




RIVER HABITAT SURVEY IN THE PICOS DE EUROPA, NORTHERN SPAIN

RESULTS FROM 2008

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WEB SITES

Google Earth: http://earth.google.com/index.html
Life in UK Rivers: www.riverlife.org.uk
Picos de Europa National Park: http://reddeparquesnacionales.mma.es/parques/picos
REBECCA project: www.environment.fi
RHS: www.rhs@environment-agency.gov.uk
STAR: www.eu-star.at
WISE: http://www.eea.europa.eu/themes/water

GLOSSARY OF ACRONYMS

ASPT	Average Score per Taxon
BMWP	Biological Monitoring Working Party
CEH	Centre for Ecology and Hydrology
CEN	Committee for Standardisation
GPS	Global Positioning System
HEP	Hydro-Electric Power
HER	Hydro-ecological Region
HMC	Habitat Modification Class
HMS	Habitat Modification Score
HQA	Habitat Quality Assessment
JNCC	Joint Nature Conservation Committee
LAWA	Länderarbeitsgemeinschaft Wasser (German National Association of Water)
MTR	Mean Trophic Rank
NTAXA	Number of Scoring (macroinvertebrate) Taxa
PCA	Principal Component Analysis
Picos-1, etc.	Reference code to identify individual sites surveyed in the Picos
REBECCA	Relationships between ecological and chemicals status of surface waters
RHS	River Habitat Survey
STR	Species Trophic Rank
STAR	STAndardisation of River Classifications
WFD	Water Framework Directive
WISE	Water Information System in Europe

PURPOSE

The purpose of our visit (1-8 June 2008) was to test River Habitat Survey (RHS) and macrophyte surveys on a selection of rivers in the Picos de Europa and to provide advice on an effective sampling and training strategy for RHS in the Cantabrian Region of Spain.

Specific objectives were to:

- Locate and survey a selection of rivers using RHS[1], plus the Joint Nature Conservation Committee (JNCC)[2] and Mean Trophic Ranking (MTR)[3] macrophyte survey methods.
- Collect RHS and macrophyte data for European inter-calibration purposes and add them to the databases already established for the Standardisation of River Classifications (STAR) project[4].
- Generate data for testing and refining the draft CEN guidance standard on the hydromorphological assessment of rivers[5].
- Recommend improvements to the RHS guidance manual for use on European rivers, in particular taking account of local characteristics found in northern Spain.
- Support training, quality assurance and database development needs for subsequent RHS survey work in the Cantabrian Region.
- Make a direct link to biological water quality results from previous project work in the upper reaches of the Río Deva catchment[6].

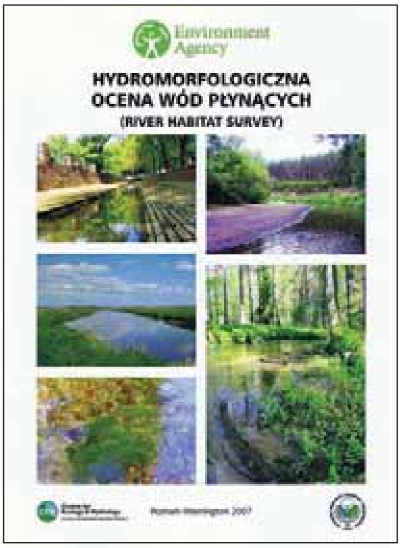
We have also included some recommendations arising from a subsequent visit to the Drawa River in Poland (late August 2008), because they are relevant to lowland rivers in the wet temperate areas of Northern Spain.

BACKGROUND TO METHODS

River Habitat Survey

River Habitat Survey is a method developed in the UK to characterise and assess, in broad simple terms, the physical character of freshwater streams and rivers. It is carried out along a standard 500m length of river. Observations on channel features and modifications are made at 10 equally spaced spot-checks, together with an overall "sweep-up" summary for the whole site. Other information such as valley form and land use in the river corridor is also collected. Field survey follows the strict protocols given in the 2003 RHS Manual[1] and surveyors in the UK are fully trained and accredited.

RHS has been carried out in several European countries: for instance, more than 200 RHS surveys were included in the STAR project[4]; 200 sites have been surveyed in Portugal; more than 600 in Poland, and a further 400 will be surveyed during 2008-9 in the Cantabrian Region of northern Spain. Portugal has recently decided to adopt RHS as a method for its Water Framework Directive (WFD) work. The RHS Manual[1] has been adapted and translated into Italian, French and Polish[7], whilst a Portuguese version is also being developed.



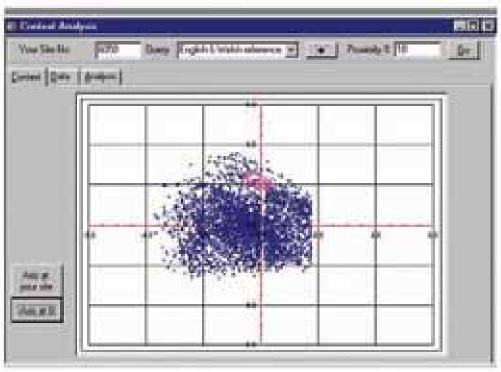
The 2007 Polish RHS Manual.

RHS survey data and site photographs are entered onto a computer database. The UK database now contains field observations, map-derived information and photographs from more than 20,000 surveys undertaken since 1994. During 1994-96, a stratified random network of nearly 5000 sites established a geographically representative baseline cross-section of streams and rivers across the UK[8]. A second stratified random survey, to establish trends in river habitat quality across England and Wales since the initial baseline, has been carried out during 2007 and 2008.

The RHS database allows sites of a similar nature to be grouped together for comparative purposes. Slope, distance from source, height of source and site altitude are used to cluster RHS sample sites for so-called "context analysis" based on Principal Component Analysis (PCA) plots[9]. A more sophisticated context analysis, using field survey data to derive seven indices of river character is now in its final stage of development and testing[10].

The database allows detailed investigation into the relationship between physical variables (e.g. bedslope, land-use), channel modifications and habitat features at spot-check and site level. These investigations can make links with water chemistry and hydrological data, plus aquatic macroinvertebrate, macrophyte, fish or breeding bird survey results where additional sampling has been done in or near RHS sites[11].

Assessment of habitat quality and extent of channel modification can be derived from RHS data, and these indices can be used as a basis for setting physical quality objectives for rivers[12].



Principal Component Analysis allows comparison of similar river-types based on map data.

Diversity of natural in-channel, bank and riparian habitat produces a high HQA score; Picos-8.

Habitat Quality Assessment (HQA) is a broad indication of overall habitat diversity provided by natural features in the channel and river corridor. Points are scored for the presence of features such as point, side and mid-channel bars, eroding cliffs, coarse woody debris, waterfalls, backwaters and floodplain wetlands. Additional points reflect the variety of channel substratum, flow-types, in-channel vegetation, and also the extent of banktop trees and the extent of near-natural land-use adjacent to the river.

Points are added together to provide the HQA. In contrast to HMS (*see below*), the higher the score, the more highly rated the site. The diversity and character of features at any site is influenced by natural variation and also the extent of human intervention both in the channel and adjacent land. The RHS database allows HQA scores to be compared using sites with similar physical characteristics (e.g. slope, distance from source) and geology. Features determining habitat suitability for individual species such as European river otter *Lutra lutra* or dipper *Cinclus cinclus* can also be selected, thereby providing a more sophisticated, species or community-based context for comparing sites[13]. Carrying out RHS and macrophyte surveys in reaches of known good or high quality has provided the necessary calibration of HQA across a wide range of river types in the UK. These specially targeted surveys have been extended to mainland Europe, including rivers in Finland, Norway, Slovenia, Bavaria, the Tyrolean Alps, the Cévennes in south-eastern France and Poland. The 2008 surveys in the Picos de Europa represent a further component in this work, which now covers 59 rivers and 106 RHS sites. Comparison of various habitat assessment methods has also been part of this European-wide initiative[14].

Habitat Modification Score (HMS) is an indication of artificial modification to river channel morphology. To calculate the HMS for a site, points are allocated for the presence and extent of artificial features such as culverts and weirs and also modifications caused by the reprofiling and reinforcement of banks. The more severe the modification, the higher the score. The cumulative points total provides the Habitat Modification Score (HMS). In contrast to HQA, higher scores reflect more artificial intervention and modification of the river channel within the site. A Habitat Modification Class (HMC) has been developed which allocates a site into one of five modification classes, based on the total score.

RHS made an important contribution to development of the CEN standard "Water quality: guidance standard for assessing the hydromorphological features of rivers (EN 14614)", which was published in 2004[15]. It is a recommended method for the agreed protocol for field survey and feature recording of morphological data. RHS is also being used to help develop an associated CEN guidance standard on determining the degree of modification on river hydromorphology[5]. In the UK it has already been used for WFD purposes to identify reference conditions, "heavily modified" riverine water bodies and hydromorphological pressures affecting river catchments.

The STAR (STAndardisation of River Classifications) project was a research initiative funded by the European Commission under the Fifth Framework Programme and was completed in 2005. A major aim was to provide standard biological assessment methods compatible with WFD requirements. It also aimed to develop a standard for determining the class boundaries of 'ecological status' and another one for inter-calibrating existing methods. In Austria, The Czech Republic, Denmark, Germany and Italy 'core' RHS sites were chosen to reflect a gradient in habitat and morphology degradation. Results from the STAR project were published in a special issue of the journal *Hydrobiologia* in 2006[4].

Aquatic macrophyte surveys

When undertaking special RHS and macrophyte surveys on UK and mainland European rivers, two methods are normally used in tandem. The JNCC method[2] records aquatic and marginal plants within the same 500m as the RHS survey. Species from the river channel and the water margins along the base of the bank are recorded separately on a three-point scale of abundance. A check-list of species is used to aid recording. Data are held on a JNCC database, and field data can be used to classify the plant community[2].

The second type is the MTR survey[3]. This records only aquatic taxa, again using a check-list of species, but within a 100m length of river. Each species is assigned a trophic rank of 1-10, depending on its tolerance to eutrophication (1=tolerant; 10=intolerant). Cover abundance of species is estimated on a scale of one to nine and the combination of cover values and trophic rank enables a MTR score to be derived. This provides an indication of the level of nutrient enrichment of the sites surveyed.

For inter-calibration purposes, methods such as RHS and MTR that have been developed for rivers in the UK need to be tested and adapted for use elsewhere in Europe where hydrology, morphology and floristic character may differ.

Artificial reprofiling and reinforcement of the banks and channel produce a high HMS score.

For JNCC macrophyte surveys, vegetation in the channel and along the water's edge is recorded.

For the MTR method, plants growing in the water are used to calculate scores.

SURVEY AND ASSESSMENT

The primary purpose of our study was to locate and survey near-natural examples of rivers to calibrate RHS and macrophyte results. In Spain many rivers are regulated for hydro-electric power (HEP) and water storage purposes, so there are very few examples of unmodified rivers in natural "wild wood" or wetland landscapes. We therefore focused on an area where regulation was not a major impact. In preparation for our visit, we used a combination of large-scale maps, *Google Earth* images, the availability of macroinvertebrate data from previous surveys of rivers[6] and advice from the National Park to target our survey on those rivers that appeared to have near-natural channel form and land-use. Local advice was used to confirm the suitability of the rivers, whilst the precise location of our RHS surveys was determined on site. Many potential reaches were inaccessible because they were located in deep canyons or gorges. In general, our final selection represented near-natural examples that could be surveyed safely by surveyors working in pairs.

The streams and rivers we surveyed were located in steep, deep, well-wooded valleys, typical of the Picos landscape. Variation was provided by local differences in channel gradient, including variations between adjacent sites on the same river (Annex A), geology (Annex B) and catchment land-use. The Río Púron site, (Picos-18), was surveyed because it had been suggested by local biologists as a candidate WFD reference condition river for its geomorphological processes and features. Visiting this site with colleagues from Spain therefore provided a good opportunity for discussion on quality assessment principles.

River Habitat Survey was undertaken by Paul Raven and Peter Scarlett, working together for quality assurance and health and safety reasons. Results are available for all 20 of the sites surveyed. Approximate site locations are shown on the back cover map.

Nigel Holmes carried out macrophyte surveys on all the rivers visited, using the JNCC and MTR methods at 18 and 15 of the RHS sites respectively.

The RHS survey form entries were cross-checked using digital photos taken in the field. Background information (e.g. altitude, bedslope, geology), was derived from various map-based and literature sources. Latitude and longitude readings were obtained using GPS in the field, but some of these were found to be unreliable when cross-checked against 1:25,000 scale maps (*Mapa Topografía Nacional de España* series), so the map-derived readings have been used. Topographical maps showing site locations appear in Annex C. These clearly demonstrate that deriving bedslope gradient estimates is tricky when sites are located in steep valleys or gorges because the contour lines are so close together. In addition, there is variation between individual but adjacent 1:25,000 scale maps, in particular the channel course and whether the river is intermittent.

Many rivers in Spain are heavily modified and regulated.

Basic water chemistry (pH and conductivity) was determined in the field by a hand-held meter. Water samples were filtered, stored and subsequently analysed in the CEH Dorset laboratory (Annex D).

As part of a previous study into the relationship between the macro-invertebrate fauna and landscape features in the upper reaches of the Río Deva catchment, biological samples were taken from 44 river reaches in April 1995[6]. At each site a standard one-minute kick/sweep with a pond-net was carried out; sampling effort for each in-channel habitat type was in proportion to the area of stream-bed it occupied. Specimens were hand-picked and preserved in alcohol for later verification. In addition, a large array of map-derived and field survey information on habitat, land cover and other features was collected and analysed to generate an environmental classification of the Río Deva catchment. For this report, we have selected only the biological water quality assessments for the three streams that we surveyed using RHS.

The weather during survey work was generally good, but water levels were rather high following prolonged wet weather throughout May and a major rainfall event on 30 May that caused flooding in Bilbao. Elevated water levels and discharge will have distorted the water chemistry results, pattern of flow types, masked the occurrence of some riffles and submerged some depositional features normally exposed during dry-weather flows. However, the good clarity of the water did not impede visual assessment of channel substratum, so the potential bias in HQA scores was probably small.

Calculation of the RHS indices (HQA and HMS) was done using the 2005 version of these systems – in similar fashion to that done for sites surveyed in Slovenia[16], the Bavarian and the Tyrolean Alps[17], the Cévennes[18] and Poland[19]. This means that assumptions have had to be made about the inclusion and scoring of special features (*see Discussion section*).

A complete set of RHS survey forms, a CD-Rom with digital photographs, maps showing locations, sketches and macrophyte lists for each site visited has been produced and are available on request. The notes in Appendix 1 appear in Section P of the RHS database entry. Site numbers, prefixed with "Picos" are unique codes that identify individual survey results in the database.

Many of the mountain streams flow through inaccessible ravines and gorges.

In total, 20 RHS sites on 10 rivers were surveyed. There were five single (500m) surveys, two paired surveys (1km), one triple set (1.5km) and two sets of four survey units (2km) (Appendix 1). We completed as many multiple surveys as we could to maximise use of our time and also to determine the variation in number and type of features recorded over different lengths of river.

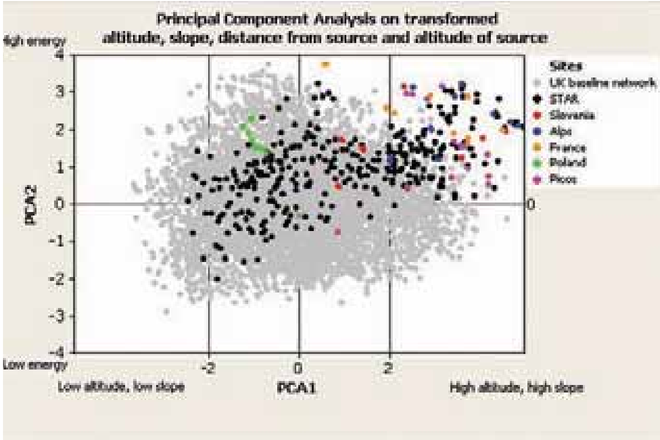


Figure 1. PCA plot, showing the Picos sites in relation to baseline UK, STAR and European benchmark sites.

Powerful springs ("issues") emerge from the rockface in several places; Río Casaño.

RESULTS

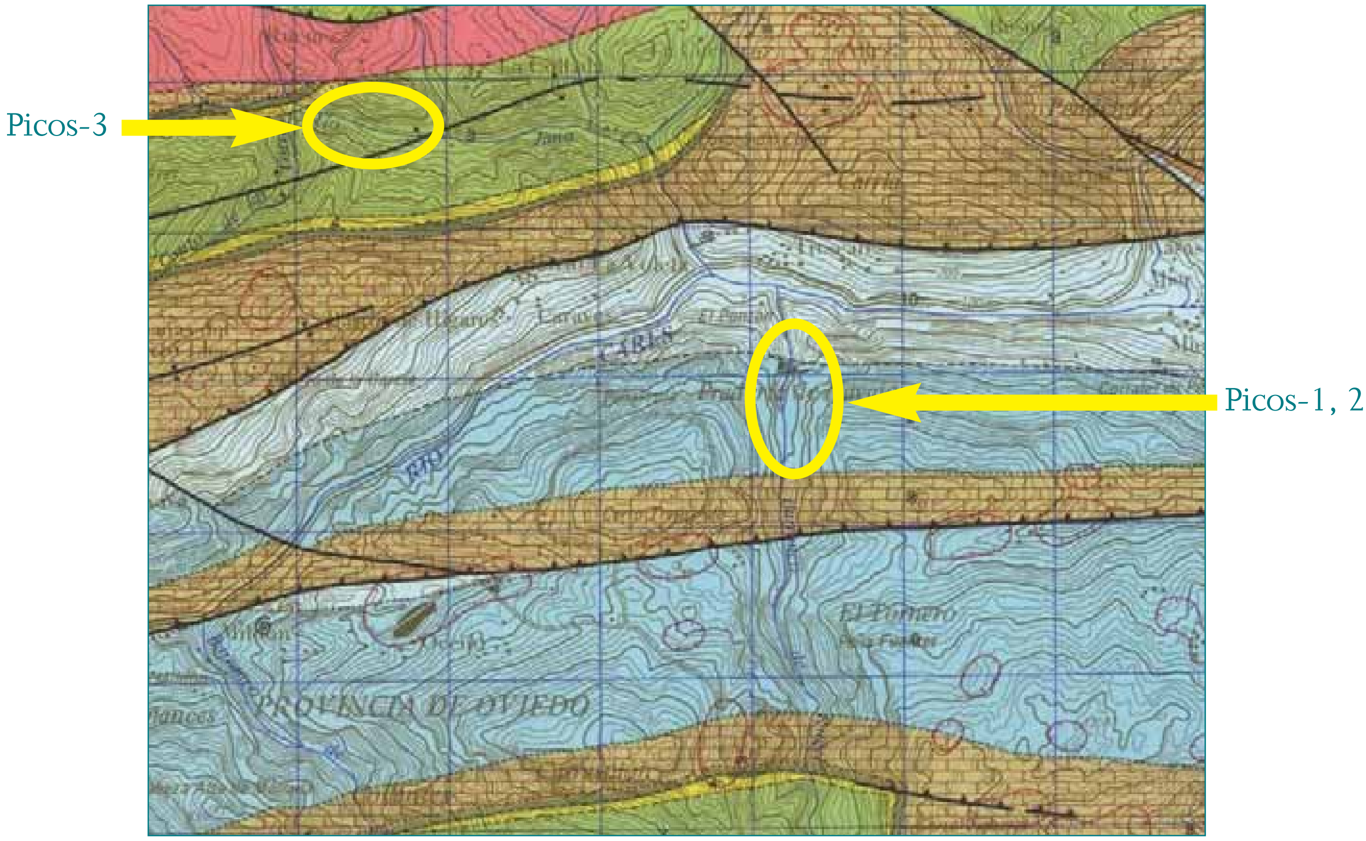
Context in relation to European hydro-ecoregions and UK rivers

The hydro-ecoregion (HER) concept, based on map and environmental data and developed as part of the REBECCA project, provides a useful broad framework for expressing river character on a European scale[20]. The Picos study area lies broadly within the Cantabric Massif West HER and has broadly similar landscape-scale characteristics to our study areas in the Julian Alps[16] (Table 1).

Figure 1 shows a PCA plot of our Picos RHS sites, compared with our previous European surveys[16-19], the STAR project sites[4] and the 1994-96 stratified random baseline network of sites in the UK. It confirms the high energy nature of the Picos rivers as a result of high relief and steep slopes.

TABLE 1: General characteristics of the "Cantabric Massif West" as defined by REBECCA[19].

Parameter	Cantabric Massif West (Picos)	Southern pre-Alps and dolomites (Julian Alps)
Altitude	700-1000m (median)	700-1000m (median)
Slope	5-9% (median)	5-9% (median)
Relief	Mountains	Mountains
Lithology	Crystalline	Calcareous mountains
Climate	Temperate mountain	Alpine mountain



Complex pattern of geological faulting, northern Picos. Source: Spanish Geological Institute.

Heavily-wooded valleys and alpine peaks characterise the landscape; Río Salvorón valley.

Río Duje near Sotres: far from near-natural riparian conditions.

Landscape and river character

The Picos de Europa is part of the Cantabrian cordillera and characterised by high mountains and precipitous slopes. The geology comprises predominantly carboniferous limestones but with outcrops of quartzites, sandstones and conglomerates to the north and the south. There is a very complicated pattern of faults and overthrusts, whilst the area was extensively glaciated in the Quaternary Period. As a result, there are abrupt changes in geology, very extensive cave systems (>1000m deep), plus canyons, gorges, dry valleys, springs and glacial deposits.

Many of the high altitude headwaters are seasonal and some of our study sites are marked as intermittent on some maps. The hydrology is extremely complex, with powerful springs emerging from several aquifers to feed the river systems. This makes "distance from source" as a PCA attribute rather meaningless, so channel width as a function of discharge is probably a much more relevant parameter.

This is the wettest part of Spain, mainly because of the proximity of a high mountain range (peak altitude is 2646m) to the Atlantic coast. Snow represents nearly 20% of precipitation on the highest peaks and annual precipitation can exceed 2000mm. Storms and torrential rain episodes are not uncommon.

A marked altitudinal series of climatic regions produces a well-developed altitude-related zonation of vegetation. This is reflected by bare alpine peaks, sub-alpine scrub, upper montane beech (*Fagus sylvatica*) forest and lower montane oak (*Quercus spp.*) forest. Below 800m, mixed broadleaf woodland is dominant, with alders (*Alnus glutinosa*), willows (*Salix* spp.) and ash (*Fraxinus excelsior*) forming riverine woodland in the valleys.

Meadows grazed by sheep, goats and cattle or managed for hay are widely distributed up to 1000m. Some parts of the National Park are heavily grazed, so many streams, particularly in plateau areas (e.g. Valle del Duje), are devoid of trees. In some places streams have been realigned and embanked to improve the pasture. Outside the National Park burning by shepherds, (a widespread practice in Asturias and Cantabria), means that woodland is replaced by heathland in several areas.

Fortunately, herb-rich meadows, the product of traditional agriculture, are still a characteristic feature of high nature conservation interest in the landscape. The low yielding but high quality foodstock crop produces astonishingly species-rich fields, with many types of orchid. The stunning landscape and exceptional botany attracts thousands of walkers and natural history enthusiasts each summer. During the last 20 years, increasing numbers of tourists, (a trend accentuated by a road building programme in valleys that were previously difficult to reach and also the advent of cheap air travel to Santander), has put pressure on the rural landscape and rural communities. Other pressures include an increasing use of artificial fertilisers, hedgerow removal and the introduction of non-indigenous cattle.

Overall, the landscape, geology and rivers are broadly similar to the Julian Alps in Slovenia[16]. Another similarity is the general trend of people moving away from subsistence-level traditional agriculture to urban life. As a consequence, many herb-rich meadows are being converted to monoculture ley pasture, or simply abandoned, leading to the encroachment of scrub.

Goat and sheep grazing produces rough pasture land on steep valley slopes and screes; Picos-1.

Heathland produced by burning is widespread in parts of Asturias and Cantabria; near Trescares.

Stunning, orchid-rich meadows attract botanists to the Picos.

The appearance of white asphodel (*Asphodelus ramosus*) in traditional hay meadows indicates the first signs of neglect.

Arterial roads are confined to the main gorges of the Sella, Cares and Deva.

The streams and rivers that flow in canyons, gorges and deep, steep-sided valleys are all basically of the same bedrock/boulder channel character. The Río Cares has an HEP generation plant at Poncebos, whilst the Río Dobra has also been dammed to provide power. The three principal rivers in the Picos (Sella, Cares and Deva) are in deep gorges which provide the only access routes for major roads (see back cover map). These roads are chiselled out of the rockface, leaving the in-channel structure below largely intact.

There are several stone-built Roman bridges, whilst the ruins of the first HEP station in Spain, located in the Casaño valley 500m downstream from Picos-7, is a feature of more recent historical interest.

Roman stone-arch bridge on the Río Cares, near Trescares.

The ruins of Spain's first HEP station, in the Casaño valley.

Morphological character

An overview of the landscape context and broad characteristics of the rivers surveyed is given in Tables 2 and 3, with more information provided in Annex A.

TABLE 2: Principal physical character of the rivers surveyed. Rivers are arranged in descending order of channel slope over the full survey length. *Superscripts indicate site number.*

Site reference (Picos)	River name	Channel slope (m/km)	Water width (m)	Predominant valley form	Altitude of source (m)	Distance from source (km)
1, 2	Rubó	340[1] 120[2]	5.0m[1] 3.5m[2]	Deep vee/gorge	1010m	4.0 - 4.5km
17	Nevandi	160	2.2m	Deep vee	1740m	5.5km
13-16	Salvorón	134[13] 170[14] 170[15] 130[16]	3.0[13] 4.0m[14] 7.0m[15] 5.5m[16]	Deep vee	1800m	2.4 - 3.9km
20	Burón	120	6.0m	Deep vee	1970m	3.4km
8-9	Pelabarda	76[8] 34[4]	4.5m[8] 7.5m[9]	Deep vee	1090m	2.5 - 3.0km
4-7	Casaño	104[4] 36[5] 44[6] 30[7]	8.0m[4] 12.0m[5, 6] 11.0m[7]	Deep vee	1295m	5.3 - 6.8km
3	Jano	30	4.5m	Deep vee	700m	4.1km
19	Cares	22	26.0m	Deep vee/gorge	1800m	27.5km
10-12	Dobra	22[10] 12[11] 10[12]	10.0m[10] 15.0m[11] 17.5m[12]	Deep vee	1640m	22.5 - 23.5km
18	Purón	14	12.0m	Deep vee	290m	2.0km

* see discussion for context

TABLE 3: Habitat quality, habitat modification and macrophyte assessment for the rivers surveyed. Rivers are arranged in descending order of channel slope over the full survey length. *Superscripts indicate site number.*

Site reference (Picos)	River name	Habitat quality (HQA)	Habitat modification score (and class)	Macrophyte assessment (MTR score)
1-2	Rubó	57[1] 58[2]	100 (2)[1] 0 (1)[2]	68[1]
17	Nevandi	65	50 (2)	60
13-16	Salvorón	72[13] 74[14] 71[15] 68[16]	0 (1)[13] 0 (1)[14] 400* (3)[15] 0 (1)[16]	67[13, 14]
20	Burón	70	20 (2)	62
8-9	Pelabarda	73[8] 70[9]	0 (1)[8] 0 (1)[9]	65[8] 70[9]
4-7	Casaño	70[4] 71[5] 64[6] 58[7]	0 (1)[4] 0 (1)[5] 0 (1)[6] 0 (1)[7]	65[5] 67[7]
3	Jano	61	0 (1)	59
19	Cares	54	100 (2)*	59
10-12	Dobra	69[10] 69[11] 67[12]	0 (1)[10] 0 (1)[11] 40 (2)[12]	64[10] 67[11] 69[12]
18	Purón	65	100 (2)*	60

* see discussion for context

Bedrock, boulder or cobble substratum were predominant in all our sites, with the channel constrained by bedrock or boulder bank material. As a result, chute flow and step-pool sequences were characteristic features.

Classical cascade-pool sequence; Picos-2.

In bedrock chutes and canyons the rockface margins were scoured clean, although not so extensively as we found in the Cévennes[18]. Overall, HQA scores were high, reflecting the near-natural ecological character of both the in-channel habitats and adjacent land-use, producing good longitudinal and lateral connectivity within the river corridor (Annex E and F).

Unvegetated and vegetated side bars are sometimes tricky to distinguish in boulder or cobble-dominated rivers because the large substratum size does not produce a gentle, smooth slope into the water like gravel or pebble material. Downslope accumulation of material from the steep valley sides produces vegetated step-like features, usually formed from cobbles or boulders, infilled with finer substratum; care is therefore needed in distinguishing these from genuine riverine depositional features.

Scouring of the bedrock channels shows evidence of powerful storm-flows; Picos-2.

Water quality

All the rivers we sampled had neutral or above neutral pH. Differences in conductivity, calcium, phosphorus, sulphate and nitrate levels (Annex D) probably reflect variations in catchment geology (Annex B) and land-use. There is a particularly noticeable contrast between the quartzite and sandstone dominated catchments of the Río Jano (Picos-3) and Río Salvorón (Picos-13 to 16) and the limestone dominated catchments elsewhere. The previous heavy rain may have affected the alkalinity and hardness values, but the extent of this is unknown.

Parts of the Picos were extensively mined for zinc, copper, mercury and lead during the 19th century[21] and there may still be a legacy of heavy metal pollution. The absence of gastropods in calcium-rich waters is often a tell-tale sign, but a confounding factor in this assumption is the instability of the channel-bed caused by the scouring force of flood waters in canyon and gorge sections.

Localised water quality problems are associated with sewage from villages and cattle slurry from farms, both of which enter streams and rivers. Consequently, our study sites were purposely located upstream from settlements to avoid poor water quality caused by organic enrichment.

The 1995 biological survey was stratified according to an environmental classification of watercourses in the Upper Deva valley[6]. Sample sites were selected from each environmental group and chosen because of little or no significant modification of the river corridor. Whilst not "reference sites" in the strictest WFD definition, they do provide a representative sample of Biotic Index values expected at sites of good or high ecological quality.

Five of the 1995 biological surveys were either entirely within the subsequent 2008 RHS sites or located less than 1.5km downstream; there were two on both the Rio Nevandi and Rio Salvorón and one on the Rio Burón (Table 4). The Biotic Index values calculated for each biological sample were the Iberian versions of the BMWP score, number of scoring taxa (NTAXA) and Average Score Per Taxon (ASPT)[22].

In each environmental group containing one or more of the five sites surveyed biologically in 1995 and by RHS in 2008, the Iberian Index values of all of the other sites in the group were averaged. These averages were constructed as a target against which the five sites of current interest could be evaluated. The target values were designated as "expected values" (E) and the index values obtained for the study sites were taken as "observed values" (O). The O/E ratio indicates relative ecological quality, where 1.0 represents the closest match to undisturbed (near-natural) conditions[23].

The O/E ratios in Table 4 have been categorised into ecological quality classes using the British biological water quality classification system, in which class A represents "very good" quality; class B "good"; and class C "fairly good".

TABLE 4: Biological water quality of five survey sites in the Upper Deva valley, derived from macroinvertebrate survey results in 1995[6]. Numbers in brackets after the river names are the 1995 survey site codes. BMWP is the Iberian Biological Monitoring Working Party score. NTAXA is the number of scoring taxa in the Iberian BMWP system present in the sample. ASPT is the Average Score Per Taxon present in the sample.

River name	Nearest RHS site (km distance upstream)	Observed Iberian BMWP System index values (O)			Expected Iberian BMWP System index values (E)			Ecological Quality Index (O/E)			Biological Classification Class†	
		BMWP	NTAXA	ASPT	BMWP	NTAXA	ASPT	BMWP	NTAXA	ASPT	NTAXA	ASPT
Nevandi (202)	Picos-17 (1.0)	142	20	7.1	99	14.2	6.9	1.44	1.41	1.02	A	A
Nevandi (206)	Picos-17 (0.0)	111	18	6.2	99	14.2	6.9	1.13	1.27	0.89	A	C
Salvorón (223)	Picos-16 (0.5)	133	19	7.0	129	19.7	6.53	1.03	0.97	1.07	A	A
Salvorón (232)	Picos-13 (0.0)	113	18	6.3	111	17	6.7	1.02	1.06	0.94	A	B
Burón (345)	Picos-20 (1.4)	94	13	7.2	101	14.5	7	0.93	0.90	1.03	A	A

† see: http://www.ni-environment.gov.uk/water/quality/rivers/river_results/gqabiolexpln.htm

In all cases, the quality class indicated by the number of taxa (NTAXA) is "very good", indicating a high range of taxa for a site of this type. The ASPT index measures organic pollution; for this index, three of the five sites are "very good" quality, and one is "good". Only at Nevandi site 206 (RHS site Picos-17) is the indicative class "fairly good", suggesting that mild organic pollution may be affecting water quality – a conclusion also made from the macrophyte results.

This interpretation makes certain assumptions: (i) target values represent a reasonable approximation to the best achievable ecological values for sites of that environmental type and (ii) the British classification scheme can be reasonably applied to the Iberian BMWP system. It also assumes that ecological quality has not deteriorated between 1995 and 2008.

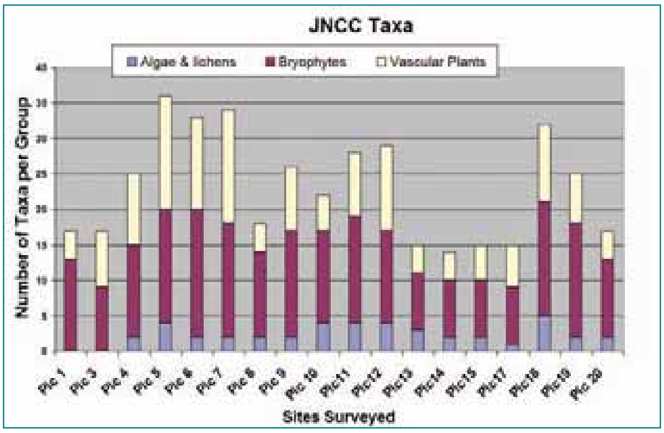


Figure 2. Number of JNCC check-list taxa recorded at sites surveyed.

Macrophytes

There was very poor macrophyte diversity in most rivers. Bryophytes were dominant in terms of cover abundance at all sites (Annex G and H) and also in species richness (Figure 2).

There were virtually no truly aquatic higher plants growing in the channel; this reflects the extreme seasonal range in temperature and discharge. Only those rivers with major springs that sustain flow throughout the year (Río Casaño and Río Purón) had aquatics such as *Apium nodiflorum* and starwort (*Callitriche*) growing in the channel. Other rivers, such as the Río Dobra, had *Apium* present, alongside other emergents such as water-mint (*Mentha*) and water forget-me-not (*Myosotis*), but these plants were typically found only at the margins where flushes were present. The limited 'flush flora' that spills into the channel masks the fact that the flora of our RHS survey sites was overwhelmingly dominated by lower plants.

The greater stability of sustained flow in the Río Casaño (Picos-5 to 7) and the Río Purón (Picos-18) not only resulted in greater species richness, but these were the only rivers where the encrusting red alga, *Hildenbrandia*, was recorded. Upstream from Fuente de los Brazos, a major spring that sustains all year round flow in the Río Casaño, the macrophyte diversity of Picos-4 was markedly lower and *Hildenbrandia* was absent.

MTR scores were 59 or higher, indicating a generally low, or very low, nutrient level (Figure 3). The heavily-shaded Río Nevandi (Picos-17) had a lower than expected MTR because of the paucity of plants generally, and the abundance of *Platyhypnidium* in particular; this ubiquitous bryophyte species has a wide nutrient tolerance and a trophic rank of 5. The MTR result concurs with the "fairly good" biological water quality assessment for this site (Table 4). The low MTR score for Picos-18 (Río Purón) may reflect nutrient enrichment from the fish farm further upstream. Enrichment of the Río Cares has been reported and the MTR score of 59 for Picos-19, the lowest recorded in all rivers surveyed, indicates elevated nutrient levels in the River Cares.

The highest MTR scores were recorded on the Río Rubo, Pelabarda, Dobra and Salvorón. All these rivers drain predominantly wooded catchments or the sites were close to their sources. Interestingly, the two sites on the Río Pelabarda (Picos-8 and 9) had scores of 65 and 70; the lower score in Picos-8 was due to the abundance of common bryophyte taxa with a tolerant trophic rank of 5 (e.g. *Amblystegium, Cinclidotus* and *Platyhypnidium*).

Several taxa that were common in our survey sites are not on the JNCC river survey check-list because they are uncommon in British rivers[2]. The alga *Hydrurus foetidus* was a noteworthy record. This is a chrysophyte that is characteristic of cold mountain streams; it coated large areas of the river bed at Picos-19 (Río Cares), which was the only place we found it.

Several rivers supported bryophytes that are rare in Great Britain. Alongside *Cinclidotus fontinaloides*, a moss common in calcareous rivers in the UK, were luxuriant growths of C. *riparius*, known as 'fountain lattice-moss' which has a very limited distribution in the UK. This moss was found in torrential flows on the Casaño, Pelabarda, Dobra, Purón and Cares rivers.

Another notable but common bryophyte was *Fissidens polyphyllus*. It is rare in the UK and typically occurs on wet rocks and banks alongside streams and ravines. It was present in torrents on the Casaño, Dobra and Cares rivers where it was deeply submerged at the time of survey.

During our surveys in the Ardèche region of France in 2007[14], we noted that some rivers with very sparse vegetation cover due to extreme flood scouring supported occasional clumps of the moss *Bryum dichotomum*. This species was also noted on the scour-smoothed rocks of the Río Dobra.

Wildlife

Birds are good indicators of landscape character and the species seen during our visit confirmed the near-natural mountainous and wooded conditions within which our study sites were located (Annex I). One notable find was the golden-striped salamander (*Chioglossa lusitanica*) on the Río Purón at Picos-18.

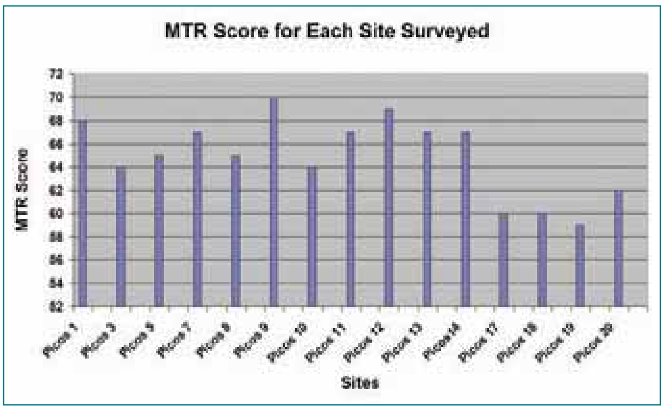


Figure 3. MTR scores for sites surveyed.

Golden-striped salamander; Picos-18.

DISCUSSION

Scale-related variability

The cumulative pattern of in-channel features on the Río Dobra, Casaño and Salvorón where we did contiguous 500m surveys is revealing (Table 5). It suggests that flow-type and predominant channel substratum occur in a similar pattern at the 500m and 1500-2000m scale. However, the number of channel and bank features recorded is more variable, because some only appear in one or two individual 500m survey units. This may be the result of subtle changes in channel bedslope determining the occurrence of specific features (Table 2). It suggests, albeit on circumstantial evidence from just three samples, that an initial inventory-based sampling strategy for these types of streams should include paired (back-to-back) RHS surveys to increase the chances of accounting for most of the channel and bank features in the most efficient way.

Our results are also interesting in the context of other sampling strategies for river habitat or hydromorphological assessment which recommend survey unit lengths related to channel width, either expressed as a ratio or a fixed length. For example, the German LAWA method uses 100m as the sample length for small and medium-sized rivers[24]. Our results suggest that one 100m sample unit would miss a considerable amount of features. However, by surveying the entire river length in 100m units the LAWA method will compensate for this shortfall, provided that assessment at the 100m level and reach level is designed to accommodate cumulative variation.

Calibrating habitat quality and modification indices

Deriving ecologically-meaningful indices of river and riparian habitat quality, particularly in relation to natural or near-natural "reference conditions", is difficult because of scale-related problems associated with the occurrence of riverine features. Early experience with RHS and subsequent development of the CEN guidance standard[15] recognised that the type and extent of channel modification is a far easier way to derive an index than one which attempts to predict the presence or extent of in-channel and riparian

A double-culvert crossing point –
the only modification along the 2km of Picos-13 to 16.

habitat features. This is particularly true in relation to a river typology generated from map-based information. For the Picos, we have demonstrated, even over a limited (1.5-2km) length of one river, the confounding effect of local changes in channel bedslope on the number and type of channel and bank features recorded (Table 5).

Predicting the occurrence and number of specific features such as riffles is also tricky. For example, riffles have been found to be most common at channel bedslopes in the range of 2.5°-7.5° on an upland British river[25]. If this finding is applied to our study area, riffles should have occurred in 10 of our sites. However, they were only present in six sites, including the Río Nevandi (Picos-17) and Río Burón (Picos-20) which have average bedslopes of 12° and 16° respectively. The conclusion is that the average bedslope value over 500m or longer distances has limited use for predicting riffle occurrence. Local bedrock constraints and the coarse nature of predominant substratum has probably prevented riffles developing in some reaches of suitable average gradient, such as along the Río Casaño. On the Río Burón and Río Nevandi, the step-pool sequence reflects a steep gradient overall, but within our 500m site sufficient lengths of lower-gradient channel with the relevant substratum size has allowed riffles to develop. A confounding factor on the Río Casaño was the high flow at the time of survey, because several riffles may be present during dry-weather flow.

TABLE 5: Cumulative number of in-channel attributes recorded for combined 500m RHS sites on the Río Dobra, Río Casaño and Río Salvorón. *Erosional and depositional features recorded at spot-checks, sweep-up and as special features.

	Cumulative number of attributes recorded				
Picos sites	**Flow types**	**Channel substrata**	**Channel features***	**Bank features***	**Total**
Río Dobra					
500m (10)	8	6	5	4	23
1000m (10, 11)	8	6	6	6	26
1500m (10-12)	9	6	7	6	28
Río Casaño					
500m (4)	7	5	3	4	19
1000m (4, 5)	7	5	4	5	21
1500m (4-6)	7	5	6	5	23
2000m (4-7)	7	6	6	5	24
Río Salvorón					
500m (13)	7	4	5	3	19
1000m (13, 14)	7	4	6	4	21
1500m (13-15)	7	4	7	4	22
2000m (13-16)	7	5	8	4	24

For variations in bedslope, see Table 2.

Almost unnoticeable realignment of boulders for bank protection; Picos-20.

Bridge reinforcement for historic bridge supports high up the bank make no impact on the channel; Picos-19.

Context for assessing impact

Neither the HQA/HMS scoring systems, nor the CEN standard[15], have been tested adequately on a scale-related or ecological/response basis. As a result, the qualitative and semi-quantitative basis for establishing the link between modification and ecological impact remains rudimentary, as does determining the class boundaries for habitat modification scores.

We can demonstrate the problem in several of our Picos study sites. For example, in Picos-1, 18 and 19 there are footbridges built on bedrock outcrops above the trashline/annual flood level. These structures provide access across the river for walkers and livestock. They are recorded as "minor bridges" and score 100 HMS points. Logically, their impact score should be zero because of the negligible, or zero, impact on the channel structure and local riverine processes. Nevertheless, the bridges still need to be recorded, but photographic evidence is needed to establish their likely impact.

In Picos-15 (the Río Salvorón) there is a low, 2m wide concrete structure, containing two pipes (culverts), which provides a fording point across the stream for forestry vehicles. Together with some associated concrete reinforcement in the immediate vicinity, this is the only modification in the site and indeed within the 2km length represented by sites Picos-13 to 16. The HMS score for "culvert" is 400, making the site HMC class 3 (obviously modified).

Site-specific assessment of impact suggests the influence of this structure is very local and minor. Although there will be an impact on geomorphological processes (caused by restricting channel width and hindering downstream movement of cobbles and boulders), the structure occupies less than 5m of channel length. This is equivalent to 1% of Picos-15 and 0.25% over the 2km length of Picos-13 to 16. There is a strong case for a contextual override to be applied which takes account of the natural or near-natural channel structure for 95% or more of river-length. This would reflect the approach taken in the draft CEN standard on assessing the degree of modification to river morphology[5].

The importance of taking photographs of structures for subsequent verification is reaffirmed because of the need to provide context to overall HQA and HMS scores. The site description and a comparison of HQA and HMS scores should provide the necessary supporting evidence and clues in an overall assessment of site character and quality assessment.

Likewise, in Picos-20 (Río Burón) which had the most diverse channel structure of all our study sites, the only modification was a 15m length of bank where boulders had been re-positioned to protect a small stand of planted pine trees. This modification affected 3% of the right bank (1.5% of total bank-length) with no obvious impact on channel processes or features of this bedrock-boulder stream. The consequent HMS score of 20, (reflecting the presence of banktop reinforcement) means Picos-20 is class 2 (predominantly unmodified). Clearly, with a high HQA score, the entire length of river-bed unmodified and 98.5% of banklength unaltered, there is a strong case for a contextual over-ride that concludes that the condition of the channel is near-natural.

Excellent channel structure on the Río Purón; Picos-18.

Dilapidated fish farm on the Río Purón; upstream from Picos-18.

Feeder channel for small-scale hydro-electric generation; Picos-18.

Encased water pipe (arrowed) above trashline level; Río Dobra; Picos-10.

The Sella, Cares and Deva gorges provide another good example. Observations suggest that about 95% of in-channel river length is unaltered. Occasional revetment reinforcement to protect roads is largely confined to vulnerable points (e.g. bridges) and mostly located above the annual flood/trashline level. Again, contextual interpretation is required to prevent erroneous interpretation using the HMS scores alone. Consideration is also needed about how to assess the minor impact of roads in the context of the overwhelming dominance of bedrock and scree in the valleys.

Considering a 500m stretch of river in isolation is also unwise. The Río Purón at Picos-18 undoubtedly has a very fine river channel structure and superficially looks to be unimpacted. However, upstream there is a major weir, fish farm and a by-pass channel drawing water from the river to power a small HEP operation, so the river is significantly modified hydromorphologically. All these modifying features are marked on the 1:25,000 scale map (Annex C); this reaffirms the importance of preparatory mapwork and local knowledge both for site selection purposes and the interpretation of habitat quality for the river as a whole.

New examples or subtle variations of habitat features and artificial modifications occur on virtually every study visit we make. These are logged and help to improve the overall and local applicability of the RHS method (Appendix 2). In some cases, a pragmatic judgement is needed on what to include as scoring features. For example, we took the decision to omit, for HMS scoring purposes, a small water supply pipe on the Río Dobra in Picos 10 and 11. This is because it was above located above trashline height, had nothing to do with bank protection and could not have had any morphological impact on the bedrock-boulder channel. Nevertheless, the structure was photographed and recorded for future reference; for instance, it would have to be taken into account for its (minor) hydrological impact as part of a wider hydromorphological assessment of the river reach.

Natural and near-natural land-use

Land-use has always been a tricky problem for RHS which as a matter of necessity uses broad categories. This is because surveyors have limited time to assess land-use type in detail as the main focus of their attention is the river channel and banks.

However, since some types are scored for HQA purposes, careful consideration of natural or near-natural land-use is needed, particularly in relation to broadleaf woodland. For instance, managed secondary forest can have most of the attributes of near-natural broadleaf woodland, but without the same ecological integrity and functioning. As an example, the beech woodland in the Río Salvorón valley (alongside Picos-13 – 16) had a uniform age structure, with very few saplings and decaying trees on the forest floor. There was some coarse woody debris in the stream, but not sufficient to create debris dams. Forestry management had therefore produced a modified broadleaf woodland habitat. To distinguish truly natural or near-natural "reference condition" (pristine) river reaches, the CEN standard[15] will need to include additional qualifying criteria for features recorded by RHS, such as woody debris and debris dams, plus verification of catchment land-use history.

Even-aged beech forest and no fallen mature trees suggests active forestry management; Picos-14.

Debris dams provide a good clue to near-natural riparian conditions; Picos-8.

Spectacular orchid-rich meadows are high nature value farmland.

Pink butterfly orchid, near Espinama.

Ascalaphid, near Pido.

Local knowledge is therefore very important in confirming natural or near-natural conditions of the river and adjacent land. This is because the current HQA scoring system provides a score 'bonus' for each bank if land-use is considered "near-natural" (e.g. broadleaf or coniferous woodland; rock/scree; wetland) for the entire length[8].

High HQA scores for land-use should therefore prompt further investigation to verify wider catchment land-use and also to see if the site potentially qualifies as reference condition for WFD purposes. Equally, the presence of small patches of tall herbs or rough pasture in an otherwise near-natural landscape may also need to be put into a broader context. Both scenarios confirm the limitations of HQA scoring for land-use and the need for additional information for contextual and interpretation purposes.

There has been much debate in the UK about whether "moorland/heath" and "rough pasture" qualify for natural or near-natural land-use. Under the current HQA scoring system in the UK, moorland/heath qualifies as a natural land-use. The key test of "near-natural" is the successional consequence of removing management intervention. Below the tree-line, moorland/heath and rough pasture would both revert to scrub and then woodland, so cannot be considered natural or near-natural. Above the tree-line, heath, subalpine and (in mainland Europe) alpine meadows are natural, climax habitats.

The current HQA scoring system for land-use could therefore be improved by better application of known ecological and morphological impacts on the river corridor. For example, rough pasture, moorland/heath, wetland, broadleaf and coniferous woodland could be used in incremental scoring categories, reflecting regional biogeographical characteristics. Pristine wetland, broadleaf and coniferous woodland would attract a premium score (expressed as 1* in CEN protocol terms[5]), after verification of current and historical land management. Results from the Río Deva valley project provide a good basis for local calibration of the impact of land-use on riverine ecology[6].

Sawfly orchid.

For our mainland European benchmarking studies, orchid and herb-rich meadows have been scored as a special feature[16-19]. Despite not being a near-natural land-use, this is to recognise their undoubted high nature conservation value, clearly distinguishing them from the broad "rough pasture/unimproved grassland" land-use category. A similar approach exists for certain types of wetland, where ecologically-valuable habitats are scored as special features.

The advantage with RHS is that the type and extent of land-use categories recorded in the field can be checked and refined afterwards using site photographs, aerial photographs and *Google Earth* images. Land-use and special feature scores can therefore be verified or modified as a result of supplementary evidence.

Reference condition and high ecological status

In the UK, land-use criteria have been used, in addition to RHS and map-derived information, to help determine whether water bodies qualify for WFD "high ecological status". Assumptions have been made about the impact of land management on geomorphological processes and the implied consequences for channel morphology and riverine ecology. Examples include soil compaction by sheep on unimproved grassland; underdrainage associated with forestry; and burning of grouse moorland.

The decision that, for WFD purposes, high ecological status equals "reference condition" (i.e. natural or near-natural river and catchment hydromorphology) means that only a tiny fraction (<0.1%) of riverine water body length qualifies as high ecological status in England and Wales. The draft

Meadow fritillary, near Pido.

Toad.

Near-natural low gradient river channel in Scotland.

CEN guidance standard provides a more realistic approach, allowing "high" to include a more ecologically-meaningful degree of disturbance (e.g. 5% of channel length). Applying a 1* classification distinguishes those river reaches that are in truly pristine ecological condition[15].

Improving HQA

It has always been acknowledged that HQA needs refinement to provide a more meaningful way of expressing habitat character and quality. Currently, HQA is a hybrid between a diversity and an ecological index. This causes several scoring anomalies, although the effect of these can be minimised by comparing similar sites on a local (catchment), regional and national basis[13]. For reporting purposes, there is a strong case for separating out diversity-related in-channel and bank scoring feature (flows, substrata, channel and bank features, in-channel vegetation types, trees/associated features) from "value" judgement scores based on wider land-use categories and special features. There is also a degree of double-counting (e.g. trees and woodland land-use) and this needs to be resolved, as does the disproportionate impact of land-use scores (*see discussion in relation to 'natural' woodland*).

In addition, the HQA scoring has so far been applied using nearest-neighbour sites on the original PCA plot[9] and geology. We are now introducing other indices and biogeographical criteria to provide more ecologically-relevant alternatives[10].

The spectacular gorge setting for Picos-1 and 2.

CONCLUSIONS

We achieved our main objectives of testing the RHS and macrophyte survey methods on rivers in the Picos. Both methods (with minor modifications to account for local morphological characteristics and floristic communities respectively) are suitable for small and medium-sized rivers in the wet-temperate climate of northern Spain.

We also produced RHS and macrophyte data that can be used for baseline information and calibration/comparison purposes. This information complements the biological results from the upper Deva valley project[6].

Following our visit, five surveyors from IH Cantabria obtained full RHS accreditation in Warrington in early July 2008 and shortly afterwards they started surveys in Cantabria. In support of this work, we established an email "help desk" link; for instance, digital photographs of features that surveyors found difficult to categorise were e-mailed to the RHS team, which provided advice on how to record them.

Woody debris and sediment bars contribute to HQA scores.

Near-natural lowland stream in the New Forest, England.

Surveyors training for RHS, Poland.

Like other countries that have little baseline information on ecological and hydromorphological features as required by the WFD, a cost-effective sampling strategy is needed in Spain.

A combination of large-scale maps and aerial photographic sources can quickly provide basic information on the broad physical structure of river channels and riparian habitat. Ground-truth samples using RHS and other methods are also needed to build up an inventory of features and modifications, verify assumptions used when interpreting aerial/satellite images and also to calibrate biological water quality and habitat quality. A strategy involving both these elements should be relatively easy to develop, with sampling density determined by variations in factors such as "river type" and land-use. We have provided circumstantial evidence that paired (back-to-back) RHS sites would be an efficient sampling strategy for developing a baseline inventory of in-channel features.

A database of Spanish RHS and macrophyte information will help to increase confidence in the reporting of WFD-related ecological status and hydromorphological pressures. This will build on the foundations created by the STAR project results[4]. The sampling of Cantabrian rivers using RHS provides a good opportunity for applying a tried-and-tested protocol, adapted for local conditions.

Fully-trained and accredited RHS surveyors, river biologists, fisheries and macrophyte specialists are all needed to provide the necessary quality assurance for classifying the biological status of water bodies and the hydromorphological pressures acting upon them. This is important in implementing the ecological objective-setting principles of the Directive and protecting areas of high conservation value, such as *Natura 2000* sites.

Ecologists who are familiar with a wide range of ecological and morphological characteristics of rivers and have access to aerial photographs, GIS information plus RHS and macrophyte databases are needed to advise on setting objectives for water bodies. This will increase confidence that the best examples of river reaches will be protected and that measures needed to maintain and achieve good ecological status will be identified.

Three major remaining challenges are: (i) dealing with scale-related quality and impact assessment; (ii) deriving a meaningful and practical hydrological element for hydromorphological assessment – something that RHS is not designed to do; and (ii) developing an RHS version suitable for intermittent, seasonal Mediterranean rivers. The latter will require careful thought and also the gathering of information to determine what features are recorded and how. This can build on RHS-related work previously developed in Italy and Portugal[26, 27], and exploratory work on this aspect will take place in April 2009 in southern Portugal.

The hydromorphology of Picos-18 is impacted by a major weir upstream.

Channels diverting water within a catchment complicate hydromorphological assessment; SE France.

APPENDIX 1: Notes for Picos-1 to Picos-20. Mid-point latitude and longitude readings derived from 1:25,000 scale maps.

Río Rubó (Picos-1, 2). 1 June 2008. HQA = 57, 58; HMS = 100(2), 0 (1).
Two back-to-back surveys (1km). 43° 18′ 37.0″ N, 4° 42′ 22.2″ W; 43° 18′ 49.5″ N, 4° 42′ 17.8″ W.

Extensive cascades; Picos-1.

Cascades at the top end of Picos-2.

A 'hanging' flush; Picos-1.

A short, steep torrent flowing into the Río Cares near the small village of Trescares. Located in a spectacular ravine, the bedrock-boulder channel has waterfalls and extensive cascades, particularly in Picos-1. Goat-grazed rough pasture, oak woodland and rock/scree dominate the steep valley sides. A gentler gradient and bedrock outcrops, produce a notable step-pool sequence in Picos-2.

High water levels at the time of survey made accurate recording of macrophytes difficult and most of the species found were those typical of woodlands, not rivers. Bryophytes totally dominated the flora, with an unusual mix of taxa, some indicative of calcareous conditions (e.g. *Palustriella commutatum and Cinclidotus*), the majority reflecting neutral conditions, but some indicating acidic rocks (e.g. *Racomitrium and Scapania*), possibly reflecting quartzite outcrops further upstream (see map on page 4).

Classic bedrock channel with a cascade-pool; Picos-2.

Río Jano. (Picos-3). 1 June 2008. HQA = 61; HMS = 0 (1).
One site (500m). 43° 19′ 38.4″ N, 4° 44′ 23.3″ W.

A small, boulder-dominated stream flowing in a deep valley with a prominent glacial terrace. There is good in-channel habitat structure and a narrow broadleaf woodland corridor, but wider catchment land-use is dominated by tall heath and bracken, caused by extensive burning of the hillsides.

In some places, large boulders have been positioned across the channel to form permeable weirs, presumably for fisheries purposes. Upstream and therefore not affecting the HMS score, there is an old mill structure and an associated dilapidated leat. The peat-stained water reflects sandstone geology and heathland soils in the catchment.

Tree-lined channel, with terrace evident on left of the picture; Picos-3.

Boulder channel; Picos-3.

Cascade and large boulders; Picos-4.

The relatively gentle gradient, cobble-boulder substratum, and heavy shading meant that aquatic bryophytes grew well on both submerged and exposed surfaces of boulders. Ferns, other woodland bryophytes and shade-tolerant wetland flowers such as hemp agrimony (*Eupatorium cannabinum*) were common on the banks. As on many of the other rivers surveyed, *Amblystegium fluviatile* was the dominant species in the channel; *Dichodontium* was the dominant moss on the margins. Royal fern (*Osmunda regalis*) was recorded only on the banks of the Río Jano and Río Purón (Picos-18).

Possible boulder alignment for fisheries? Picos-3.

Fern understorey; Picos-4.

Río Casaño (Picos-4, 5, 6, 7). 2 June 2008. HQA = 70, 71, 64, 58; HMS = 0(1), 0(1), 0(1), 0(1).
Four back-to-back surveys (2 km). 43° 17′ 25.6″ N, 4° 56′ 37.8″ W; 43° 17′ 40.0″ N, 4° 56′ 32.7″ W; 43° 17′ 52.4″ N, 4° 56′ 22.2″ W; 43° 17′ 58.0″ N, 4° 56′ 03.3″ W.

A picturesque boulder-dominated river in a steep, heavily wooded valley located two kms upstream from La Molina. Waterfalls, cascades, exposed boulders and bedrock outcrops typify this 2km reach. A major spring or "issue" (Fuente de los Brazos) is a notable feature in Picos-5.

There were many different niches suitable for macrophyte growth. These ranged from stable, shaded bedrock, dominated by bryophytes, to small sheltered backwater flushes with fool's water-cress (*Apium nodiflorum*) present. In addition to Fuente de los Brazos, where *Fissidens polyphyllus* was present, several small flushes entering at the margins were characterised by growth of calcicole bryophytes such as *Palustriella commutata*. Apart from the more shaded upstream site (Picos-4), the Río Casaño supported one of the richest macrophyte communities recorded on our visit.

Boulder-cobble channel; Picos-5.

Major spring (issue); Picos-5.

Exposed boulders; Picos-6.

channel. There is a fine waterfall at the downstream end of Picos -9. Fallen trees across the channel are a notable feature. The woodland is grazed by cattle.

Bryophyte cover was relatively sparse, probably due to scour resulting from the transport of cobbles during spates. As elsewhere, bryophytes were more common on exposed surfaces of boulders in shaded locations. In small areas of slow-flowing water protected from spate flow by large woody debris or massive boulders, some vascular plants were present (e.g. the endemic *Cardamine raphanifolia*), but in general higher plants were very rare. The moss *Philonotis fontana* was found only on this river.

Cascades; Picos-6.

Fallen trees; Picos-8.

Rock chute; Picos-7.

Diverse channel and bank habitats; Picos-8.

Two bridges marked on the 1:25,000 scale map (Annex C) are no longer present. A further 500m downstream are the remains of the first HEP in Spain, which used the powerful discharge from the spring emerging from the mountainside (see page 6).

Río Pelabarda/Río la Beyera (Picos-8,9). 3 June 2008. HQA = 73, 70; HMS = 0(1), 0(1). Two back-to-back surveys (1 km). 43° 16′ 22.4″ N, 5° 01′ 06.1″ W; 43° 16′ 23.2″ N, 5° 01′ 25.0″ W.

A tributary of the Río Dobra (see Picos-10 – 12), this heavily-shaded stream flows in a deep, wooded steep valley. Extensive cascades and a marked step-pool sequence are caused by bedrock outcrops across the

Lightly grazed beech woodland; Picos-9.

Attractive waterfall;
Picos-9.

Sculptured bedrock and boulders;
Picos-10.

Encased water pipe (arrowed) and sand deposit;
Picos-10.

**Río Dobra (Picos-10, 11, 12). 4 June 2008. HQA = 69, 69, 67; HMS = 0(1), 0(1), 40(2).
Three back-to-back surveys (1.5 km). 43° 17′ 22.8″ N, 5° 06′ 31.7″ W; 43° 17′ 33.2″ N, 5° 06′ 43.8″ W; 43° 17′ 44.8″ N, 5° 06′ 56.1″ W.**

Located in a deep, wooded valley, with crystal clear water and diverse substratum and flow types, this 1.5km stretch is immediately downstream from a spectacular and inaccessible gorge section. The only within-site impact is a small water supply pipe that has been encased in concrete and runs the length of the left bank in Picos-10 and 11. Hydrologically, the impact of this is negligible, but there is a major dam (Embalse de la Jocica) 15 kms further upstream.

A huge circular pool, popular with swimmers, known as the Olla de San Vicente has been formed by the scouring force of water as it exits a narrow bedrock chute (which also marks a geological fault-line) at the downstream end of Picos-12.

Macrophytes were rare and with mosses occurring only on the most protected surfaces, usually at or just below the average discharge level. Small flushes entering from the left bank resulted in more wetland taxa growing at the margins, such as hard rush (*Juncus inflexus*), yellow-sedge (*Carex viridula*) and the mosses *Calliergon cuspidatum* and *Cratoneuron filicinum*. Where discrete sand deposits had accumulated in the shelter of large boulders, species such as reed canary-grass (*Phalaris arundinacea*) were found, but nowhere else on the river.

Downstream from our study area the river is modified; boulders have been removed from the channel and placed on the banks, low level weirs installed, and the valley floor managed as herb-rich hay meadow or improved grassland.

Bedrock channel and crystal-clear water;
Picos-10.

Gorge and steep, wooded valley slopes;
Picos-10 and 11.

Point bar and bedrock substrate;
Picos-11.

Panoramic view of Olla de San Vicente; Picos-12.

Río Salvorón (Picos-13, 14, 15, 16). 5 June 2008. HQA = 72, 74, 71, 68; HMS = 0(1), 0(1), 400(3), 0(1). Four back-to-back surveys (2 km). 43° 06′ 32.4″ N, 4° 47′ 53.3″ W; 43° 06′ 43.2″ N, 4° 48′ 12.2″ W; 43° 06′ 50.8″ N, 4° 48′ 30.0″ W; 43° 07′ 03.6″ N, 4° 48′ 32.2″ W.

Boulder channel; Picos-13.

Mature island; Picos-15.

Luxuriant undergrowth in even-aged woodland; Picos-14.

Bedrock chute at the downstream end of Picos-16.

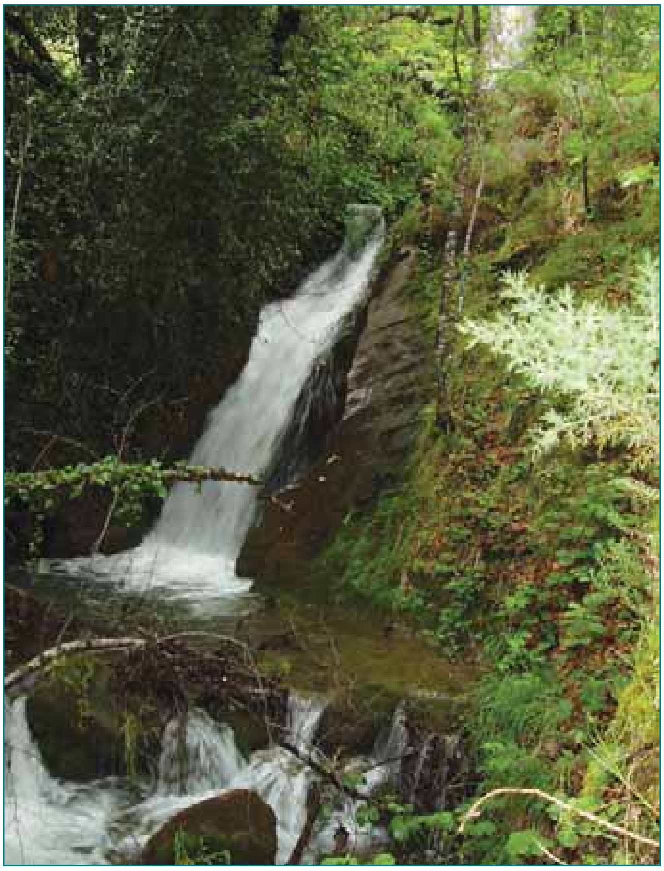
Terrace feature; Picos-16.

A heavily-shaded, boulder-strewn stream with a marked step-pool pattern which joins the Río Deva near Pido. It flows in a steep-sided wooded valley and there is a notable altitude-related change in the type of woodland tree community as the river drops from 1392m to 1090m.

A large spring-fed tributary, the Volta de Mobeja, joins in Picos-15, increasing the discharge considerably, whilst at the downstream end of Picos-16 the channel narrows to form a deep bedrock chute. Glacial valley terraces appear in Picos-16 and continue down the rest of the valley where they support herb-rich meadows.

Macrophytes were scarce due to the very unstable nature of the channel-bed, strewn with boulders with very smooth surfaces. The densely-shaded channel margins and banks were dominated by woodland species, comprising a mixture of bryophytes, ferns, herbs and grasses, with wood club-rush (*Luzula sylvaticus*) common. The in-channel assemblage was dominated by the ubiquitous *Platyhypnidium*, with *Thamnobryum* sub-dominant. Bryophyte cover increased downstream as substratum size increased and the channel-bed became more stable.

There is a small concrete fording point, incorporating a small-bore double culvert at the downstream end of the Picos-15. Together with some associated removal of boulders from the channel and placed on the bank, this represented the only noticeable impact, other than some cattle grazing in the woods. However, the even-aged tree structure and absence of debris dams in the channel suggest that forestry management has been an important factor in woodland development (*see Discussion*).



Bedrock chute; Picos-17.

Herb-rich meadows alongside the Río Nevandi; Picos-17.

Río Nevandi (Picos-17). 5 June 2008. HQA = 65; HMS = 50(2).
One site (500m). 43° 08′ 25.6″ N, 4° 46′ 36.6″ W.

A steep, heavily-shaded stream that flows into the River Deva at Espinama. A very diverse in-channel structure is enhanced by natural oak woodland within the National Park and further downstream by extraordinarily herb-rich meadows, with several species of orchid present.

The macrophyte community is very limited, both in cover and species richness, and totally dominated by bryophytes. The assemblage is similar to the nearby Río Salvorón, but with *Platypnidium* thriving wherever light is able to penetrate through the canopy.

Boulder-strewn channel; Picos-17.

Scour-pool in bedrock channel; Picos-18.

Río Purón (Picos-18). 6 June 2008. HQA = 65; HMS = 100(2).
One site (500m). 43° 22′ 38.8″ N, 4° 41′ 46.6″ W.

This site is on a small river 2km upstream from the village of Purón. It was recommended by local biologists as a potential "reference" (near-natural) river for its morphological processes and features. Within the 500m site there is a diverse in-channel structure; however, there are several notable impacts further upstream, including a dilapidated, but still functioning fish-farm, a major weir and associated bypass channel, plus a bridge and track. Catchment land-use includes heathland (the result of regular burning) and rough pasture.

Good channel and bank habitats; Picos-18.

Hildenbrandia encrusting cobbles; Picos-18.

The channel supported a rich macrophyte community because the survey site was only about 250m from the perennial source of the river, a massive rock-face spring that provides a very stable discharge. This is in marked contrast to most of the other rivers surveyed, except the Río Casaño. The rich community was dominated by bryophytes typically found at other survey sites, but the liverwort *Riccardia* was recorded only here, as was blanketweed (*Cladophora*). Four taxa had cover values exceeding 5%, including the encrusting red alga *Hildenbrandia*.

Río Cares (Picos -19). 6 June 2008. HQA = 54; HMS = 100(2).
One site (500m). 43° 15′ 12.3″ N, 4° 50′ 16.7″ W.

Gorge, scree and blue water; Picos-19.

Sheer rock and scree banks; Picos-19.

Puente de la Jaya; Picos-19.

Located at the base of sheer rockfaces and scree in the spectacular Cares gorge, Picos-19 is one km upstream from Poncebos. The water is strikingly blue in colour, has a powerful flow and the channel substratum is a mixture of pebbles, cobbles and boulders. A stone Roman bridge marks the end of the site.

The macrophyte flora was very sparse. A black ‘slime’ covered many unshaded stones at the medium discharge level, caused by extensive growth of the alga *Hydrurus foetidus*. As on many rivers we surveyed, *Fissidens polyphyllus, Cinclidotus riparius, C. fontinaloides* and *Platyhypnidium* were common on submerged rock faces.

The hydropower unit at Poncebos is fed by water taken from the river near Caín, seven kms upstream and, in an incredible example of engineering, transported down the gorge in an artificial channel (Canal de la Electra del Viesgo) excavated into the precipitous valley side and including short tunnel sections.

Riffle on the Río Cares; Picos-19.

Río Burón (Picos-20). 8 June 2008. HQA = 70; HMS = 20(2).
One site (500m). 43° 10′ 32.9″ N, 4° 41′ 40.0″ W.

A steep, heavily-shaded stream two km north of the small settlement at Lon. It has a very complex in-channel habitat structure, with 22 pools, numerous cascades, riffles, side bars, fallen trees and woody debris. Broadleaf woodland, rock and scree dominate the left valley side, with some lightly grazed, unimproved pasture and woodland on the right.

A combination of dense tree-shade and a highly-mobile substratum means that macrophyte growth within the channel is very limited, and dominated by bryophytes. *Platyhypnidium* was the only species with a cover value exceeding 0.1% on the bed or at the base of the bank.

An almost unnoticeable 15m length of re-positioned boulders along the right bank represents the only channel modification. Further down the catchment, cattle grazing and improved pasture become more evident.

Step-pool sequences; Picos-20.

Boulders and fallen trees produce cascades; Picos-20.

Cattle graze the woodlands in several places; Picos-20.

Roman bridge; Rio Dobra, downstream from Picos-12.

APPENDIX 2: Recommendations for improving the RHS manual.

These recommendations are in addition to those made in the reports for Slovenia[16], Bavaria and the Tyrolean Alps[17], the Cévennes[18] and Poland[19].

Recommendations from the Picos de Europa visit

1 Walkie-talkie sets are used for sites in difficult terrain. They are useful to keep in contact when bankside vegetation is dense and river flow is very noisy. 'Line of sight' versions are relatively small and inexpensive.

2 'Hard hats' are worn in areas where rockfall is a possibility (e.g. areas with scree, cliffs).

3 In remote areas, site location is referenced using compass bearings to prominent natural features distinguishable on a map wherever possible or distance estimated to fixed features such as a bridge. Map-derived locational information is needed as back-up because GPS readings can be unreliable. Our Picos GPS readings differed from map estimations by up to 230m with no consistent pattern of variance (average discrepancy for northings, 78m; for westings, 66m). Because of variation in bedslope it is important to maximise confidence in location co-ordinates. Calibrating the GPS each day will also help.

4 Discrete deposits (silt, sand, gravel, cobble) are recorded as bankside features at spot-checks, because in steep-gradient rivers in particular they are a characteristic feature. For instance, they occurred in at least one spot-check in Picos-13, 14, 15, 16 and 19. It would ease the problem of differentiating between side bars and discrete deposits. A suitable new unique acronym would need to be derived.

5 Where minor bridges have foundations on bedrock outcrops above bankfull or trashline height they should not be scored in the HMS protocol because they do not modify the channel or bank. They are still recorded as 'minor bridge' but photographic evidence is needed to support HMS scoring decisions.

6 Dry-stone or other walls built for livestock and with foundations at or above bankfall (or trashline in deep vee valleys) are not recorded as "reinforced banktop". Walls built on banks that have been reprofiled and are obviously helping to prevent overtopping should be considered as "banktop reinforced".

7 The definition of riffle should emphasise the distinctiveness of the feature – i.e. unbroken wave flow type often diagonal to the channel, gravel-pebble substratum, separated by different flow types up and downstream, usually no longer than 3 times channel width (*see reference 25*).

8 Reaffirm that the 'chaotic flow' flow is genuinely only where several different faster flow-types cannot be separated into a single predominant one. Surveyors should always try to select one flow-type rather than rely on a chaotic flow as a 'catch-all'.

9 Reaffirm that the presence of "fallen trees" (i.e. one or more) recorded in Section K does not have to be at least 1% of channel length. An asterisk needs to be added to the RHS form and the explanatory text revised.

10 Reaffirm that guidance on trashline height in vee-shaped valleys with no obvious banktop should include other clues such as the top level of discrete deposits.

11 Reaffirm that the guidance on 'flush' features needs to be improved to emphasise the spring-fed nature of the feature to differentiate it from seasonally-flowing rivulets.

12 Reaffirm that for deep-vee valley bank modification assessment (Section K), banktop is determined by trashline level.

Additional relevant recommendations from observations on the River Drawa, Poland, August 2008

13 Much clearer guidance on natural berm, terrace and riparian floodplain is required. The progression from natural berm to riparian floodplain is particularly tricky, but nevertheless very important, because the definition and location of 'banktop' will influence bankface and banktop vegetation structure and land-use recording. For example:

- **natural berm** will generally have a distinct step profile, well below banktop or trashline height and vegetated with reeds, sedges and occasional shrubs or saplings; the feature is associated with actively down-cutting and migrating channels, which are relatively common in mainland Europe, but rarer in the UK where natural berms are more usually associated with readjustment (infilling) of over-widened modified channels;

Bridge footings well above trashline height.

Natural berms have distinct step profiles.

Riparian woodland; Drawa River, Poland.

Discrete sand deposit in cobble-gravel bed river, Poland.

- **riparian floodplain** will be near or at banktop or trashline height, with well established trees - again commonly associated with unmanaged riparian zones along migrating channels in mainland Europe but rare in the UK where land is often managed right to the channel edge;
- **terraces** will be above current bankfull/trashline height and marked by a break in slope caused by active natural down-cutting of the channel-bed.

14 Riparian (wet) woodland should be an additional land-use category recorded at spot-checks since this is a common feature of riparian floodplains in many parts of lowland Europe, although rare in the UK. It should be retained as a "special feature".

15 Marsh occurring on natural berms and riparian floodplains should be recorded as "wetland" in the land-use sweep-up (Section H). Not to be confused with the "fringing reed" feature of the bank margin and bankface.

16 Better definition is needed for discrete silt/sand/gravel deposit, (formed downstream from a natural or artificial obstruction in the channel or along the bank), to distinguish it from a side or point bar. A discrete deposit can be distinguished by its size and distinct contrast with the substratum in its immediate vicinity either on the river-bed or bank.

17 Terraced valley form is noted in Section B where glacial terracing is the predominant formation and valley form is otherwise indeterminate.

18 "Simple" vegetation structure is recorded where bankside tree roots alone form the predominant bankface feature. This is because bank structure categories reflect resistance to water flow and hence lateral erosion. As tree roots are woody, the bankface structure where they alone are present, is simple by definition.

Young riparian woodland growing on river terrace; Drawa River, Poland.

Glacial terraced valley form; Picos-17.

Marsh on river terrace; Drawa River, Poland.

Alder roots – counted as 'simple' bankface structure; Drawa River, Poland.

ANNEX A: Characteristics of the rivers surveyed. Superscripts represent site numbers.

	Rubó Picos-1, 2	Jano Picos-3	Casaño Picos-4, 5, 6, 7	Pelabarda Picos-8, 9	Dobra Picos-10, 11, 12	Salvorón Picos-13, 14, 15, 16	Nevandi Picos-17	Purón Picos-18	Cares Picos-19	Burón Picos-20
Predominant catchment geology†	Limestone, quartzite	Quartzite, sandstone	Limestone, quartzite	Limestone	Limestone	Sandstone, siltstone	Limestone, moraine	Limestone	Limestone	Limestone, sandstone
Predominant land-use	Scree, beech forest	Heathland	Beech forest	Beech forest	Beech forest	Beech forest	Oak woodland and pasture	Heathland and pasture	Rock and scree	Beech forest
Valley shape	Deep vee	Deep vee	Deep vee	Deep vee	Deep vee	Deep vee	Deep vee	Deep vee	Deep vee	Deep vee
Valley relief (m)	500m	150m	650m	300m	550m	650m	400m	150m	1200m	500m
Mid-site altitude (m)	220m[1] 120m[2]	142m	465m[4] 430m[5] 406m[6] 392m[7]	790m[8] 763m[9]	135m[10] 126m[11] 120m[12]	1360m[13] 1280m[14] 1190m[15] 1120m[16]	1050m	36m	230m	722m
Channel slope (m/km)	340/mkm[1] 120m/km[2]	30m/km	104m/km[4] 36m/km[5] 44m/km[6] 30m/km[7]	76m/km[8] 34m/km[9]	22m/km[10] 12m/km[11] 10m/km[12]	134m/km[13] 170m/km[14] 170m/km[15] 130m/km[16]	160m/km	14m/km	22m/km	120m/km
Distance from source (mid-point) (km)	4.0km[1] 4.5km[2]	4.1km	5.3km[4] 5.8km[5] 6.3km[6] 6.8km[7]	2.5km[8] 3.0km[9]	22.5km[10] 23.0km[11] 23.5km[12]	2.4km[13] 2.9km[14] 3.4km[15] 3.9km[16]	5.5km	2.0km	27.5km	3.4km
Height of source (m)	1010m	700m	1295m	1090m	1640m	1800m	1740m	290m	1800m	1970m
Water width (m)	5.0m[1] 3.5m[2]	4.5m	8.0m[4] 12.0m[5, 6] 11.0m[7]	4.5m[8] 7.5m[9]	10.0m[10] 15.0m[11] 17.5m[12]	3.0m[13] 4.0m[14] 7.0m[15] 5.5m[16]	2.2m	12.0m	26.0m	6.0m
Trashline channel width (m)	7.0m[1] 7.5m[2]	7.3m	12.0m[4] 15.0m[5] 16.0m[6] 14.5m[7]	7.5m[8] 10.5m[9]	20.0m[10] 25.0m[11] 24.0m[12]	5.0m[13] 6.0m[14] 8.0m[15, 16]	4.2m	15.0m	28.0m	8.0m
Predominant channel substratum*	Boulder-bedrock	Boulder	Boulder[4] boulder-cobble[5, 6] Cobble-bedrock[7]	Cobble-boulder[8] cobble[9]	Boulder-bedrock[10] cobble-boulder[11] cobble-pebble[12]	Boulder-cobble[13-16]	Boulder-pebble	Cobble	Cobble-pebble	Bedrock-cobble-pebble
Predominant flow type*	Chute	Unbroken waves	Chute - broken waves	Chute-rippled	Smooth-broken wave[10] Smooth-rippled[11] Rippled-smooth[12]	Chute-rippled[13] Chute-broken wave[14-16]	Chute-broken wave	Rippled	Rippled-broken wave	Chute-rippled
HQA	57[1] 58[2]	61	70[4] 71[5] 64[6] 58[7]	73[8] 70[9]	69[10] 69[11] 67[12]	72[13] 74[14] 71[15] 68[16]	65	65	54	70
HMS (and class)	100 (2)* 0 (1)	0 (1)	0 (1)[4-7]	0 (1) 0 (1)	0 (1) 0 (1) 40 (2)	0 (1) 0 (1) 400 (3)** 0 (1)	50 (2)	100 (2)**	100 (2)**	20 (2)
MTR score	68[1]	59	65[5] 67[7]	65[8] 70[9]	64[10] 67[11] 69[12]	67[13] 67[14]	60	60	59	62
Impacts on site	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Major weir upstream	Negligible	Negligible
Inside the National Park?	No	No	No	Yes	Mostly	Yes	Partly	No	Yes	No

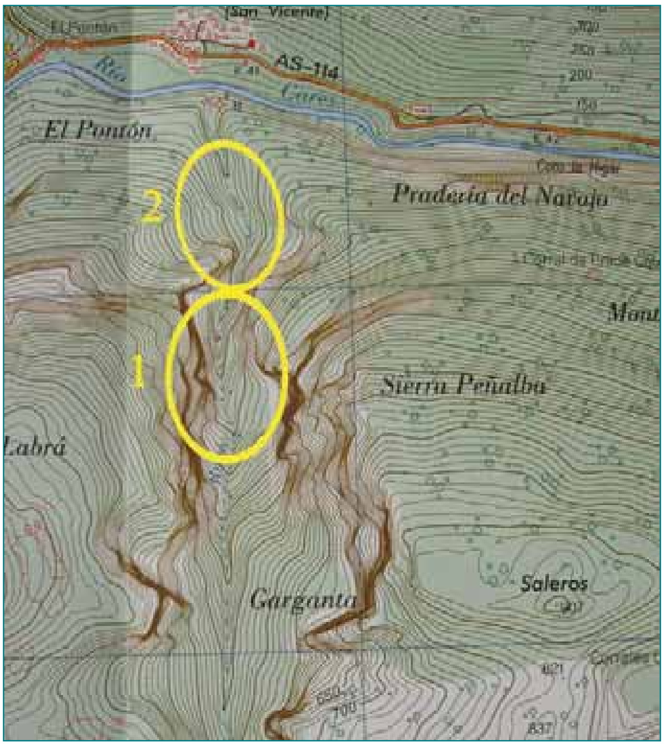
* recorded at 3 or more spot-checks
** see discussion for context
† see Annex B for detail

ANNEX B: River catchment geology. Figures represent approximate percentage of surface catchment area upstream from survey sites. Superscript refers to geology at individual Picos sites.

	Rubó	Jano	Casaño	Pelabarda	Dobra	Salvorón	Nevandi	Purón	Cares	Burón
Holocene/Pleicestocene deposits			<1	<1	5		40[17]		<1	5
Permian sandstones and siltstones		30								
Carboniferous limestones	75[1,2]	10	65	100[8,9]	95[10-12]	5	50	90	100[19]	60
Carboniferous conglomerates and sandstones			10[4]		<1				<1	
Carboniferous siltstones and sandstones						95[13-16]	10			35[20]
Devonian sandstones and conglomerates								<1		
Devonian conglomerates	5	5							<1	
Ordovician quartzites	20	50[3]	25[5-7]		<1[10-12]			10[18]		

Source: www.igme.es/internet/default.asp (Spanish Geological Institute)

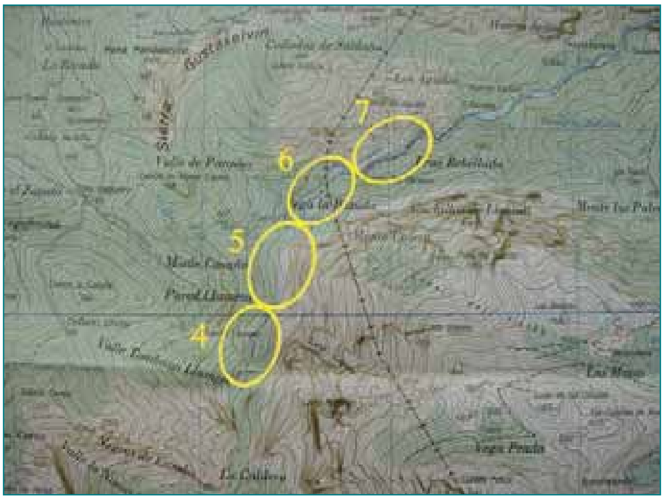
ANNEX C: Maps showing Picos-1 to Picos-20.



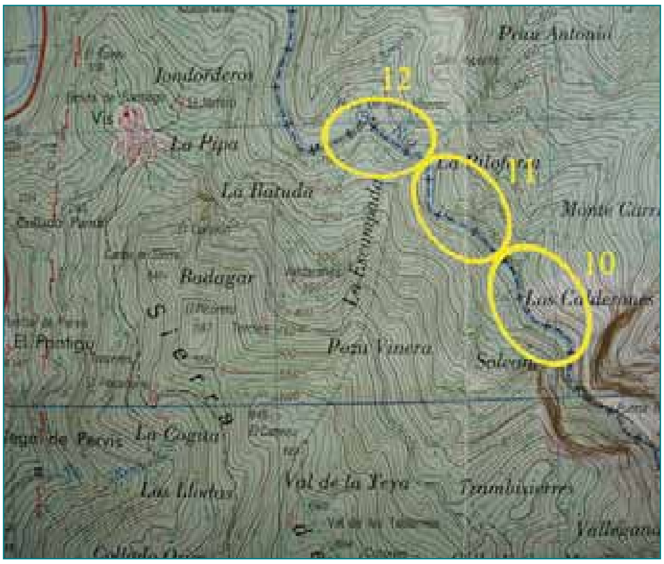
Picos-1 and 2.

Picos-3.

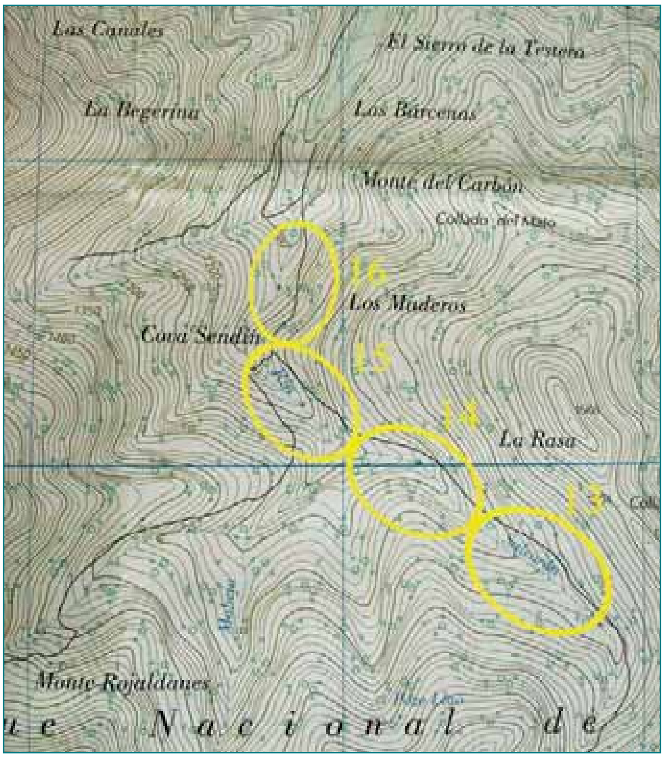
Picos-8, 9.



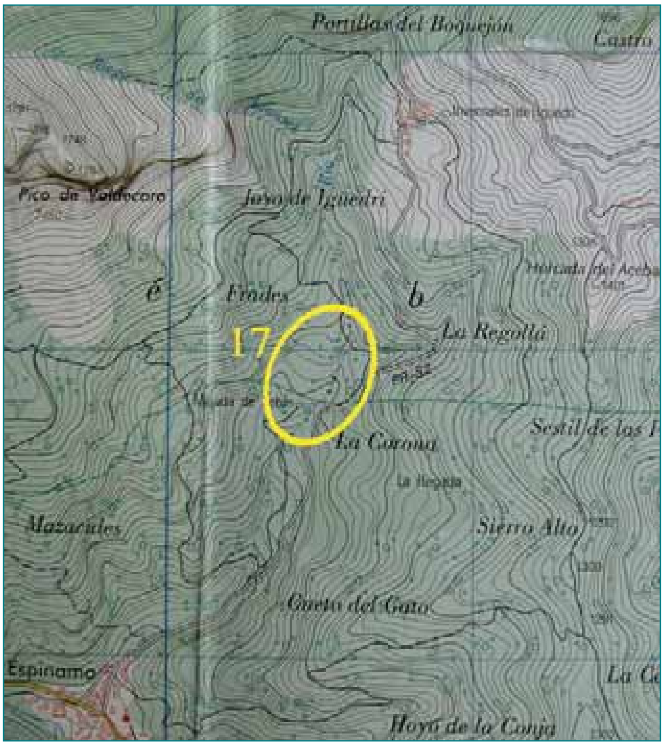
Picos-4, 5, 6, 7.



Picos-10, 11, 12.



Picos-13, 14, 15, 16.



Picos-17.

Picos-18.

Picos-19.

Picos-20.

ANNEX D: Water chemistry. Water pH and conductivity determined on-site by calibrated hand-held meter. Filtered water samples were collected in full sealed containers and subsequently analysed within 14 days.

Key: Total hardness scale as calcium carbonate: 'trace' = <30mg/l; 'very soft' = 30-70mg/l; 'soft' = 70-125mg/l; 'medium' = 125 – 250 mg/l.

Site reference and river name	Field determination by hand-held meter		Total dissolved phosphorus (µg/l)	Total hardness (Ca and Mg as $CaCO_3$)	Calcium, (mg/l)	Carbonate (mg/l $CaCO_3$)	Nitrate (mg NO_3-N/l)	Sulphate (mg/l)
	pH	Conductivity (µS cm^{-1})						
Picos-1, 2 (Rubó)	8.25	283	19.0	Soft	54	77	0.22	2.55
Picos-3 (Jano)	7.78	128	22.0	Very soft	30	35	Not detectable	3.92
Picos-4-7 (Casaño)	8.38	216	11.0	Soft	48	62	0.15	1.39
Picos-8, 9 (Pelabarda)	8.50	221	14.0	Soft	47	68	0.14	1.51
Picos-10-12 (Dobra)	8.17	220	11.0	Soft	48	59	0.16	2.40
Picos-13-16 (Salvorón)	7.95	67	11.0	Trace	17	24	0.04	2.45
Picos-17 (Nevandi)	8.55	297	14.0	Medium	62	86	0.66	4.03
Picos-18 (Purón)	8.23	240	12.0	Soft-medium	51	71	0.39	3.00
Picos-19 (Cares)	8.46	169	15.0	Very soft-soft	38	53	0.14	1.81
Picos-20 (Burón)	8.62	276	7.0	Soft-medium	44	74	0.20	3.17

ANNEX E: HQA sub-scores and total scores for Picos-1 to Picos-20.

Site number (Picos)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
HQA sub-score category																				
Flow-types	10	10	10	10	10	11	10	11	10	10	12	11	11	10	10	10	11	12	10	11
Channel substrata	7	8	7	8	8	8	7	7	7	10	9	9	9	7	8	8	7	8	9	9
Channel features	7	8	7	7	6	7	7	8	9	7	8	6	8	10	9	10	10	11	8	12
Bank features	0	0	2	3	2	2	2	5	3	7	4	6	2	4	2	2	2	5	2	8
Bank vegetation structure	9	11	12	12	12	12	12	11	12	11	12	12	10	12	11	10	10	11	5	9
In-stream vegetation	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	3	2	2
Land-use ‡	6	6	8	14	14	9	6	13	12	9	10	10	14	14	14	10	4	3	14	5
Trees and associated features	6	8	11	9	9	9	9	9	10	10	9	9	11	10	10	10	10	10	2	9
Special features ‡	10	5	2	5	8	4	3	7	5	3	3	3	5	5	5	6	9	2	2	5
Total HQA score	**57**	**58**	**61**	**70**	**71**	**64**	**58**	**73**	**70**	**69**	**69**	**67**	**72**	**74**	**71**	**68**	**65**	**65**	**54**	**70**

‡ assumptions made regarding near-natural land-use and special features

ANNEX F: HMS and habitat modification class for Picos-1 to Picos-20.

Site number (Picos)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
HMS score	100*	0	0	0	0	0	0	0	0	0	0	40	0	0	400*	0	50	100*	100*	20
Habitat modification class	2*	1	1	1	1	1	1	1	1	1	1	2	1	1	3	1	2	2*	2*	2

* see text for discussion on the context of these modifications.

Annex G: MTR survey results.

STR = Species trophic Rank; SCV = Species Cover value (scale 1-9); CVS – Cover value Score (STR x SCV)

Latin names	Common names	STR	Picos-1		Picos-3		Picos-5		Picos-7		Picos-8		Picos-9		Picos-10		Picos-11		Picos-12		Picos-13		Picos-14		Picos-17		Picos-18		Picos-19		Picos-20	
			SCV	CVS	SCV	CVS	SCV	CVS	SCV	CVS	SCV	CVS	SCV	CVS	SCV	CVS	SCV	CVS	SCV	CVS	SCV	CVS	SCV	CVS	SCV	CVS	SCV	CVS	SCV	CVS	SCV	CVS
Hildenbrandia rivularis	Red encrusting alga	6		0		0	1	6	1	6		0		0		0		0		0		0		0		0	3	18		0		0
Lemanea fluviatilis	Wire alga	7		0		0		0		0		0		0		0		0		0		0		0	1	7		0		0		0
Vaucheria sp(p.)	Yellow-green molepelt	1		0		0		0		0		0		0		0		0		0		0		0		0	1	1	1	1		0
Cladophora sp(p.)	Blanketweed	1		0		0		0		0		0		0		0		0		0		0		0		0	1	1		0		0
Chiloscyphus polyanthos	Liverwort	8		0		0	1	8	1	8		0		0		0		0		0	1	8		0		0	1	8	1	8		0
Pellia endiviifolia	Liverwort	6	1	6	1	6	2	12	1	6		0		0	1	6	1	6	1	6		0		0	2	12	2	12	1	6	2	12
Jungermannia sp.	Liverwort	8		0		0	1	8		0		0		0		0		0		0		0		0		0		0		0		0
Marsupella sp.	Liverwort	10	1	10		0		0		0		0		0		0		0		0		0		0		0		0		0		0
Scapania undulata	Liverwort	9		0	1	9		0		0		0		0		0		0		0		0		0		0	1	9		0		0
Amblystegium fluviatile	Moss	5		0	3	15	6	30	4	20	3	15	1	5	2	10	2	10	1	5	1	5	1	5	2	10		0		0	1	5
Brachythecium rivulare	Moss	8	1	8	1	8	1	8	1	8	2	16	2	16	1	8	1	8		0	1	8	1	8	1	8		0		0	1	8
Bryum pseudotriquetrum	Moss	9		0		0	1	9	1	9		0		0		0	1	9	1	9		0		0		0		0		0	1	9
Calliergon cuspidatum	Moss	8		0		0		0		0		0		0		0	1	8		0		0		0		0	1	8		0		0
Cinclidotus fontinaloides	Moss	5	1	5	1	5	2	10	3	15	3	15	2	10	4	20	3	15	3	15		0		0		0	5	25	4	20	1	5
Dichodontium flavescens.	Moss	9		0	1	9	3	27		0	1	9	1	9	1	9	1	9	1	9		0		0		0	2	18	1	9		0
Dichodontium pellucidum agg.	Moss	9		0		0		0		0	1	9	1	9	1	9		0		0	1	9	1	9	1	9	1	9		0		0
Fontinalis antipyretica	Moss	5		0		0	5	25		0		0		0	2	10	1	5	1	5		0		0		0		0		0		0
Platyhypnidium riparioides	Moss	5	1	5	1	5	1	5	4	20	5	25	3	15	3	15	2	10	1	5	2	10	3	15	5	25	5	25	4	20	4	20
Hygrohypnum luridum	Moss	9		0		0	2	18	2	18	1	9	1	9	1	9	1	9	2	18		0		0		0	1	9	2	18	1	9
Hygrohypnum ochraceum	Moss	9		0		0	1	9	2	18	2	18	2	18	2	18	2	18	2	18		0	1	9		0		0		0		0
Racomitrium aciculare	Moss	10		0		0		0	2	20		0		0		0		0		0		0		0		0		0		0		0
Thamnobryum alopecurum	Moss	7	1	7	1	7	3	21	1	7	4	28	3	21	2	14	1	7	1	7	1	7	2	14	2	14	2	14	1	7		0
Sub-scores for calculating MTR Scores			6	41	10	64	30	196	23	155	22	144	16	112	20	128	17	114	14	97	7	47	9	60	14	85	26	157	15	89	11	68
MTR Scores			**68**		**64**		**65**		**67**		**65**		**70**		**64**		**67**		**69**		**67**		**67**		**60**		**60**		**59**		**62**	

Annex H: JNCC macrophyte survey results.

Figures (1-3) are relative and absolute estimates of cover within the river channel (first two figures) and the water edge/margin (second two figures). For more details, see JNCC reference[2]. Where only two figures, taxon only present at margin.

Latin names	Common names	Picos-1	Picos-3	Picos-4	Picos-5	Picos- 6	Picos-7	Picos-8	Picos-9	Picos-10	Picos-11	Picos-12	Picos-13	Picos-14	Picos-15	Picos-17	Picos-18	Picos-19	Picos- 20
Hildenbrandia rivularis	Red encrusting alga				1100	1100	1100											3300	
Lemanea fluviatilis	Wire alga															1100			
	Blue-green algal scum				1100		1100			3221	1111	1111	1111	1111	1111		1122	2222	2121
Vaucheria sp(p.)	Yellow-green molepelt																1111		1100
Cladophora/Rhizoclonium	Blanketweed																1100		
	Filamentous green algae									1100	1100	2200	1100	1100	1100			2200	
	Encrusting lichens			1111	1111	1111	1111	11	11	11	11	11	11				1111		
	Foliose lichens			1111	1111			11	11	11	11	11							
Chiloscyphus polyanthos	Liverwort			1111	1111	1111	1111						1111	1111	1111		2211	1111	1111
Conocephalum conicum	Liverwort	21	11	11		11	11	11	11	11	11	11					22	1111	11
Jungermannia sp.	Liverwort				1111				1111										
Lunularia cruciata	Liverwort					11					11						11	1111	
Marchantia polymorpha	Liverwort			11	11	11	11			11	11	11					11	1111	
Marsupella sp.	Liverwort	1111																	
Pellia endiviifolia	Liverwort	1121	1111	1111	1111	1111	1111	1111	1111	1111	1122	1111				1121	2233	1122	2121
Riccardia chamedryfolia	Liverwort																2222		
Scapania sp.	Liverwort	1111	1111														1111		
Amblystegium fluviatile	Moss	3232	3222	3222	3333	3322	3222	2222	1111	3222	3222	3222	1111	1111	1111	1121	2211	1111	1100
Brachythecium rivulare	Moss	2132	2132	22	1122	1122	1122	33	1132	11	11	11	1121	1121	1132	1132	1122	1122	21
Bryum pseudotriquetrum	Moss					1111	11		1111	11									
Calliergonella cuspidatum	Moss						11				1111	11					1111	11	
Cinclidotus fontinaloides	Moss	2121	1111	2232	2222	2222	3222	2222	2232	2232	2232	2232					3333	2233	1111
Cratoneuron filicinum	Moss	1111		1111	1121	1111		1111	11		1111					2121		1111	1122
Dichodontium pellucidum agg.	Moss	1121	2133	22	1122	1122	1122	1122	1122	1122	1122	1122	1121	1121	1121	1111	1122	1122	
Fontinalis antipyretica	Moss				2211	11				2211	1111	1111							
Hygrohypnum luridum	Moss	1111			1111	2211	1111	1122	1122	2222	2222	2232					1111	1111	1111
Hygrohypnum ochraceum	Moss			1111	1111	1122	2211	1111	1111				1111					1111	
Orthotrichum sp.	Moss				11	11	11												
Philonotis fontana	Moss								1111										
Platyhypnidium riparioides	Moss	1111	1111	1111	1111	1111	1111	3311	3222	2222	2222	1111	3221	3232	3232	3333	3322	3232	3232
Racomitrium aciculare	Moss	11	2121											1121	1121				
Schistidium rivulare	Moss			11	21	22	1111	11	11	11	11	11	11	21	21	11	1111	1122	11
Thamnobryum alopecurum	Moss	1132	2122	1133	1133	1133	1133	2233	1132	1122	1122	1122	1132	1132	2132	1132	2222	1122	21
Osmunda regalis	Royal Fern		1121														1100		
	Other ferns	21	21		11	22	22	11	11		11	11	11	11	11	21	11	11	11
Angelica sylvestris	Wild Angelica				11	11	11	11	11							11			
Apium nodiflorum	Fool's Water-cress				2211							1111							
Callitriche stagnalis	Common Starwort																1100		
Caltha palustris	Marsh Marigold				11														
Eupatorium cannibinum	Hemp Agrimony		11															1111	11
Lotus pedunculatus	Marsh Trefoil					11	11		11										
Mentha aquatica agg.	Water Mint			11	1111	1111	1111		1111	1111	1111	1111					1111	1122	1111
Myosotis scorpioides	Water For-get-me-not				1111														
Potentilla erecta	Common Tormentil		11		11	11	11												
Sagina procumbens	Pearl-wort		32	11	11	11	11										11		
Scrophularia auriculata	Water Figwort				11	11	11					11				1111	11	1111	

Annex H: continued

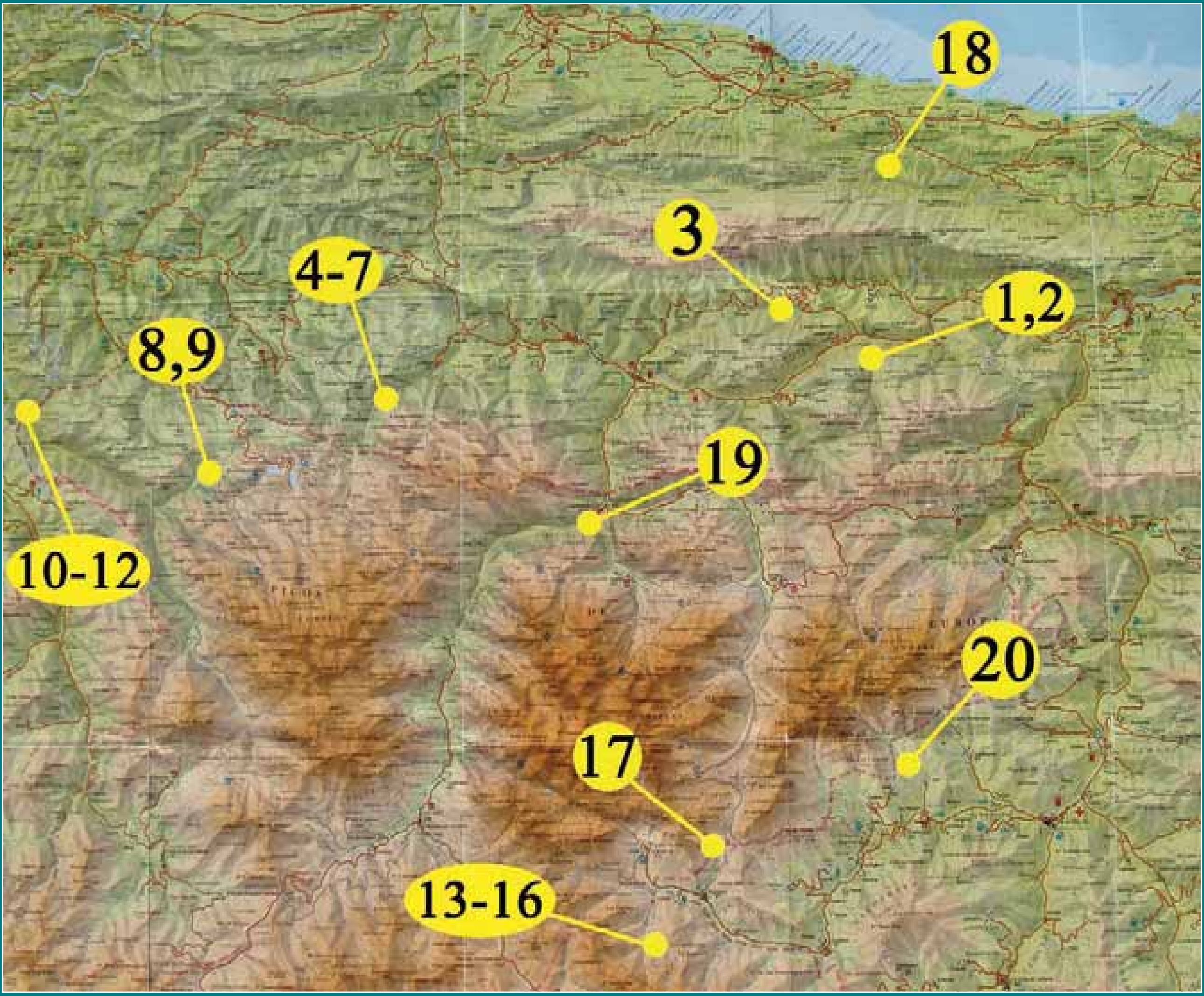
Latin names	Common names	Picos-1	Picos-3	Picos-4	Picos-5	Picos- 6	Picos-7	Picos-8	Picos-9	Picos-10	Picos-11	Picos-12	Picos-13	Picos-14	Picos-15	Picos-17	Picos-18	Picos-19	Picos- 20
Senecio aquatica	Marsh Ragwort																11		
Tussilago farfara	Colt's-foot										11	1111							
Alnus sp(p.)	Alder			1121			1111			11	11	11					1111		
Salix spp.	Willow			1121	11	11	1111				1122	1111			11				
	Other trees	11	11	1121	11	11	11				11	11	1111	1121	1121	1132	1122	11	
	other dicotyledons	21	21	11	22	22	11	11	11	11	11	11	21	21	1121	11	22	11	
Carex nigra	Common Sedge						11		11										
Carex pendula	Pendulous Sedge											11							
Carex remota	Remote Sedge			11	11		11												
Carex viridula	Yellow-sedge			11					11										
Glyceria notata/fluitans	Sweet-grass								1111										
Juncus effusus	Soft Rush			11	11	11	11												
Juncus inflexus	Hard Rush				11	11	11				11	11							
Phalaris arundinacea	Reed Canary-grass									11									
	Other monocotyledons	21	21	11	11	11	11	11	11	11	11	11	21	1121	1121	21	1122	11	11
Non Check-list species																			
Nostoc sp(p.)	Blue green alga		2100	1100	1100	1100	1100			1111	1111	1100							
Hydrurus foetidus	Chrysophyte alga																	3300	
Collema sp(p.)	Foliose lichen			1111	1111			11	11	11	11	11							
Plagiochila asplenioides	Liverwort																		11
Neckera complanata	Liverwort	11										11	11						
Amblystegium tenax	Moss												1111	1111	1111	1121	2211	1111	1111
Bryum dichotomum	Moss				11	11	11												
Cinclidotus riparius	Moss			3222	2222	2222	2211	2222	222	3221	3211	3221					3311	3211	
Didymodon spadiceus	Moss						11							11	11				
Eucladium verticillatum	Moss															11			
Fissidens polyphyllous	Moss				2211	3311	2211	1111		2200	1100	3200					1100	2200	
Grimmia hartmanii	Moss																		11
Mnium hornum	Moss			32	11	11	11	11	11				11	11		11	11		
Palustriella commutatum	Moss	11			1122	1111		1111			1111					1122			1111
Plagiomnium rostratum	Moss		21	21	11	11	11	11	11	11	11	11	11	11	11	21	22	11	11
Plagiomnium undulatum	Moss		21		11	11		11	11				11	11	11	11	11		
Rhizomnium punctatum	Moss		21		11	11		11	11								11		11
Scleropodium cespitans	Moss													11	11				
	Other woodland mosses	21	32	11	22	11	11						11	21	21	21			
Equisetum arvense	Creeping Horse-tail			1121	1111	1111	1111		11	1111	1111	1111					1111	1111	
Euonymus europaeus	Spindle			11															
Cardamine raphanifolia	Iberian Bitter-cress	1111	1111		1121	1111	1111	1111					1111	1111	1121				
Carex strigosa	Wood Sedge				11														
Chrysosplenium oppositifolium	Opposite-leaved Golden-saxifrage	11	11	11	11									11	11	11	1111	1111	
Luzula sylvatica	Great Wood-rush												21	1121	1121				
Myosotis palustris	Marsh For-get-me-not												21	1121	1121				
Prunella vulgaris	Selfheal			11															
Saxifraga granulata	Meadow Saxifrage			11	11	11	11												
Valeriana sp.	Valerian							1111	1111							1111	1111		

ANNEX I: Selected habitat features and *ad hoc* observations of wildlife.

Key:Habitat features: P = present; E = extensive. Species present indicated by •.

	Rubó Picos-1, 2	Jano Picos-3	Casaño Picos-4, 5, 6, 7	Pelabarda Picos-8, 9	Dobra Picos-10, 11, 12	Salvorón Picos-13, 14, 15, 16	Nevandi Picos-17	Purón Picos-18	Cares Picos-19	Burón Picos-20
Habitat features										
Major springs			P			P				
Waterfalls	P			P			P			P
Debris dams			P	P			P			P
Herb-rich meadows	P		P			P	E			P
Wildlife observations										
Black woodpecker (*Dryocopus martius*)					•					
Booted eagle (*Hieraaetus pennatus*)									•	
Crag martin (*Ptyonoprogne rupestris*)	•				•	•			•	
Dipper (*Cinclus cinclus*)	•	•	•	•	•	•	•	•	•	•
Grey wagtail (*Motacilla cinerea*)			•	•	•			•		
Goshawk (*Accipter gentilis*)					•					
Griffon vulture (*Gyps fulvus*)	•			•		•			•	
Kingfisher (*Alcedo atthis*)					•					
Red-billed chough (*Pyrrhocorax pyrrhocorax*)	•					•			•	
Short-toed eagle (*Circaetus gallicus*)									•	
Banded demoiselle (*Calopteryx splendens*)		•								
Beautiful demoiselle (*Calopteryx virgo*)					•					
Otter (*Lutra lutra*) (spraints, footprints)			•		•					
Wild boar (*Sus scrofa*) (uprooting of earth)		•	•	•	•	•	•			

Herb-rich meadows with plenty of orchid species, such as tongue orchid (*Serapias*), were common.



Source: Los Picos de Europe y Costa Oriental de Astorias; Miguel A. Adrados

APPROXIMATE LOCATIONS OF SITES SURVEYED

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