topics is


4°51'00" W
4°47'00" W
43° 15'00" N
43°12'00"
43°09'00"
Cares
Río
Duje
Collado de Pandébano
1.212
1.605
1.446
Torre de Cerredo
2.648
Naranjo de Bulnes
2.519
Torre del Llambrión
Áliva
1.655
Cordiñanes
Fuente Dé
Río Deva
0
5000 m
Contour interval 500 m
H
N

GEOMORPHOSITE DESCRIPTION CARD				
Identification	Name: Lloroza moraine complex with rock glacier		Place: Central massif Urrielles	No 7
Situation	Commune: Camaleño (Cantabria)	Coordinates: x- 352.600; y- 4.780.470	Altitude: 1809 m	
Geomorphology	TYPE: (SP)	Singular Place:		
		Series of glacial moraines with seasonal lakes, karstic processes, and a relict rock glacier. The existence of two lakes and the rock glacier make this place singular, because there are very few lakes in the Picos, only one in the central massif, and no rock glacier is recorded in the Picos de Europa		
	Genesis	Glacial and periglacial processes related to karstic processes.		
	Landform description, morphostructures, erosion	Complex made up of three moraine arches in the western part of the glacio-karstic depression of the Hoyos de Lloroza. Inside the moraines the two glacial lakes and the rock glacier are linked by debris talus with the calcareous walls of Peña Olvidada		
	Dynamic	Gravity, avalanches, and karst		
	Chronology	Retracted glacial phase following the Last Glacial Maximum.The existence of moraines and the rock glacier evoke two phases, the late Pleistocene, a period of advance during the retreat, and another cold, non-glacial, which has been correlated to the Late-glacial time		
	Main interest	Intra-mountain moraine complex and rock glacier		
	Secondary interest	Intra-moraine glacial lakes and semi-active debris talus within a calcareous high mountain landscape framework		
	Geosite attributes	Glacial and periglacial landforms		
Uses	Cultural content	Cattle farming and mining use in adjacent areas		
	Accessibility	Very good, Cable car — 500 m — and functioning trail		
	Level of interest	Very high due to the exceptional intra-mountain glacial accumulation forms and the existence of a rock glacier in a highly accessible location		
	State of conservation	Good, only altered by a track in the upper part		
	Current uses	Tourism and walking. Crowded by the proximity of the cable car		
	Communications	Taxis and public cable car		
	Infrastructures	Surrounding trail		
	Impacts	Trail in the debris talus		
	Legal Status	Picos de Europa National Park (PRUG and PORN)		

References: Carmona and Escribano (1982); Obermaier (1914); Clark (1981); Serrano and González Trueba (2002, 2004).

Table 1 – **Geomorphosite descriptive card. Example of assessment and management procedure.**

Tableau 1 – ***Fiche descriptive d'un géomorphosite. Exemple de processus d'évaluation et de gestion.***

Fig. 2 – **Geomorphological sketch of Picos de Europa central massif.** 1: crest and ridge; 2: scarp; 3: river; 4: lake and pool ; 5: glacier cirque; 6: glacier trough; 7: rock bar; 8: overdeepened basin; 9: infilled overdeepened basin; 10: glaciokarstic depression; 11: moraine; 12: till; 13: abraded surfaces; 14: lateral complex; 15: fluvioglacial terrace; 16: glacier diffluence; 17: rock glacier; 18: relict ice, 19: snowpatch; 20: protalus rampart; 21: debris slope; 22: straight slope; 23: cemented stratified debris; 24: solifluction lobes; 25: sheet solifluction; 26: debris flow; 27: doline; 28: cave; 29: karren,; 30: karstic spring; 31: stream sink; 32: polje; 33: ponor; 34: landslide; 35: rock fall; 36: avalanche couloir; 37: fluviokarstic gorge; 38: National Park boundary. Numbers in circle refer to geomorphosite numbers in table 5.

Fig. 2 – ***Esquisse géomorphologique du massif central du Picos de Europa.*** *1: arête et éperons ; 2: escarpement ; 3: ruissellement concentré ; 4: lac ; 5: cirque glaciaire ; 6: auge glaciaire ; 7: verrou ; 8: ombilic ; 9: ombilic remblayé ; 10: dépression glacio-karstique ; 11: moraine ; 12: till ; 13: roches moutonnées ; 14: moraine latérale ; 15: terrasse fluvio-glaciaire ; 16: diffluence glaciaire ; 17: glacier rocheux ; 18: glace morte ; 19: névé ; 20: moraine de névé ; 21: tablier d'éboulis ; 22: versant réglé ; 23: éboulis ordonné ; 24: loupe de solifluxion ; 25: coulée de solifluxion ; 26: éboulis fluant ; 27: doline ; 28: cavité ; 29: lapié ; 30: résurgence karstique ; 31: perte ; 32: poljé ; 33: ponor ; 34: glissement ; 35: éboulement ; 36: couloir d'avalanche ; 37: canyon fluvio-karstique ; 38: limite du Parc national. Les nombres dans des cercles font référence aux nombres du tableau 5.*

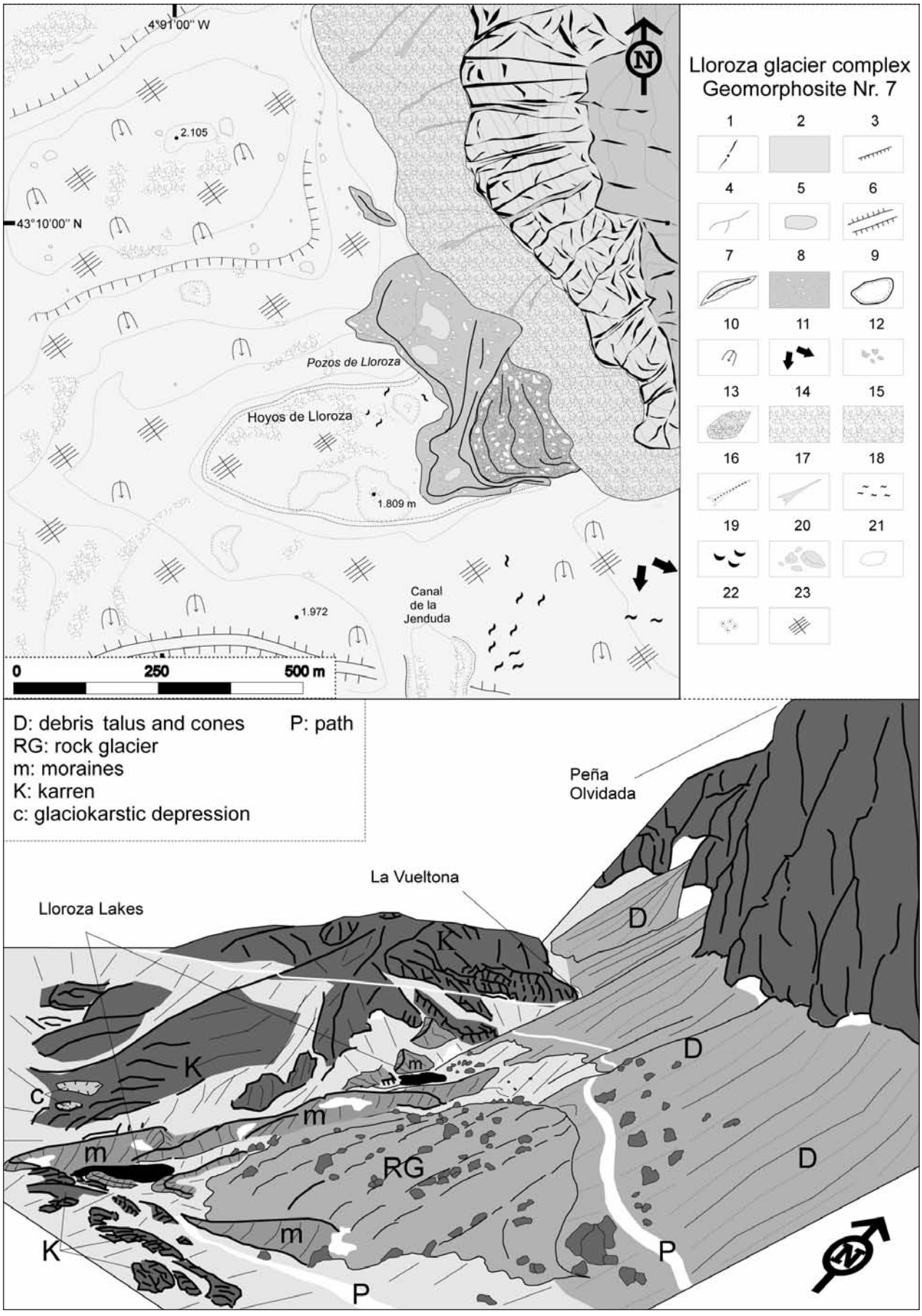

4°91'00'' W
43°10'00'' N
2.105
Pozos de Lloroza
Hoyos de Lloroza
1.809 m
Canal de la Jenduda
1.972
0
250
500 m
N
Lloroza glacier complex
Geomorphosite Nr. 7
1 2 3
4 5 6
7 8 9
10 11 12
13 14 15
16 17 18
19 20 21
22 23
D: debris talus and cones
RG: rock glacier
m: moraines
K: karren
c: glaciokarstic depression
P: path
Peña Olvidada
La Vueltona
Lloroza Lakes
K
D
c
m
RG
P

Fig. 3 – **Detailed geomorphological sketch and interpretative view of Lloroza glacier complex (geomorphosite No. 7).** 1: crest and ridge; 2: wall; 3: scarp; 4: rivers; 5: lake and pool; 6: rock bar; 7: moraine; 8. till; 9: glaciokarstic depression; 10: abraded surface; 11: glacier diffluence; 12: erratic block; 13: rock glacier; 14: debris talus; 15: debris cone; 16: debris flow; 17: avalanche couloir; 18: sheet solifluction; 19: solifluction lobes; 20: rock fall; 21: doline; 22: cave; 23: karren.

*Fig. 3 – **Carte géomorphologique détaillée et vue interprétative du complexe glaciaire de Lloroza (géomorphosite N° 7)**. 1: arête et éperon ; 2: paroi ; 3: escarpement ; 4: ruissellement concentré ; 5: lac ; 6: verrou ; 7: moraine ; 8: till ; 9: dépression glacio-karstique ; 10: roches moutonnées ; 11: diffluence glaciaire ; 12: bloc erratique ; 13: glacier rocheux ; 14: tablier d'éboulis ; 15: cône d'éboulis ; 16: éboulis fluant ; 17: couloir d'avalanche ; 18: coulée de solifluxion ; 19: loupe de solifluxion ; 20: éboulement ; 21: doline ; 22: cavité ; 23: lapié.*

EVALUATION		POINTS	DEFINITION
Genesis		Maximum 10	Processes that have intervened in the formation
Morphology	Morphostructures		Number of landforms composing the geomorphosite
	Erosional landforms		
	Accumulation landforms		
Dynamic	Inherited processes		Inherited and functional elements witness to past or active processes.
	Current process		
Chronology			Genetic periods or phases
Lithology			Materials shown
Geologic structures			Number of visible structures
Sedimentary structures			Number of visible structures

Table 2 – **Scientific assessment of geomorphosites.**

*Tableau 2 – **Évaluation scientifique des géomorphosites.***

closely related to landscape analysis, and assessments of geomorphic features at local and regional scales have been carried out mainly in relation to international and national geological heritage (Barettino *et al*. 2000; Martínez de Pisón *et al*. 2003; Reynard and Pralong, 2004). There are also studies of environmental impact assessment on geomorphic sites with quantitative contributions and works applied to territory management (Panizza and Piacente, 1993; Rivas *et al*. 1997;

EVALUATION		POINTS	DEFINITION
Landscape and aesthetic		Maximum 10	Landscape and aesthetic scale consideration: non existent (0), local and uncharacteristic component (1-2), medium-scale component (valley, municipality) (3-4), district component (5-6), essential component of the landscape in regional panoramas (7-8), protected or managed element due to landscape contents (9-10)
Cultural elements	Association with elements of heritage value	Maximum 10	Heritage elements (monuments, populations, popular constructions, ethnological elements, …)
	Cultural content	Maximum 10	Cultural aspects (myths, legends, literature, painting …)
	Historical content	Maximum 10	Historical phases of use or occupation
Educational	Educational resources	Maximum 5	Educational contents
	Educational levels	Maximum 5	Primary, secondary, university students
Scientific	Scientific value	Maximum 5	Scientific areas of significant value
	Scientific representativeness	Maximum 5	Local, (1), district (2), regional (3), national (4), international (5)
Tourism	Real tourist contents	Maximum 5	Historical-artistic; activities (excursions, others); landscape; simple leisure; others
	Potential for tourist attraction	Maximum 5	Capacity for tourist attraction: local, district, regional, national, international

Table 3 – **Cultural or added-value assessment of geomorphosites.**

*Tableau 3 – **Valeur culturelle et valeurs ajoutées de géomorphosites.***

EVALUATION	POINTS	DEFINITION
Accessibility	HIGH: 2. Good accessibility	Utility due to the accessibility of the geomorphosite for its use and management
	MEDIUM: 1. Difficult accessibility	
	LOW: 0. Poor accessibility	
Fragility	HIGH: 0. Use not recommended	Degree of fragility of geomorphosite due to its intrinsic characteristics
	MEDIUM: 1. Potential use	
	LOW: 2. High value of use	
Vulnerability	HIGH: 0. Elements capable of transforming the structure or dynamic of the geomorphosite	Elements of the geomorphosite environment that can entail irreversible changes in its intrinsic and extrinsic values
	MEDIUM: 1. Low degree transformation	
	LOW: 2. No vulnerability	
Intensity of use	HIGH: 0. Intense use, not permitting any increase in activities	Current use of the geomorphosite
	MEDIUM: 1. Moderate use	
	LOW: 2. Low level of use	
Risk of degradation	HIGH: 0. High risk of degradation	Possible damage to the geomorphosite with loss of intrinsic and added values
	MEDIUM: 1. Medium risk of degradation	
	LOW: 2. Low risk of degradation	
State of conservation	HIGH: 2. Allows use	Degree of conservation of the intrinsic and extrinsic values of the geomorphosite
	MEDIUM: 1, Restricted use	
	LOW: 0. Use not recommended	
Impacts	HIGH: 0. Advice against use, with restoration possibility	Human elements directly affecting the geomorphosite (roads, quarries, civil works)
	MEDIUM: 1. Allowed use but restoration or impact elimination advised	
	LOW: 2. No intense impact	
Quality of view	HIGH: 2. High quality of view	Conditions for observation (landscape, location, accessibility, etc.) for the use of geomorphosites
	MEDIUM: 1. Medium quality of view	
	LOW: 0. Low quality of view	
Limits of acceptable change	HIGH: 2. Low fragility and weak intensity of use, changes do not imply loss of values	Potential for changes that the geomorphosite can undergo without loosing its intrinsic and added values (his is related to fragility and intensity of use)
	MEDIUM: 1. Current fragility and uses allow moderate changes without loss of values	
	LOW: 2. High fragility or intensity of use, change implies loss of values	

Table 4 – **Use and management values assessment of geomorphosites.**

*Tableau 4 – **Évaluation des valeurs d´usage et de gestion des géomorphosites.***

Cendrero and Panizza, 1999; Panizza, 2001; Giusti and González, 2002; Coratza and Giusti, 2003).

The methodology applied to the Picos de Europa National Park is based on the geomorphological mapping of the NPAs, a basic tool for the inventory of all the landforms and processes present in the study area and their spatial relationships. The map allows the identification of individual or representative sites earmarked for assessment. The aim of the methodology of analysis of geomorphosites in NPAs and at a the local scale is the achievement of maximum objectivity in the analysis of geomorphic elements from a scientific point of view and the inclusion of added values and those of use and management subject to a greater social, historical, personal subjectivity. The assessment of geomorphosites cannot be made by means of statistical parameters or mathematical formulae since, as A. Cendrero (2000) observes, we are faced with intangible values. Nevertheless, it is necessary to develop a method that could be as objective as possible, which would allow comparative assessment. The distinction between singular and representative geomorphosites leads to a better understanding of the resource.

A three-layered evaluation has been established based on geomorphological mapping (fig. 2) and on geomorphosite cards (fig. 3, tab.1). Once an inventory of landforms, processes, and landform systems in the study area has been carried out, the geomorphosites are analysed, assessing for each the intrinsic value of each element or shape, alongside its added value and its use and management value. Those three categories of assessment are defined as follows:

Scientific or intrinsic value are based on geomorphic topics, allowing a more objective and thorough knowledge of the site. Landforms and landform systems are analysed and assessed by means of the enumeration of intervening elements in the morphogenetic system. A maximum of ten individual elements are used for each site to obtain a significant parameter between 0 and 10. The total value is 100, but

is expressed between 0 and 10 for ease of comparison with the scale used for added and use values (tab. 5).

Cultural or added value are based on the consideration of cultural and environmental elements affecting and enriching the intrinsic values (tab. 3). The maximum value is 70, but will be expressed between 0 and 10 (i.e., scaled down by dividing by 7) for ease of comparison with intrinsic and use values (see tab. 5).

Use and management value are territorial components and the potential for use of geomorphosites are assessed. From a detailed knowledge of intrinsic and added values along with fieldwork (location, geomorphological mapping and images), the potential for use and management are evaluated. Three categories are used: high (2 points), potential for use while guaranteeing conservation; medium (1 point), potential for use with suitable management; low (0 points), impossibility of use without suitable management and possible serious deterioration (tab. 4). The cultural and use values are prone to a more subjective approximation and so are assessed separately. For intrinsic and added values a binary scoring system is used (present =1; absent =0), without subjective weighting of one over the other. For use and management, a semi-quantitative scale of values is established. The results of the assessment are threefold. An alphanumerical evaluation of the three elements allows the comparison of the importance of each attribute in the assessment and management of the geomorphosite. In this way, the manager can assess the intrinsic and added values, alongside those concerning use and management, for all the geomorphosites of the NPA, and bring out their spatial distribution. The points from 0 to 10 of the first two categories allow an immediate comparison of the dominant (natural or added) values, therefore providing the context in which the management of the different types of use and conservation apply.

Results

A total of twenty-two geomorphosites were identified in the central massif of the Picos de Europa (tab. 5), including singular elements (3), representative elements (3), singular places (3) and representative places (13). Geomorphosites of medium intrinsic value predominate, while six have a high value – No. 5, 6, 7, 8, 9 and 13 – and four a low value (tab. 5). Geomorphosites with high and medium intrinsic values make up 82% of the total, while only four had low values (18%). These characteristics summarize the natural geomorphological value of the Picos de Europa National Park on a regional (Cantabrian Range) and national scale.

Nº	NAME	Type*	EVALUATION		
			Scientific value	Added value	Use and management
1	Naranjo de Bulnes	RE	5.2	8.1	4.4
2	Peña Vieja peak	RE	5.3	3.5	7.7**
3	Traviesas de Salinas	LR	4.8	2.2	8.3**
4	Horn of Tesorero peak	RE	4	3.7	8.3
5	Fuente Dé – Pido glacier complex	RP	6.5	6.5	6.5
6	Cirques and moraines of Áliva	RP	7.2	5.7	7
7	Lloroza glacier complex	SP	6.4	2.7	5.5
8	Jou Negro glacier complex	SP	6	4.1	5
9	Trasllambrión glacier complex	SP	6.4	4.3	6.1
10	Torre Blanca-Hoyo de los Llagos glacier complex	RP	4.8	3.7	6.6
11	Balcosín glacier trough	RP	4.4	3	7.3
12	Complejo glaciar y canales de Amuesa glacier complex and couloir	RP	4.4	3.2	7.7**
13	Cares fluvio-karstic gorge	RP	5.6	7.1	2.8
14	Dobresengos corridor	RP	5	3.9	8.3
15	Asotín corridor	RP	5.2	4.1	8.3
16	Boches glacio-karstic depression	RP	5.4	3.7	5
17	Vega de Liordes polje	SE	5.2	1.8	8.8**
18	La Vueltona debris talus and cones	RP	4.2	3.6	3.3
19	Duje cemented stratified debris	SE	3.8	1.7	7.7
20	Peña Castil ice cave	SE	3.4	2	4.4
21	Torca del Cerro cave (-1589 m)	RP	3	1.7	5**
22	Trave cave system (-1441 m)	RP	3	1.7	5**

* RP, representative place. SP, singular place. RE, representative element. SE, singular element. ** Poor accessibility.

Table 5 – **Results of geomorphosite assessment in the Picos de Europa.**

*Tableau 5 – **Résultats de l´évaluation de géomorphosites du Picos de Europa.***

GROUPS	Nº	CHARACTERISTICS
High intrinsic value High added value Medium and low use and management value	1 and 13	Most outstanding and most visited geomorphosites. Management of flow of visitors and intense use needed to avoid loss of value. Impacts tend to be occasional due to difficulty of access of some areas, good conservation of those inaccessible and the risk of irreversible damage to some sites. Some landscape elements are of singular regional and national importance.
Medium to high intrinsic value Medium-high added value Medium-high use and management value	2,5,6,7, 8,9,10	Geomorphosites of high intrinsic and added value, with high values of use. Due to their easy access, their intensity of use and visits must be regulated (cases 5, 6, 7): traffic of vehicles within it and suitability must be limited to the use capacity of the environment. Given that natural dynamics predominate over human impacts, the poor accessibility of some geomorphosites favours their conservation. In these cases the task of preservation must be a priority.
Medium-low intrinsic value Medium-low added value High use and management value	3,4,11, 12,13, 14,15, 16,17	Geomorphosites of low intrinsic and added values but a good degree of conservation, with high values of use and management. Planned intervention requires previous studies of the sustainability and use capacity of the geomorphosites. Each geomorphosite presents a set of problems and a limited potential, which must be assessed in order to adopt appropriate management measures.
Low intrinsic value Low added value Low use and management value	18,20, 21,22	Mainly karstic caves, the forms and dimensions of which make them representative of the Picos de Europa, are exceptional on a national and international scale. Low intrinsic values but great scientific educational and sporting interests. Natural fragility hinders increase in the intensity of their use and in mass tourism, otherwise an irreversible loss of value could occur. Suitable management involves the promotion of study and exploration of the caves.

Table 6 – **Assessment and management orientations of geomorphosites of Picos de Europa.**

*Tableau 6 – **Évaluation et orientations de gestion des géomorphosites du Picos de Europa.***

In terms of added value, low-scoring geomorphosites are predominant (15) against only four of high value (No. 1, 5, 6 and 12). As this is a high mountain area its level of occupation is sparse, and thus human use and added value of the geomorphosites of the Picos de Europa are consequently low. The dominance of the natural landscape, the inaccessibility and low historical human occupation of the high mountain geomorphosites mean that their cultural content is also low. Nevertheless, in terms of their natural value, some have high added value deriving from their scientific, educational, cultural or historical potential, to which are added the strong landscape and aesthetic content. These factors favour the presence of a mountain culture, "mountain emotion", which in scientific, artistic (literature, painting, history) and sporting activities.

Regarding its values of use and management, the percentage of high-scoring geomorphosites is outstanding (14 in total, making up 64%: No. 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 15, 17 and 19), while six sites are of medium value and only two are evaluated as low (tab. 5). This shows the potential of the NPA as a resource, although we must take inaccessibility into account as an insurmountable barrier to the use of some geomorphosites. Their potential needs to be understood not just for tourism but also for educational and cultural purposes. Contrasts are observed between two types of geomorphosites: while most geomorphosites experience low stress levels from visitors, others in the most frequented areas (such as Vega de Urriello and Cares) are under stress from visitors and offer low potential for use. This pressure mainly arises from the excessive numbers of visitors (hikers and 4x4 vehicles) in peripheral areas (Áliva, Lloroza, Vega de Urriello) against the high potential for use of the remainder, which is, in all cases, hindered by inaccessibility. The existing impacts are numerous and are concentrated around the most visited tourist destinations and itineraries. They must be taken into account in the management policies.

Regarding the relationships between the three assessment parameters, four large groups of geomorphosites can be defined (tab. 6). A final overall assessment shows three groups of geomorphosites, among which a core of seven individual sites stand out for their overall value. These three groups are, in descending order of value, the following: high (No. 6, 5, 9, 8, 1, 13 and 7); medium (No. 15, 14, 16, 2, 10, 12, 17, 11, 3, 4 and 18); and low (No. 20, 19, 21 and 22). These last four are of lesser interest due to their thematic specialisation (caves) and inaccessibility. All the geomorphosites in the National Park have high landscape and ecological value.

Conclusions

In this work we carried out an inventory and assessment of twenty-two geomorphosites of the central massif of Picos de Europa in the Picos de Europa National Park, all of which were classified according to intrinsic value, added value and use and management value (tab. 5). Relationships among the three categories allow the differentiation of four main types of geomorphosites (tab. 6): (i) high intrinsic and added values with medium or low use value; (ii) medium-high

intrinsic, added and use values; (iii) medium-low intrinsic and added value with high use value; and (iv) low intrinsic, added and use values. From a use and management potential point of view, we established three value groups: high, medium and low. These classifications and typologies take into account the geomorphological values of the Picos de Europa National Park, and to incorporate the geomorphological values in the management and conservation policies. In the National Park high levels of human pressure (tourism, hiking, 4x4) on sites of medium and high intrinsic value have been observed. The impacts of tourist activities on geomorphosites is concentrated around the itineraries and resorts. This contrasts with low levels of pressure on geomorphosites of high intrinsic value in poorly accessible areas. The poor accessibility of some of the geomorphosites of high value may assist in the task of conserving them, but the most accessible must be carefully managed if irreversible impacts are to be avoided.

The method adopted for the analysis and assessment of geomorphosites in NPAs allows the establishment of intrinsic, added and use values of each geomorphosite selected. It also decribes how to make a comparative assessment of the geomorphosites of the National Park. The methodology proposed in this work would certainly facilitate the assessment of geomorphosites in NPAs, but could also represent a useful educational and management tool.

Acknowledgements

This work was carried out for the Spanish Ministry of Science and Technology and FEDER, project BTE2003-05113, FEDER funds and a grant of Marcelino Botín Foundation. We are grateful to E. Reynard, J. Brilha, an anonymous referee and the journal Editors for their useful suggestions.

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Article soumis le 6 décembre 2004, accepté le 27 juin 2005