




RIVER HABITAT SURVEY IN SOUTHERN PORTUGAL

RESULTS FROM 2009

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CONTENTS

REFERENCES

1. Environment Agency (2003). *River Habitat Survey in Britain and Ireland*. Field Survey Guidance Manual: 2003. Bristol.
2. Holmes, N T H, Boon, P J and Rowell, T A (1999). *Vegetation Communities of British Rivers: A Revised Classification.* Joint Nature Conservation Committee, Peterborough.
3. Holmes, N T H, Newman, J R, Chadd, S, Rouen, K J, Saint, L and Dawson, F H (1999). *Mean Trophic Rank: A User's Manual.* R&D Technical Report E38, Environment Agency, Bristol.
4. Furse, M T, Hering, D, Brabec, K, Buffagni, A, Sandin, L and Verdonschot, P F M (Eds) (2006). The ecological status of European rivers: evaluation and intercalibration of assessment methods. *Hydrobiologia,* 566: 1-555.
5. CEN (draft – unpublished). *Water Quality – Guidance Standard on Determining the Degree of Modification of River Hydromorphology.*
6. Cortes, R M V, Hughes, S J, Varandas, S G, Magalhães, M and Ferreira, T (2009). Habitat variation at different scales and biotic linkages in lotic systems: consequences for monitorisation. *Aquatic Ecology.* DOI 10.1007/SI0452-009-9228-9.
7. Agricultural University of Poznań (2009). *Hydromorfologiczna Ocena Wód Płynących (River Habitat Survey Manual).* Poznań, Poland.
8. Raven, P J, Holmes, N T H, Dawson, F H, Fox, P J A, Everard, M, Fozzard, I and Rouen, K J (1998). *River Habitat Quality: the Physical Character of Rivers and Streams in the UK and the Isle of Man.* Environment Agency, Bristol.
9. Jeffers, J N R (1998). Characterisation of river habitats and prediction of habitat features using ordination techniques. *Aquatic Conservation, Marine and Freshwater Ecosystems,* 8, 529-540.
10. Vaughan, I P (in press). Habitat indices for rivers: derivation and applications. *Aquatic Conservation, Marine and Freshwater Ecosystems, Special Issue.*
11. Vaughan, I P, Noble, D G and Ormerod, S J (2007). Combining surveys of river habitats and river birds to appraise riverine hydromorphology. *Freshwater Biology,* 52, 2270-2284.
12. Walker, J, Diamond, M and Naura, M (2002). The development of physical quality objectives for rivers in England and Wales. *Aquatic Conservation, Marine and Freshwater Ecosystems,* 12, 381-390.
13. Raven, P J, Holmes, N T H, Dawson, F H and Everard, M (1998). Quality assessment using River Habitat Survey data. *Aquatic Conservation, Marine and Freshwater Ecosystems,* 8, 405-424.
14. Raven, P J, Holmes, N T H, Charrier, P, Dawson, F H, Naura, M and Boon, P J (2002). Towards a harmonised approach for hydromorphological assessment of rives in Europe: a qualitative comparison of three survey methods. *Aquatic Conservation, Marine and Freshwater Ecosystems,* 12, 477-500.
15. CEN (2004). *Water quality: guidance standard for assessing the hydromorphological features of rivers.* EN 14614: 2004. European Committee for Standardisation.
16. Gasith, A, and Resh, V H (1999). Streams in Mediterranean climate regions: Abiotic influences and Biotic Responses to Predictable Seasonal Events. *Annual Review of Ecological Systems,* 30, 51-81.
17. Magalhães, M F, Beja, P, Schlosser, I J and Collares Pereira, M J. (2007). Effects of multi-year droughts on fish assemblages of seasonally drying Mediterranean streams. *Freshwater Biology,* 52, 1494-1510.
18. Bonada, N, Zamora Muñoz, C, Rierdevall, M and Prat, N. (2005). Ecological and historical filters constraining spatial caddisfly distribution in Mediterranean rivers. *Freshwater Biology,* 50, 781-797.
19. Magalhães, M F, Beja P, Canas, C and Collares Pereira, M J. (2002). Functional heterogeneity of dry-season fish refugia across a Mediterranean catchment: the role of habitat and predation. *Freshwater Biology,* 47, 1919-1934.
20. Hughes, S J, Ferreira, T, and Cortes, R V (2008). Hierarchical spatial patterns and drivers of change in benthic macroinvertebrate communities in an intermittent Mediterranean river. *Aquatic Conservation, Marine and Freshwater Ecosystems,* 18, 742-760.
21. Hooke, J M (2006). Human impacts on fluvial systems in the Mediterranean region. *Geomorphology,* 79, 311-335.
22. Raven, P J, Holmes, N T H, Dawson, F H, and Withrington, D (2005). *River Habitat Survey in Slovenia. Results from 2005.* Environment Agency, Bristol.
23. Raven, P J, Holmes, N T H, Dawson, F H, Binder, W and Mühlmann H (2007). *River Habitat Survey in Southern Bavaria and the Tyrolean Alps. Results from 2006.* Environment Agency, Bristol.
24. Raven, P J, Holmes, N T H, and Dawson, F H (2007). *River Habitat Survey in the Ardèches and Cévennes areas of South-eastern France. Results from 2007.* Environment Agency, Bristol.
25. Raven, P J, Holmes, N T H, Scarlett, P, Szoszkiewicz, K, Ławniczak, A and Dawson, F H (2008). *River Habitat and Macrophyte Surveys in Poland. Results from 2003 and 2007.* Environment Agency, Bristol.
26. Raven, P J, Holmes, N T H, Scarlett, P, Furse, M and Ortiz, J B (2009). *River Habitat Survey in the Picos de Europa, Northern Spain. Results from 2008.* Environment Agency, Bristol.
27. Buffagni, A, and Kemp, J L (2002). Looking beyond the shore of the United Kingdom: addenda for the application of River Habitat Survey in Southern European rivers. *Journal of Limnology,* 61, 1999-214.
28. Vasson, J-G, Candesris, A, Garcia-Bautista, A, Pella, H and Vaileneuve, B (2006). *Combined pressures and geographical context: hydro-ecoregions framework.* Cemagref. REBECCA project report; produced for Finnish Environment Ministry. 40pp.
29. INAG, I.P. (2008). *Tipologia de Rios em Portugal Continental no âmbito da implementação da Directiva Quadro da Água. I – Caracterização abiótica.* Ministério do Ambiente, do Ordenamento do Território e do Desenvolvimento Regional. Instituto da Água, I.P.
30. Hughes, S J, Santos, J M, Ferreira, M T, C, Caraça, R and Mendes, A M (2009). Ecological assessment of an intermittent Mediterranean river using community structure and function: evaluating the role of different organism groups. *Freshwater Biology,* D01:10.1111/j.1365-2427.2009.02253.x.
31. National Research Council (NRC) (2002). *Riparian Areas: Functions and Strategies for Management.* The National Academies Press, Washington, DC.
32. LAWA (2000). *Gewässerstrukturgütebewertung in der Bundesrepublik Deutschland, Verfahren für kleine und mittlegroße Fließgewässer,* Berlin.
33. Munné, A Prat, N, Solà, C, Bonada, N and Rierradevall, M (2003). A simple field method for assessing the ecological quality of riparian habitat in rivers and streams: QBR index. *Aquatic Conservation: Marine and Freshwater Ecosystems,* 13, 147-163.
34. Branson, J, Hill, C, Hornby, D D, Newson, M and Sear, D (2005). *A Refined Geomorphological and Floodplain Component River Habitat Survey (GeoRHS).* R&D Technical Report SCO20024/TR. Environment Agency, Bristol.
35. Ferreira, M T, Rodríguez-González, P M, Aguiar, F C, Albuquerque, A (2005). Assessing biotic integrity in Iberian rivers: development of a multimetric plant index. *Ecological Indicators,* 5, 137-149.
36. Raven, P J, Holmes, N T H, Vaughan, I, Dawson, F H and Scarlett, P (in press). Calibrating habitat quality: observations using River Habitat Survey in northern and western Europe. *Aquatic Conservation, Marine and Freshwater Ecosystems, Special Issue.*

WEB SITES

Google Earth: http://earth.google.com/index.html
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

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
INAG	Instituto da Água (Portuguese Water Institute)
JNCC	Joint Nature Conservation Committee
LAWA	Länderarbeitsgemeinschaft Wasser (German National Association of Water)
MTR	Mean Trophic Rank
PCA	Principal Components Analysis
Port-1,etc.	Reference code to identify individual sites surveyed in Portugal
REBECCA	Relationships between ecological and chemicals status of surface waters
RHS	River Habitat Survey
RVI	Riparian Vegetation Index
SCI	Site of Community Interest
STR	Species Trophic Rank
STAR	STAndardisation of River Classifications
UTAD	University of Trás-os-Montes e Alto Douro
WFD	Water Framework Directive
WISE	Water Information System in Europe

PURPOSE

The purpose of our visit was threefold: (i) to test River Habitat Survey (RHS) and macrophyte surveys on a selection of Mediterranean rivers in southern Portugal (16-18 April 2009); (ii) to provide training for RHS surveyors in Portugal (20-23 April 2009); (iii) to give advice on an effective sampling and training strategy for RHS in Portugal.

Specific objectives were to:

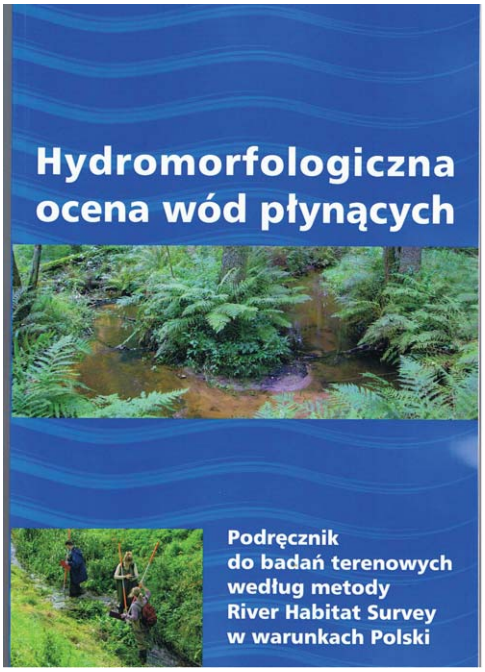
- Locate and survey a selection of rivers using RHS[1], plus the Joint Nature Conservation Committee (JNCC)[2] and Mean Trophic Ranking (MTR)[3] macrophyte survey methods.
- Collect RHS and macrophyte data for European inter-calibration purposes and add them to the database already established for the 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 Mediterranean rivers, taking account of features characteristic of southern Portugal.
- Provide training support and advice on quality assurance, database development and technical capacity-building for future RHS work in Portugal.

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 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 protocol given in the 2003 RHS Manual[1] and surveyors in the UK are required to be fully trained and accredited.

Beyond the UK, RHS has also been carried out in several other European countries. For instance, more than 200 RHS surveys were included during the STAR project[4] (Figure 2); in addition, 200 sites have been surveyed in Italy; more than 600 in Poland, and a further 400 in the Cantabrian Region of northern Spain. Portugal has decided to adopt RHS as one of its methods for Water Framework Directive (WFD) work and more than 400 sites have been surveyed for WFD implementation purposes. As part of this work, in 2004-5, sixteen river catchments across Portugal were sampled using RHS in a study of the geographical variation in river habitat, the impact of human influence and an assessment of habitat-biota associations[6]. This involved surveying 299 sites, of which about half were considered to have channels in a predominantly undisturbed condition. A further 86 RHS sites have been surveyed on Madeira. The RHS Manual[1] has been adapted and translated into Italian, French and Polish[7], whilst a Portuguese version is also being developed.



The 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 22,000 surveys undertaken since 1994. During 1994-96, a stratified random network of nearly 5000 sites provided baseline information from the physical character of a geographically representative sample of streams and rivers across the UK[8]. A second stratified random survey was carried out during 2007 and 2008 and a report on the state of river habitats in England and Wales and trends since the initial baseline will be published in March 2010.

The RHS database allows sites of a similar nature to be grouped together for comparative purposes. Channel 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 Components Analysis (PCA) plots[9]. A more sophisticated context analysis, using field survey data to derive seven indices of river channel character has now been developed[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 use of 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].

RHS records morphological features that can then be related to habitat suitability for species such as dipper.

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].

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, large 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 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. bedslope, 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 aquatic macrophyte surveys in reaches of known good or high quality has provided the necessary calibration of HQA across a wide range of river types. Between 1994 and 2009, this 'benchmarking' exercise has involved 181 RHS sites on 82 rivers in Britain and Ireland. These specially targeted 'benchmark' surveys have been extended to mainland Europe, including rivers in Finland, Norway, Slovenia, Bavaria, the Tyrolean Alps, the Cévennes in south-eastern France, Poland and the Picos de Europa, northern Spain (Figure 1). Our surveys in southern Portugal represent a further component of this mainland European work, which now comprises 114 RHS sites on 62 rivers. Comparison of RHS and other habitat assessment methods has also been part of this European-wide initiative[14].

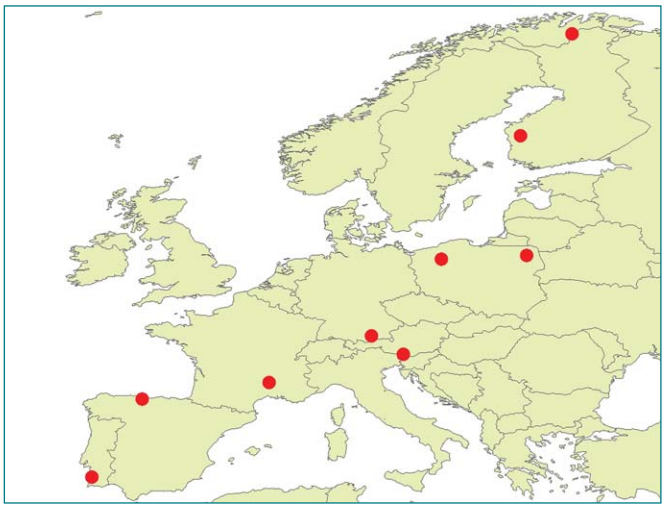


Figure 1 Locations in mainland Europe where 'benchmark' surveys undertaken.

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

Many rivers in Portugal are heavily modified and regulated.

total provides the Habitat Modification Score (HMS). A Habitat Modification Class (HMC) has been developed which allocates a site into one of five modification classes, based on the total score (1 = semi-natural; 5 = severely modified). In contrast to HQA, higher scores reflect more artificial intervention and modification of the river channel within a site.

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 recording of morphological features. 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 been used already for WFD purposes to help 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 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 *Hydrobiologia* in 2006[4].

Aquatic macrophyte surveys

When undertaking benchmark 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 for recording and to aid interpretation of results. 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, floristic and landscape character differ.

CHARACTERISTICS OF MEDITERRANEAN RIVERS

Climatic and human influence

Mediterranean rivers are physically, chemically, and biologically influenced by sequential and seasonally predictable flooding and drought events. These vary in intensity according to the amount and duration of annual and inter-annual rainfall levels. Mediterranean river systems can show major changes in flow regime over relatively short periods of time, ranging from spate conditions, when side channels carry flood flows and new channels can be formed, to intermittent reaches characterised by isolated pools separated by lengths of dry river bed during the hot summer period[16]. This extreme variation can lead to rapid changes in channel substrata and flow type and strongly influences aquatic biological community traits and distribution patterns[17-20]. Aquatic Mediterranean flora and fauna are ecologically adapted to severe conditions, whilst woody riparian vegetation and terrestrial plants are often found in the channel of intermittent streams and rivers. Flow and substratum variability determine riparian seed dispersal and also the occurrence of lotic habitats that provide important refuge areas for macroinvertebrates and juvenile fish[19].

These extreme environmental factors can also make it difficult in some cases to separate the effects of natural hydromorphological processes from those resulting from human intervention. Iberian Mediterranean rivers and their catchments have a very long history of human intervention, including intensive agriculture and forestry, dam construction, water abstraction and urbanisation[21]. This has resulted in extensive habitat fragmentation, soil erosion, disrupted longitudinal connectivity along rivers and alteration of natural flow regimes. These impacts

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

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

Many rivers are intermittent, with stretches remaining dry for several months.

affect river structure and function in systems already subject to a harsh natural seasonal cycle of drought and flood.

Nature conservation interest of our study areas

In a Mediterranean context of water scarcity and environmental extremes, fluvial ecosystems have considerable intrinsic conservation value and require special protection to maintain their composition, structure and function. For example, permanent Mediterranean rivers with *Paspalo-Agrostidion* species and hanging curtains of willows *Salix* spp. and white poplar *Populus alba* and intermittently-flowing Mediterranean rivers of the *Paspalo-Agrostidion* are listed in Annex I of the European Habitats Directive (92/43/EEC). Both are widespread in Portugal.

Two of our survey areas are located within Sites of Community Importance (SCIs) in the Mediterranean biogeographical region, classified under the Habitats Directive. The Vascão and Odeleite rivers are partially within Guadiana and Caldeirão SCIs respectively.

Riparian galleries of trees and shrubs are common.

Cistus – a widespread colonising shrub.

SCI Guadiana has key areas of arborescente matorral with *Juniperus turbinate* subsp. *turbinate*, holm oak *Quercus rotundifolia* and also significant areas of *montados* - Dehesas with evergreen oak *Quercus* spp., several small areas of *Ceratonia siliqua* forest and temporary ponds. Riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*), Oro-Iberian *Festuca indigesta* grasslands and *Salix alba/Populus alba* galleries are important habitats associated with Mediterranean intermittent rivers. Plant species of special interest associated with those habitats are *Marsilea batardae, Salix salvifolia* subsp. *australis* and *Festuca duriotagana*.

These aquatic habitats and associated features are of special ecological value for several animal species, notably: Iberian painted frog *Discoglossus galganoi*; marbled newt *Triturus marmoratus*; natterjack toad *Bufo calamita*; Iberian green frog *Rana perezi*; European pond terrapin *Emys orbicularis*; Spanish terrapin *Mauremys leprosa*. Saramugo *Anaecypris hispanica* and Guadiana nase *Pseudochondrostoma willkomii* are fish species endemic to the Guadiana river basin. Comizo barbel *Luciobarbus comizo*, small-head barbel *Luciobarbus microcephalus* and minnow *Iberochondrostoma lemmingii* are Iberian endemic fishes. Invertebrates of special conservation interest include the thick-shelled river mussel *Unio crassus*, the damselfly *Coenagrion mercuriale* and the dragonfly *Oxygastra curtisii*. European otter is common.

The **SCI Caldeirão** landscape is dominated by extensive areas of *Cistus* spp. and *montados* - Dehesas and evergreen oak *Quercus* spp., with a well-developed scrub and shrub understorey. Pseudo-steppe with grasses and annuals of *Thero-Brachypodietea* can occur on dry fallow agriculture land, whereas on steep and moist areas there can be dense cover of arborescente matorral, featuring strawberry tree *Arbutus unedo* and cork oak *Quercus suber* forest. Like the SCI Guadiana, intermittent Mediterranean rivers of the *Paspalo-Agrostidion* habitat areas are associated with southern riparian galleries and thickets, which are also important to saramugo and minnow. Otters are also common.

Typical Alentejo-Algarve landscape showing riparian woodland and scrub.

SURVEY AND ASSESSMENT

The primary purpose of our brief study was to locate and survey near-natural examples of rivers to calibrate RHS and macrophyte results. In Portugal many rivers are dammed and regulated for hydro-electric power (HEP) and water storage purposes, so there are very few examples of unmodified river channels in natural "wild wood" catchments or extensive wetland landscapes. We therefore focused on areas where river regulation was not a major impact. In preparation for our visit, we used a combination of large-scale maps, *Google Earth* images, previous RHS surveys[6] and advice from local biologists to confirm the suitability of rivers, but the precise location of our RHS sites was determined on arrival. Our final selection represented some examples of Mediterranean-type rivers that were suitable for calibration and benchmarking purposes (Annex A).

Many rivers in Portugal are regulated by large dams.

The rivers we surveyed were typical of the Alentejo geology and landscape of southern Portugal (Annex B and C). Visiting sites with colleagues from the Instituto da Água (INAG) provided a good opportunity for discussion on the difficulties of applying standard RHS to Mediterranean rivers (see '*Applying RHS in Portugal*').

River Habitat Survey was undertaken by Paul Raven assisted by João Pádua, Samantha Hughes and João Ferreira. Nigel Holmes carried out macrophyte surveys on all the rivers visited, using the JNCC[2] and MTR methods[3] at all eight RHS sites respectively. Water chemistry and biological water quality data for monitoring sampling points close to our RHS sites were provided by INAG.

The weather during survey work was rather cool and cloudy for the time of year. Water levels were not affected by showers and heavy overnight rain during our visit. By contrast, two weeks before our visit some sections of river had been much lower following a prolonged spell of dry weather.

Calculation of HQA and HMS scores was based on the 2005 version (2.1) of these systems – in similar fashion to that done for sites surveyed in Slovenia[22], the Bavarian and the Tyrolean Alps[23], the Cévennes[24], Poland[25] and Picos de Europa[26]. This means that assumptions were made about the inclusion and scoring of special features and land-use (*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 these are available on request. Site numbers, prefixed with "Port" are unique codes that identify individual survey results in the database.

Eight RHS sites on three river systems were surveyed (Annex A); approximate site locations are shown on the back cover map. There were two single (500m) surveys, one paired survey (1km) and one set of four survey units (2km) (Appendix 1). By completing double and multiple surveys we maximised the use of our time and could also determine the variation in number and type of features recorded over different lengths of river.

Complex riparian and channel structure; Port-5.

Cork oak woodland.

APPLYING RHS IN PORTUGAL

There are several difficulties in applying RHS *sensu stricto* to Mediterranean rivers and adaptations to RHS have been developed for southern Europe[27]. Some of the difficulties encountered using the RHS methodology in Portugal, particularly in intermittent Mediterranean river systems, are summarised in Appendix 2. Some of the problems are common to all river types in Portugal, while others are more specific.

To address these concerns and resolve difficulties in the definition of features and application of RHS scoring systems, a four-day training course was held in northern Portugal during 20-23 April 2009. The trainers were Lucy Baker, Lucy Taylor and Katherine Seager. A total of 23 delegates attended the course which was based at the University of Trás-os-Montes e Alto Douro (UTAD) in Vila Real. Site visits to the Corgo, Olo, Pinhão, and Tanha rivers were used to demonstrate features recorded by RHS (*see back cover map*).

RESULTS

Context in relation to European hydro-ecoregions and UK rivers

The hydro-ecoregion (HER) concept was developed as part of the REBECCA project and is based on map and environmental data. It provides a useful framework for broadly expressing river character on a European scale[28]. Our study sites are located in the "low Alentejo-Algarve" HER in southern Portugal (Table 1). The three rivers we visited are also classified as "small southern rivers", "medium/large southern rivers" and "sedimentary deposits rivers" in the Portuguese river typology[29]. The training sites were examples of "small and medium/large northern rivers".

Figure 2 shows a PCA plot of our southern Portugal sites, compared with our previous European surveys[22-26], the STAR project sites[4] and the 1994-96 stratified random baseline network of sites in the UK[8].

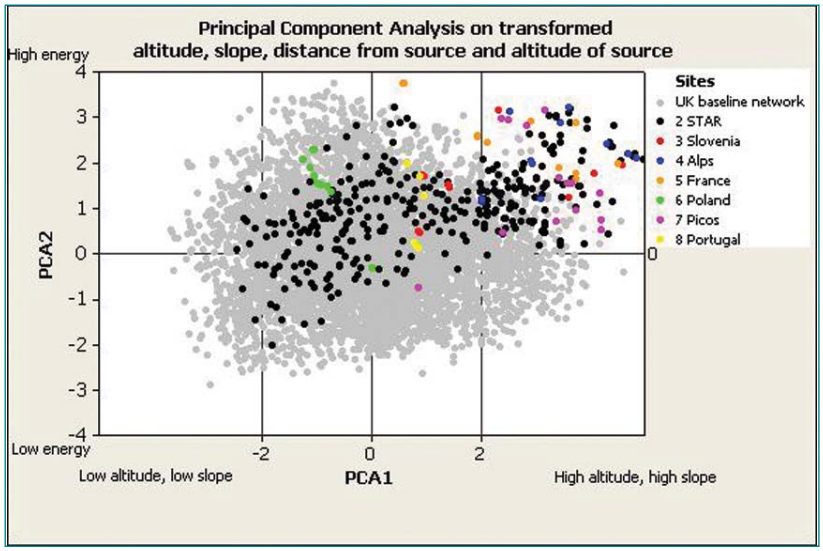


Figure 2. PCA plot, showing our Portugal sites in relation to baseline UK, STAR and other European benchmark sites.

TABLE 1: General characteristics of the "Low Alentejo-Algarve" hydro-ecoregion (HER) as defined by REBECCA[28].

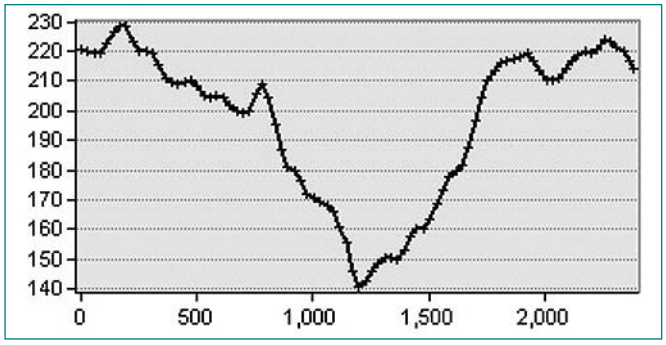
Parameter	Low Alentejo-Algarve
Altitude	Median: 125-250m
Slope	Median: 1-2.5%
Relief	Mediterranean depressions
Lithology	Crystalline
Climate	Hyper-Mediterranean

Landscape and river character

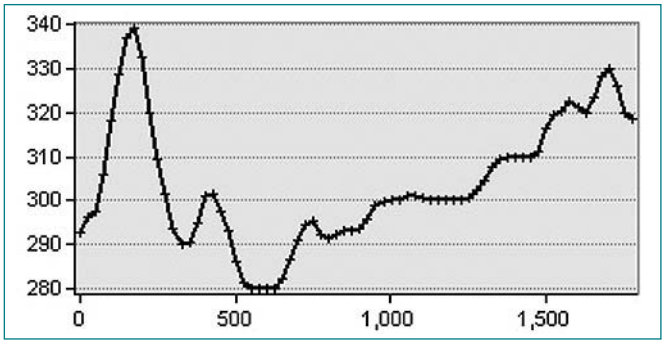
The Alentejo region is characterised by gently rolling hills and plains and by a Mediterranean climate of winter rainfall and hot, dry summers. The geology of our study area is dominated by sandstones and limestones (Annex B). The soils are generally thin and poor and the landscape is dominated by "*montado*". This is an agro-forestry-pastoral ecosystem comprising scattered trees (largely cork oak and holm oak), with pasture and arable fields (clover, wheat, barley, oats) as understorey, usually in a rotation scheme that includes fallow (Annex C). Non-agricultural land and abandoned farmland have an understorey dominated by woody shrubs (e.g. *Cistus, Erica, Lavandula, Ulex*), with *Cistus* predominant as an early colonising plant. On the steepest slopes there is remnant natural broadleaf woodland. Other land-use includes olive groves, vineyards and both pine and *Eucalyptus* plantations.

Boulder outcrop; Port-7.

Asymmetrical valley with contrasting land use; Port-5.



Graph of deep V-shaped valley-form; Port 1-4.



Graph of asymmetric valley-form.

The main characteristics of the rivers we surveyed are gentle gradient, with long stretches of slow or imperceptible flow punctuated by narrower, faster-flowing sections (Table 2; Annex D). The deeper reaches become ponds (known locally as *pegos*) separated by dry river bed in the summer. Flat cobbles and pebbles were the predominant substrata in all our sites (Table 2).

Local valley form influences the river habitat character in each of our study sites (Annex A). The intermittent headwater of the Grândola (Port-1 to 4) flows in a vee-shaped valley. The Vascâo (Port-5) and Vascanito (Port-6) sites illustrate the complex riparian habitat that can develop on the inside of large meanders in an asymmetrical valley location. The Odeleite (Port-7, 8) demonstrates clearly how bedrock outcrops influence the location of depositional bars in deeply-incised meandering channels.

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

Site reference (Port)	River name	Channel slope (m/km)	Water width (m)	Predominant valley form	Altitude of source (m)	Distance from source (km)
1, 2, 3, 4	Grândola	8.1	2.0-5.5	Deep vee	248	8.2-9.7
7, 8	Odeleite	4.9	7.0-12.5	Deep vee	481	32.7-33.2
6	Vascanito	4.1	14.0	Asymmetrical	409	20.5
5	Vascão	2.4	23.0	Asymmetrical	500	40.4

Managed cork oak, with little understory structure.

Managed cork oak with dense scrub developing.

Massive erosion and deposition features, with scrub/tree-lined wetted channel; Port-8.

Massive erosional and depositional forces during floods produce large side and point bars and also scoured sub-channels that are dry in summer. In many cases these bars are colonised by scrub or have trees well-established along the channel edge. A complicated array of gravel or cobble-sized deposits, scoured sub-channels, vegetated bars, natural berms and developing terraces, side channels and riparian vegetation provides a very dynamic and diverse riparian habitat structure. This makes some of the standard RHS features difficult to interpret and record, hence the need to adjust the recording of features to reflect local riverine character (*see Appendix 3 and 'riparian zone' discussion*).

Overall, HQA scores were high, reflecting the variety of flow-types, channel features, in-channel vegetation and riparian vegetation structure (Table 3; Annex E and F). However, broadly similar HQA scores mask important site-specific differences in channel and bank features (Table 4) and also in-channel vegetation and bank vegetation structure (Annex E). Local variation is also reflected in the cumulative number of features recorded over four consecutive surveys on the Grândola River (Table 5).

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 (Port)	River name	Habitat quality (HQA)	Habitat modification score (and class)	Macrophyte assessment (MTR score)
1, 2, 3, 4	Grândola	68[1, 2] 69[3] 81[4]	120(2)[1] 80(2)[2] 130(2)[3] 90(2)[4]	57[1] 60[2] 51.5[3] 58[4]
7, 8	Odeleite	70[7] 73[8]	75(2)[7] 0(1)[8]	60[7] 72.5[8]
6	Vascanito	68	0(1)	65
5	Vascão	76	0(1)	60

TABLE 4: Occurrence of selected features on the Ribeira de Grândola (Port-1 to 4) and Odeleite (Port-7 and 8). ***All features, except for number of riffles and pools, represent occurrence at spot-checks (maximum = 10).***

River feature	Grândola				Odeleite	
	Port-1	Port-2	Port-3	Port-4	Port-7	Port-8
Unbroken wave flow	5	3	-	2	-	2
Rippled flow	-	2	4	2	2	4
Smooth flow	2	2	3	5	4	3
No perceptible flow	3	3	3	1	4	1
Bedrock substratum	-	1	1	2	1	1
Boulder substratum	-	2	3	2	2	2
Cobble substratum	3	6	5	4	5	6
Gravel-pebble substratum	7	1	1	2	2	2
Sand substratum	1	-	-	-	-	-
Exposed boulders	-	4	2	-	-	-
Vegetated side bar	1	4	1	2	1	1
Eroding cliff	2	-	-	1	-	-
Number of riffles	8	6	5	8	2	4
Number of pools	9	1	2	4	4	4

TABLE 5: Cumulative number of in-channel features recorded for consecutive RHS sites on the Grândola and Odeleite. *From spot-check, sweep-up and special features data.*

Port sites	Cumulative number of attributes recorded				
	Flow-types	Channel substrata	Channel features	Bank features	Total
Grândola					
500m (1)	5	5	4	6	20
1000m (1, 2)	6	7	7	6	26
1500m (1-3)	6	7	7	8	28
2000m (1-4)	7	7	9	8	31
Odeleite					
500m (7)	5	7	4	4	20
1000m (7, 8)	7	7	7	4	25

Only on the Grândola were there many MTR species due to greater bed stability.

Mobile material on the banks and in the channel reduces macrophyte diversity.

Water chemistry and biological water quality

The neutral-basic waters in all three river systems (Annex G) reflect the mixed sandstone-limestone nature of the catchment geology. Benthic macroinvertebrate communities in the Grândola and Vascão produce good Iberian Biological Monitoring Working Party scores (131 and 137 respectively), and high Iberian Average Score per Taxon ratios (5.70 and 5.71) respectively. Water quality based on diatom communities for both these rivers and the Odeleite is classified as 'high'.

Macrophyte data suggest reasonably good water quality at all sites surveyed, with MTR scores in the range of 54-73. The occurrence of the moss *Leptodictyum riparium* suggests some unnatural enrichment in Port 1-4. Caution is needed in applying a method for assessing water quality based on a system devised in a different country and on rivers of very different character with contrasting macrophyte assemblages. The species needed to assess water quality were often too few, and where present only sparsely distributed on our surveyed rivers. The two consecutive sites on the Odeleite, with MTR scores of 60 and 73, show the effect of insufficient taxa to determine water quality confidently, and the influence of bed stability at Port-8 which resulted in abundant growth of the moss *Fontinalis squamosa*. The results re-affirm the importance of developing national modifications of the core MTR system to reflect differences in assemblages found in other parts of Europe; this has been done successfully in Poland[25].

Baldellia, a species more typical of lakes than rivers; Port-5.

Aquatic macrophytes

Considerably more 'JNCC checklist' taxa (*n*= 32-37) were recorded in the four Grândola sites compared with on the Vascão, Vascanito and Odeleite (Annex I). The composition of the flora reflected the hydromorphological character of the rivers we visited. The Vascão, and to a lesser extent the Grândola, had several taxa that are more closely associated with lakes or ponds. Species we found that are rare in UK rivers included quillwort *Isoetes*, lesser water-plantain *Baldellia*, adder's-tongue spearwort *Ranunculus ophioglossifolius* and the liverwort *Riccia*. Periodically-inundated margins of the rivers were also colonized with dense stands of two rushes that are Red Data List species in the UK – round-headed club-rush *Scirpoides holoschoenus* and galingale *Cyperus longus*. *Ranunculus trilobus*, a species not present in the UK but with similar character and habitat preferences to celery-leaved buttercup *Ranunculus sceleratus*, was sporadically present in sites Port-1-6. River jelly-lichen *Collema dichotomum* was found on the Grândola at Port-2 – a new record for the whole of the Iberian Peninsula.

Some taxa could not be determined to species level with certainty. The *Ranunculus* which was present and sometimes locally abundant, for example on the Grândola and Vascão, was recorded as R. *peltatus*, but no mature fruits were found. This suggests the possibility of a hybrid form. In the UK this species is most typically associated with winterbourne headwaters of chalk and limestone rivers that regularly dry out each year. A 'succulent' emergent macrophyte species, with paired leaves (provisionally identified as *Gratiola officinalis*), was a common component of the Grândola and Vascão, and was also seen in other rivers in Portugal where incidental observations of the flora were made.

River jelly lichen (*Collema*), a new record for Iberia; Port-2.

Natural berm; Port-2.

Side bar; Port-5.

Wildlife

Birds are good indicators of broad-scale landscape character and local riparian habitat, and have been shown to respond to riparian vegetation clearance and bank resectioning in Portuguese Mediterranean systems[30]. The species seen during our visit confirmed the Mediterranean scrub and woodland character of our study sites (Annex J).

DISCUSSION

Recording RHS features on Mediterranean rivers

Proposals and options for adapting parts of the recording form for use in Portugal were based on: (i) observations during the visit to southern Portugal (15-18 April); (ii) feedback during the training course on 19-23 April (Annex K). The main areas of uncertainty and proposals for resolving these are summarised in Tables 6 and 7, with more detail and illustrations in Appendix 2 and 3.

Many areas of uncertainty were similar to those highlighted during training courses run in the UK – identifying banktop and recognising natural berms and terraces are consistently the most difficult elements of the survey. The existing RHS definition of banktop is generally clear enough to remove most uncertainty when surveyors have been trained to apply it. However, there were a number of deep vee valleys where the identification of a trash line or notch was necessary to determine banktop. These features are not always obvious, and more specific guidance on this is required to improve the confidence of surveyors.

Dry secondary channels were recorded in most sites surveyed.

Complex riparian habitat makes banktop and bankface structure difficult to determine; Port-6.
Arrow shows woody debris trash-line set well back from the wetted channel.

TABLE 6: RHS features that need to be more precisely defined for Portuguese rivers.

Channel and banks	Land-use and vegetation
Banktop	Coniferous plantation (contour planting)
Bars (counts)	*Eucalyptus* plantation
Channel/banktop width (trashline height)	Montado-cork and holm oak (with/without understorey)
Discrete deposits	Non-native species (giant reed; silver wattle; *Eucalyptus*)
Mature mid-channel islands (dry sub-channel)	Olive groves
Natural berm	Vineyards
Natural terrace	
Ponded reaches (*pegos*)	
Predominant and sub-dominant substrata	
Riparian habitat/vegetation	
Scrub-trees on bars	
Side channel	
Slumping (to distinguish from side bars)	
Sub-channels (not braided)	
Trashline height	

TABLE 7: Features that need to be the focus for training surveyors in Portugal

Channel and banks	Points of uncertainty
Banktop	Flow variation makes it hard to define channel limits and banktop, and therefore to record channel and bank features. Other signs (e.g. vegetation, trashline, scouring) should be taken into account, especially when training.
Banktop/bar	Point at which a bar ends and the banktop starts – bars are far less consolidated than banktop and regularly overtopped by water.
Trashline	May be required to determine banktop in vee-shaped valleys, but trashlines are not always obvious.
Natural berm	Differences between depositional bars/berms/banktop – berms have distinct step into water compared with bars, less consolidated than banktop but more so than bars, more frequently over-topped than banktop but less so than bars.
Dry channels	Difficulties in identifying banktop and bars, recording of channel vegetation.
Weirs	Many artificial weirs appear to be built on existing natural rocky steps. This makes it extremely difficult in some cases to distinguish between a natural 'step' in the reach and an artificial weir.

Trash-line height exceeded 4m in some sites; Port-6.

Banks can be prone to erosion and form cliffs.

Rivers with secondary channels flowing through floodplain woodland are rare in the UK.

Bank collapse often results in the formation of composite bank profiles; these are not bar deposits.

Riparian zone

"Riparian zone" is generally a poorly-defined term, but can be described as the corridor of land between the water level during dry-weather flow in a permanent channel and the level of regular or periodic flooding adjacent to it. Generally speaking, in its unmodified state it is characterised variously by wetland, scrub or woodland vegetation depending on catchment hydrology and also the local climatic and geological conditions. Along Mediterranean rivers the riparian zone is often characterised by bare ground and sparsely-vegetated alluvial deposits; consequently, where it occurs, riparian habitat gallery woodland is extremely important ecologically, providing structural habitat and an exchange of energy and organic matter between terrestrial and aquatic ecosystems. Therefore, for river habitat assessment purposes, recording the extent, character and integrity of the riparian zone, is very important[31].

In the UK, riparian habitat and floodplain woodland *sensu stricto* are extremely rare because they have been destroyed by centuries of river and land management. Although evidence of old side channels are widespread in terraced valley floors of upland areas in England, Wales and especially Scotland, these remnant features represent a very degraded riparian habitat. Indeed, the only extensive areas of genuinely intact riparian habitat occur in Scotland – for example, on the short, braided section of the River Feshie, near Aviemore, and the River Spey near its mouth at Spey Bay. As a result, the term "riparian zone" was dropped during the prototype phase of the RHS in the UK because of confusion, caused by very unreliable recognition and recording by surveyors.

In contrast, along active rivers on mainland Europe where hydrological ranges are greater and where land alongside rivers is often state-owned, wetland and woodland riparian habitat, including gallery woodland, is much more distinctive and widespread.

For intermittent Mediterranean streams and rivers the recognition and recording of riparian habitat is not straightforward. This is because "bankfull" or "flood level" height is difficult to determine, particularly in deep vee and asymmetrical valleys. Trashlines vary considerably in height because of the erratic hydrological regime, so careful judgement using several clues has to be made during a survey.

Recording the extent, character and ecological functioning of riparian habitat needs to be developed if it is to be successfully incorporated alongside, or into, the RHS protocol. Wetland, scrub, trees and wet woodland on bars, islands, berms, terraces and floodplains are commonly associated with near-natural, active, single and braided channel rivers in mainland Europe. These features, plus side and back channels, sub-channels, large woody debris, fallen trees and debris dams are all recorded during RHS (2003 version; subsequent recommendations[22-26]) (Table 8).

TABLE 8: RHS attributes that can be classified as aquatic, riparian habitat and riparian vegetation features.

In-channel (aquatic) features	Riparian (bank) habitat features	Riparian vegetation types
Flow-type	Point and side bars	Sedge/reed fringe
Substrata	Islands	Marsh/fen
Riffles and pools	Berms	Wet woodland
Aquatic vegetation	Terraces	Floodplain woodland
Braided channels	Dry sub-channels	Scrub
Backwaters, side channels		

Complex riparian and channel habitat; Port-5.

Complex riparian zone showing trashline (yellow arrow), side bar (blue arrow) and riparian gallery (red arrow), Port-7.

A more elaborate checklist, broadly equivalent to the RHS recording of bankside trees, vegetation structure and bank modification is used by the German LAWA river habitat assessment method to assess riparian structure[32]. Observations of individual features could be supplemented by recording the presence and extent of riparian habitat generally in the special features list in Section M. Simple diagnostic clues that are easily recognised and consistently recorded need to be used. Modifications to Section J (the presence and extent of woody shrubs) and Section O (riparian width categories) have already been made by INAG for recording riparian structure as part of RHS in Portugal (Annex L).

A more practical alternative is to use a specific method to provide a more detailed assessment, undertaken separately or in parallel with RHS and cross-referenced to the 'special features' section. For example, the QBR (Riparian Forest Quality) method has been tested on Spanish and northern Portuguese rivers[33] and could provide a basis for riparian habitat evaluation, provided there is good evidence for consistent recognition of diagnostic features by surveyors. However, in southern Portugal QBR does not perform well because of less well-defined structure and lateral connectivity of riparian habitats.

In the Cantabrian Region of northern Spain, a method for mapping riparian corridors using aerial photographs and large-scale topographic maps is being tested (José Barqúin Ortiz, *pers. comm.*). A similar approach, to establish the distribution of riparian gallery woodland, is being used in Portugal on academic studies. This could provide a cost-effective way of determining the extent and structure of riparian habitat over entire catchments. In the UK, scrutiny of aerial photographs delineated by the "1 in 100 year flood" maps could usefully establish remnant riparian habitat, and build on the Geo-RHS survey method[34]. If the method is simple and robust, assessment of riparian habitat structure could be retrospectively cross-referenced on entries in the RHS database.

Aquatic and riparian plant communities have also been used to develop a prospective multimetric plant index to assess the biotic integrity of Iberian rivers based on the effect of human disturbance[35]. One example is the Riparian Vegetation Index (RVI) which was developed and tested with data from 385 river sites to support WFD implementation[29].

Aerial photographs

The importance of aerial photographs to verify and interpret RHS survey data and to define riparian habitat distribution is illustrated by the *Google Earth* images in Annex A. The image of the *Odeleite* (Port-7, 8) confirms the continuous or semi-continuous nature of tree cover provided by the riparian gallery trees along the wetted channel, the location of point and side bars and the lateral extent of the riparian zone. The image was taken in October 2006 and clearly shows the intermittent nature of the river in the dry season, with isolated pools separated by dry river bed.

The *Google Earth* image of the Vascão (Port-5) clearly shows the complex nature of the riparian habitat, including sub-channels and the large mature island. Comparison with our panoramic photographs of the site clearly shows that scrub on the northern valley slope has increased since December 2004 when the *Google* image was taken.

The occurrence of diverse riparian habitat features on the inside of meander bends in asymmetrical valleys on the Vascão is shown in the *Google Earth* image that shows the Vascanito at Port-6. This illustrates the benefit of a systematic search for good riverine habitat using aerial images prior to survey work.

Google Earth images are less useful for verification and interpretation of small watercourses in heavily wooded valleys such as the Grândola (Port-1 to 4). This is because the resolution is insufficient for channel or riparian features to be identified, although useful land-form and land-use context can be provided.

Land-use and impacts on the river channel

The scarcity of long term biological information and the rarity of true reference conditions makes ecological quality assessment of rivers difficult in southern Portugal. This reaffirms the need for a consistent approach for morphological assessment within the Mediterranean Hydro-ecoregions. The CEN guidance standard on hydromorphological assessment could provide the basis for doing this[15].

Colonization by semi-terrestrial plant communities is frequent in intermittent Mediterranean river channels. This effect is enhanced by increasing modification and disturbance to the river channel, such as flow regulation, water abstraction and livestock grazing[33]. In most cases there are obvious cause-effect factors, but in some cases subtle effects such as historical channel realignment could be difficult to detect, so old maps should be used to verify assumptions about 'natural' channels.

Effect of seasonal flow

The extreme seasonal variation in intermittent streams and rivers represents a major problem for analysing data collected during different flow conditions. It is crucial to record conditions at the time of survey and to compare similar sites surveyed under similar conditions during analysis. It is therefore very important to establish the objective of a study programme before embarking on survey work and also being clear beforehand which parameters and indices will be used for analytical and descriptive purposes.

Impact of version changes on the RHS database

A major advantage of the UK and STAR databases is that core RHS information can be compared within and between several different hydrological, geographical and morphological 'types'. However, the ability for direct comparison over time decreases when the form is modified or additional features or data-fields added. Significant changes to the way flow-type, riparian zone and bankface-banktop structure were made to the UK version of RHS between 1994 and 1995. Other improvements were made in 1997 and 2003. These had knock-on impacts for database design, analytical capability and the HQA scoring protocol. Overall, the underlying principle remains – not to over-complicate or lengthen the RHS survey. This is because of problems caused by feature recognition, time taken to complete a survey, and most important, a move away from a simple characterisation of river habitat. Changes to RHS arise from new features encountered and feedback from surveyors on the difficulties of recognising or recording existing features. Additional guidance on existing features is regularly issued to surveyors as technical advisory notes, but changes to the form itself are strictly controlled and adopted only after technical peer review, user-testing and database design have all been taken into account. A similar version control approach is needed as the Portuguese version of RHS develops (Appendix 3).

As many rivers are intermittent in southern Portugal, recording flow conditions at the time of survey is essential.

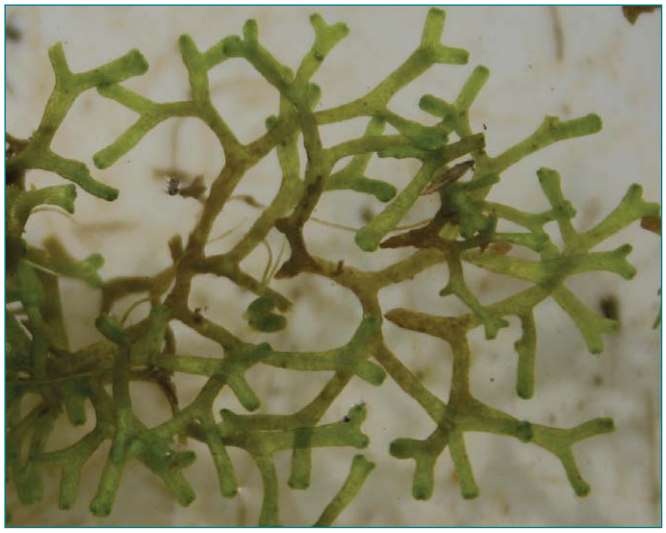
Using special features and land-use HQA scores.

For the purpose of this and previous reports[22-26] the HQA scoring for special features was based on core UK examples, plus additional features reflecting local river and riparian character. For example, mixed mature broadleaf woodland and well-established scrub occurring at our study sites has been categorised as 'near-natural' and scored accordingly. The resulting HQA scores are therefore only to demonstrate the utility of the method (Annex E). A scoring protocol relevant for Portugal will need to be agreed using features that genuinely reflect good habitat in Mediterranean river systems as the basis for quality assessment[36].

Macrophytes as indicators of riverine hydrology

The macrophyte communities had several interesting features that can be attributed to hydrology, many of which are not seen on rivers in the UK. Most notable was the occurrence of macrophytes usually associated with lakes – good examples being quillwort, lesser water-plantain and the bryophyte *Riccia*. The first two are extremely rare in UK rivers, and only occur downstream of lakes. In intermittent Portuguese rivers the main growing season for these species is characterised by static water.

Backwaters are recorded as special features and contribute to HQA scores.



Riccia, a liverwort more associated with standing waters, was recorded in our surveys.

At the other extreme, several bryophytes we found indicate intense scouring during floods and the ability to survive out of water for several months a year. *Fontinalis squamosa* was the most common moss present: in the UK it occurs where erosive floods are characteristic. Bryophytes such as *Bryum dichotomum* and *Didymodon insulanus* occurred in cracks in bedrock sheltered from extreme flood flows and intense sunlight. These species were found in high energy rivers in our benchmark surveys in the Cévennes[24] and the Picos[26] where they would also be exposed to extreme desiccation in summer; in the UK they are not common components of the riverine flora.

Invasive non-native plants

Non-native invasive species are widely established along Portuguese rivers, particularly those which have been modified or have a high degree of disturbance. One of the most invasive is the giant-reed *Arundo donax* which, once established, can form impenetrable thickets along river banks and in riparian galleries. *Arundo* was planted to provide local material for roofing and sheltering crop plants. Reduced management along rivers may have contributed to its recent increase in distribution, whilst land abandonment may also be a factor, through reduced grazing pressure.

On the hillsides and in some riparian gallery woodland, silver wattle *Acacia dealbata* and *Eucalyptus globulus* are spreading quickly.

Bryum dichotomum is a bryophyte capable of surviving torrent flows and periodic desiccation.

Giant reed (*Arundo donax*) establishing along the channel edge can quickly form an impenetrable thicket.

Developing RHS expertise and training support

There is a need to build and maintain capacity for RHS and other methods within Portugal. A long-term strategy that services a Portuguese training capability, database development and roll-out of applications for WFD and other purposes is required. The 2009 training provides a good start for home-grown capacity-building, but a training schedule, self-help facilities using established 'experts' within Portugal and advisory support from the RHS team in the UK represents the best blend to maximise the chances of building and maintaining technical expertise.

Strengthening close links between INAG and other institutions involved in RHS within Portugal and also those in Spain and Italy is essential to develop a Mediterranean 'network' of expertise. There are also good learning points from training, capacity-building and RHS survey programmes in Poland[25]. Expertise and experience should be shared, possibly through a web-based facility for RHS data and on-line training and provision of advice.

More broadly, ecologists familiar with a wide range of ecological and morphological characteristics of rivers (and who have access to aerial photographs, GIS information plus RHS and macrophyte databases) are needed to advise on setting WFD objectives and monitoring the ecological quality of 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.

Eucalyptus is widespread: like giant reed, it is an alien that is increasing in southern Portugal.

RHS training in northern Portugal.

Complex riparian habitat; Port-7.

CONCLUSIONS

We achieved our main objectives by testing the RHS and macrophyte survey methods on rivers in southern Portugal, albeit only on three river systems. The core methods (with modifications to account for local morphological characteristics and floristic communities respectively) are suitable for small and medium-sized Mediterranean rivers when surveyed in the spring when they are still flowing. The RHS and macrophyte data we generated can be used for baseline information and calibration/comparison purposes.

The single most important technical requirement is development of a standard protocol for recording and assessing, in simple terms, the extent and character of riparian habitat that can be used as an addendum and cross-referenced to the core RHS survey. The benefit of using aerial images to locate potential survey sites, provide wider contextual information and to verify field survey results was reaffirmed.

Like other countries that have little baseline information on the ecological and hydromorphological features as required by the WFD, a cost-effective sampling strategy is needed in Portugal. A combination of large-scale maps and aerial photographic sources could quickly provide basic information on the broad character of river channels and riparian habitat and the extent of modification caused by channel realignment, impoundments, major bank reprofiling or reinforcement and land management.

Ground-truth samples using RHS and other methods are also needed to build up a more detailed inventory of features and modifications. This can be used to verify assumptions used when interpreting aerial images and also to calibrate biological and habitat quality[30]. An inventory is also needed to develop a robust HQA scoring protocol for Mediterranean rivers. A strategy involving aerial imagery and RHS survey should be relatively easy to develop, with RHS sampling density determined by variations in factors such as stream density, "river type" and land-use.

A database of RHS and macrophyte information in Portugal will also 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[4] and subsequent river studies that have used RHS.

Fully-trained and accredited RHS surveyors, river biologists, fisheries and macrophyte specialists are 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 riverine areas of high conservation value such as *Natura 2000* sites.

Aerial photographs cannot reveal in-channel character when the riparian zone is dominated by shrubs, making ground-truthing essential.

APPENDIX 1: Notes for Port-1 to Port-8.

Constrictions caused by vegetated side bars produced naturally ponded or sluggish reaches; Port-2.

Bedrock provides stable substrate for bryophytes.

Ribeira de Grândola (Port-1, 2, 3, 4). 16 April 2009. HQA = 68, 68, 69, 81; HMS = 120, 80, 130, 90. Four back-to-back surveys (2 km). 38° 08′ 36.06″ N, 8° 37′ 23.77″ W; 38° 08′ 49.99″ N, 8° 37′ 23.48″ W; 38° 08′ 58.09″ N, 8° 37′ 21.58″ W; 38° 09′ 07.27″ N, 8° 37′ 15.53″W.

A small active intermittent stream bordered by riparian scrub and some trees, with managed cork oak dominating valley land-use. The wide variation in channel bedform and water width along the 2km length is caused by subtle changes in channel gradient and bedrock outcrops. Old channels and terraces are evident. Constrictions caused by vegetated side bars create riffles and long naturally ponded reaches (50-100m) known locally as '*pegos*'. In the dry season the river becomes a series of isolated 'ponds'. Catchment pressures include cork oak management (mainly the removal of undergrowth) and fording points for forestry tracks, which sometimes are protected upstream by small, permeable boulder weirs.

The presence of bedrock provided habitat suitable for abundant growth of mosses, with *Fontinalis squamosa* and an extremely large form of *Hygroamblystegium fluviatile* the most common taxa. The moss *Octodiceras fontana* was present in all four sites; this species had never before been recorded in either UK or our mainland European benchmark surveys[22-26]. A notable find was river jelly lichen, a UK Species Action Plan taxon that had never previously been found on the Iberian Peninsula. Water crowfoot *Ranunculus* was common in the more sluggish sections.

Ranunculus was present in all the sites surveyed on the Grândola.

Fording points for forestry vehicles are common, but have minimal impact.

Rio Vascão (Port-5). 17 April 2009. HQA = 76; HMS = 0(1). Single survey (500m). 37° 24′ 47.41″ N, 7° 55′ 20.75″ W.

Located on part of a large meander, this is an example of good riparian habitat on an active, low gradient river in rolling countryside. There is a complicated pattern of morphological features, backwaters and side channels associated with a large mature mid-channel island. The site coincides with a STAR reference site surveyed in 2003. The asymmetrical valley has near-natural vegetation on the steep slopes and agricultural land reverting to scrub opposite. There are similar examples of this habitat on meanders in asymmetrical valley further upstream (Annex A).

The site demonstrates the difficulty of recording the complexity of channel features and is also unusual because it is largely unmodified and has low intensity land-use bordering the channel compared with further upstream and downstream.

The presence of backwater pools and shallow ledges along the edges of the unstable river provided habitat for macrophytes not recorded elsewhere. Quillwort *Isoetes echinospora,* pearlwort *Illicebrum verticillatum* and adder's tongue spearwort *Ranunculus ophioglossifolius* were found here. The third species is very like lesser spearwort *Ranunculus flammula*, but on the Iberian Peninsula this is a plant commonly associated with temporary wetlands.

Mature island with complex wetland also present; Port-5.

Coral necklace is associated with small floodplain ponds formed from old channels.

Extensive bar deposits and scrub; Port-5.

Large backwater connected to the main channel; Port-5.

Bryophytes were rare as the substrate was predominantly unstable. *Ranunculus* was also present, but confined to more stable sections. Lesser water-plantain *Baldellia*, a species typical of lakes and ephemeral ponds, was also present. Its presence, along with quillwort, suggested a strong standing-water component to the flora.

Ribeira do Vascanito (Port-6). 17 April 2009. HQA = 68; HMS = 0(1). Single survey (500m). 37° 21′ 28.80″ N, 8° 0′ 04.82″ W.

This site is on a small tributary of the Vascão about 20km upstream from Port-5. It is also on a meander bend in an asymmetrical valley with near-natural woodland on the steep slopes and scrub (notably *Cistus* spp.) invading recently burnt, abandoned cultivation opposite. Massive scouring during floods creates a secondary, dry channel beyond the main one. The wetted channel is lined with riparian gallery trees and dense scrub, including some invasive giant reed.

This site had a sparse macrophyte flora, both in terms of species diversity and cover, and no taxa were present here that were not found elsewhere (Annex I).

Bed instability and shade result in poor macrophyte growth; Port-6.

Oleander was especially common on the side bars of Port-6.

The hidden channel (arrowed) was lined on both banks by willow and alder.

Tufted sedge was common on the Odeleite, but not found on the other rivers surveyed.

Ribeira de Odeleite (Port-7, 8). 18 April 2009.
HQA = 71, 73; HMS = 75(2), 0(1).
Back-to-back surveys (1 km). 37° 16′ 35.47″ N, 7° 47′ 6.11″ W; 37° 16′ 25.10″ N, 7° 47′ 0.74″ W.

A cobble-bed river flowing in a deep vee valley with oak woodland and dense mature scrub vegetation. Various trashline heights occur 2.0 – 4.0 m above water level. The river channel is characterised by long pools and a steeper, narrow faster-flowing section. Located on a large incised meander, there are massive cobble and pebble deposits in the form of side and point bars (Annex A). The channel edge is lined with willow and alder *Alnus glutinosa* forming a riparian gallery. This creates a well-shaded channel, contrasting with the dry exposed cobble and pebble deposits behind. These features form a complex pattern of habitats in a riparian zone which is more than 30m wide in places. Impacts include minor ponding caused by a ford at the downstream end of Port-7 and the presence of some giant reed.

Macrophyte species composition was similar in both sites, but the abundance of individual species varied considerably depending on local conditions. This was reflected in the MTR scores, with Port-8 having a much higher score (72.5 compared to 60) due the very high cover of *Fontinalis squamosa* on stable rocks that dominated the substratum. The water margins were locally stabilized by tufted sedge *Carex elata*. The Odeleite had much less in common with the flora of the other rivers we surveyed, with tufted sedge and alder only recorded here (Annex I).

The incised meander pattern of the Odeleite.

Ponded stretches form '*pegos*' in the dry season.

Massive bar deposits downstream of a major rock outcrop; Port-7.

APPENDIX 2: Difficulties and uncertainties of recording RHS features in Portuguese rivers.

Observations are based on training courses and subsequent fieldwork since 2004.

Feature	Observations	Conclusions and training requirements
Natural berms	Difficulty in identifying the feature or overlooking it entirely.	Improved guidance and, targeted training required.
Minor fords and weirs	Many streams and rivers are affected by small and old dams and weirs. These affect both upstream (ponded) and downstream flow and substrate patterns.	Care needed in recording and interpretation of impact.
Sub-channels, side-channels and braided channels	Sub-channels and side channels are relatively common features in Mediterranean systems where seasonal flow has extreme variations. Channel braiding occurs only when a channel can migrate across a broad alluvial plain and this is extremely rare in Portugal.	Improved locational diagnostics to distinguish truly braided channels and better guidance to differentiate sub-channel and side channel features.
Substratum, bars and islands in intermittent channels	Recording of substratum type, mid-channel bars and islands is difficult, particularly when intermittent rivers become partially dry.	Recommend an optimum time for survey in relation to (permanent) river flow.
Flow-types	Large stretches of homogeneous smooth or no-perceptible flow makes it difficult to separate artificial and naturally-ponded flow.	Better explanation of naturally-ponded flow-type and clues for modifications causing ponded water.
'Vernal' pools	Intermittent Mediterranean river systems have no flow during the dry season, but isolated pools remain in deeper areas of the river bed. These features, referred to as "*pegos*" in Portuguese are referred to variously as "vernal pools", "pools", or "intermittent reaches". It is not clear how these features should be recorded.	Record as 'present' or 'extensive' in "Special features". Consider counting, as for pools and riffles.
Side bars	Some sites have very large side bars (e.g. Port-8), recorded at several spot-checks along the survey reach. To avoid misinterpretation the Portuguese version of RHS has now included count of side bars in Section C of the survey form.	Add a count for side bars and check with aerial photographs.
Land-use	Several different types of land-use occur in Mediterranean areas that are not included on the original RHS form.	Add relevant land-use, but minimise additions, by direct substitutions if possible or inclusion as sub-types within existing categories.
Bank-top definition	Due to the extreme variation in flow regime it is very difficult to define the banktop. There will often be "two levels" one for the high flow season and another for the low flow season.	Clarity over definition and seasonal context is needed, but 'true' banktop refers to trashline.
Seasonal variability	The extreme annual flow variability directly affects features such as macrophyte development and complexity, substrate characteristics and the accumulation of organic debris. In particular, dominant flow types and flow diversity are affected. The timing of survey is critical.	Improved guidance on the time of survey; this will influence interpretation of results (*see HQA recommendations-Appendix 3*).

APPENDIX 3: RECOMMENDATIONS FOR USING RHS IN PORTUGAL

These recommendations and suggestions are in addition to those made in the reports for Slovenia, Bavaria and Tyrolean Alps, the Cévennes, Poland and Picos de Europa[22-26].

Aerial photographic images: *recommendation* – aerial images should be used to verify tree distribution and land-use, and to assist in the differentiation and counting of point and side bars.

Banktop: *recommendation* – this should be determined using several clues (e.g. 'annual flood' trashline, permanent vegetation level) and a note made on how this was done on the RHS form. Local diagnostics are needed to allow surveyors to become more confident in recognising diagnostic features.

Aerial images can assist in site assessment.

Berms, terraces and riparian floodplain: *reaffirm* that much clearer definitions of natural berm, terrace and riparian floodplain are required. In actively eroding natural channels the progression from natural berm to riparian floodplain is particularly difficult to classify, but nevertheless very important, because the definition and location of 'banktop' will influence bankface and banktop vegetation structure and land-use recording.

- **Natural berms** will generally have a distinct, stepped 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. [In the UK 'natural berms' profiles are more usually associated with readjustment (in-filling) of over-widened, modified channels.]

An obvious 'natural berm', but frequently they are not so clear-cut.

- **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 up to the channel edge.

The riparian zone on the Vascão is at least 100m wide.

- **Terraces** reflect downcutting and lateral erosion of the channel. The 'step' profile is caused by active natural down-cutting of the channel-bed.

Discrete deposits (silt, sand, gravel, cobble): *reaffirm* these should be recorded as bankside features at spot-checks, because in bedrock-cobble rivers in particular they are a characteristic feature. It would ease the problem of differentiating between side bars and discrete deposits. A suitable new unique acronym would need to be derived.

Reaffirm that better definition is needed for **discrete sit/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.

Fords/minor weirs: *recommendation* – a clearer link is made between the recording of minor, intermediate and major weirs and fords and the impact of impoundment (present, extensive) in section D on the form.

A ford that has minor impact on channel form and function.

HQA: *recommendation* – a national scoring protocol should be developed in Portugal to reflect river and riparian features that contribute to natural habitat and diversity and quality.

Land-use categories: *reaffirm* that these should reflect local/regional land management and be, wherever possible, additional categories within standard RHS types (e.g. olive groves are equivalent to orchards).

Managed cork oak: *suggestion* – a ring is put round the 'BL' land-use category to identify managed cork with some scrub understorey, whilst cork oak with no understorey at all is classified equivalent to 'orchard'. Well-established scrub in unmanaged cork oak is broadleaf woodland 'BL'.

Marsh occurring on natural berms and riparian floodplains: *reaffirm* that marsh 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.

Mature island/vegetated mid-channel bar: *suggestion* – where the equivalent features occur in the riparian area but are only islands or bars surrounded by water during higher flows, a ring should be put round 'MI' or 'MB'. This allows RHS to record the variety of habitats in similar fashion to that for truly braided channels. HQA scoring of these 'ringed' entries needs to be consistent because of the dangers of double-counting if riparian zone complexity is also scored using the same features as qualifying criteria.

Cork oaks in river valleys provide an important income to local communities.

Non-native species: *reaffirm* that high impact species relevant to the locality are included on the list in Section O.

***Pegos*/vernal pools:** *recommendation* – a precise definition is developed and the feature is included as 'present' or extensive as a 'special feature' (Section M) and a count is made in Section C.

Riparian (wet) woodland: *reaffirm* that this 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 mainland Europe, although rare in the UK. It should be retained as a "feature of special interest" (Section M).

Riparian zone: *recommendation* – there should be a clear definition to include the area between the wetted channel and banktop determined by the flood-level trashline. It should include an assessment of all riparian features and the width of riparian habitat (see Annex L).

Side bar count: *recommendation* – as side bars often occur extensively on many mainland European rivers, a count should be made in Section C.

Side bar definition: *reaffirm* better diagnostic clues and illustrations to distinguish between side bars and discrete gravel/cobble deposits are needed in the RHS Manual and during training.

For intermittent Mediterranean rivers, seasonality of survey is important.

Side and sub-channels: *recommendation* – better guidance is developed because truly braided channels are extremely rare in Mediterranean rivers. Dry and wet sub-channels can already be recorded by RHS at individual spot-checks (Section E) and they should also be included as 'present' or 'extensive' in the special features.

Survey season: *recommendation* – clear guidance on when to survey is agreed because of the major seasonal flow differences on intermittent watercourses.

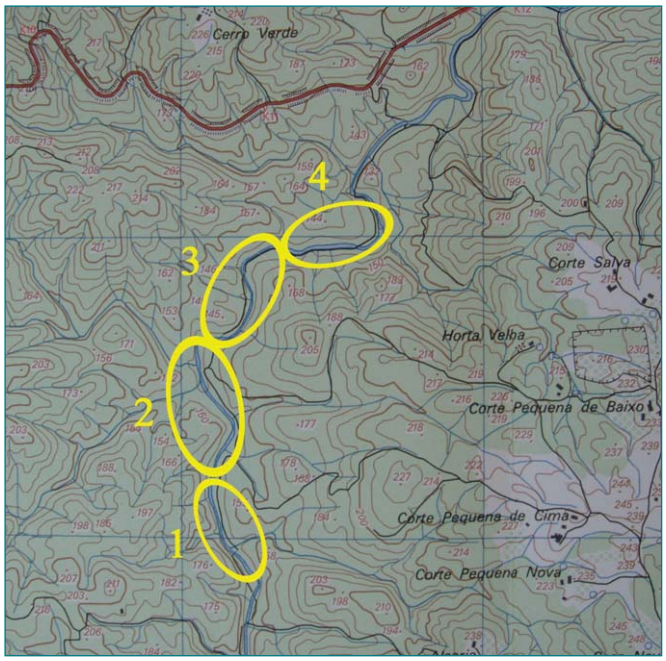
Tandem survey work: *recommendation* – two surveyors should work in tandem on opposite banks in sites where the riparian zone is complicated. They should communicate (for instance, by walkie-talkie) to agree survey form entries where the 'far bank' would otherwise not be visible. This paired working for complicated sites where visibility is restricted, is also essential for health and safety reasons.

Tree distribution: *recommendation* – where riparian habitat is extensive, the distribution of riparian trees should be recorded along the wetted channel margin, because this reflects the contribution of gallery trees to the riverine habitat. Field-survey assessment of tree distribution should be verified using aerial images.

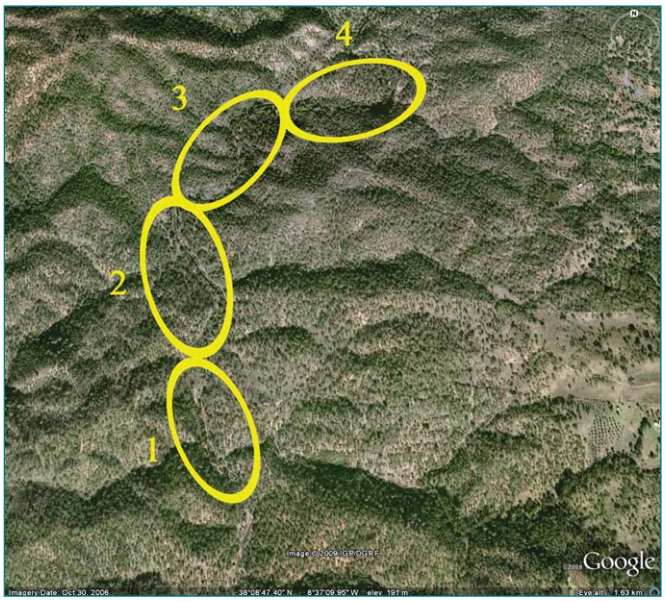
Recording the number of bars in each site is recommended.

ANNEX A: Maps and *Google Earth* images of Port-1 to Port-8.

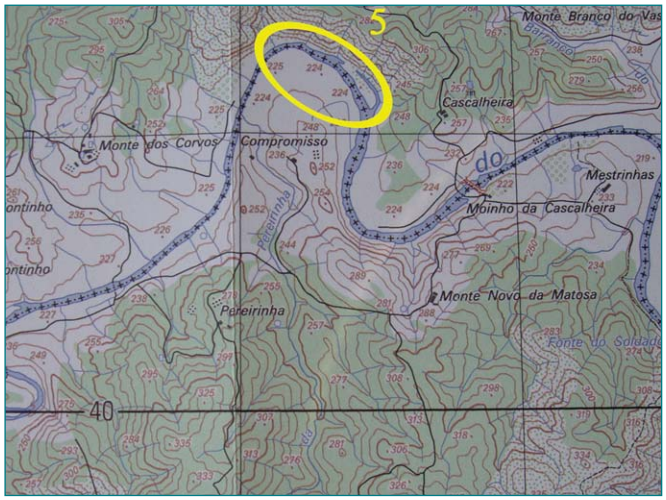
Maps: Instituto Geográfico do Exército (Carta Militar de Portugal)



Port-1-4 Map.



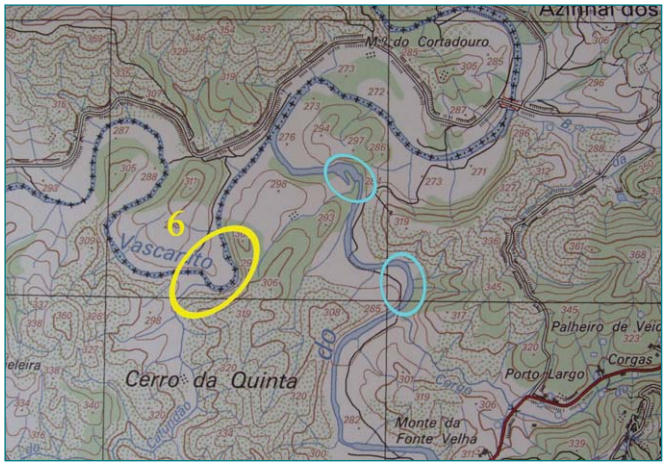
Port-1-4 *Google* Image.



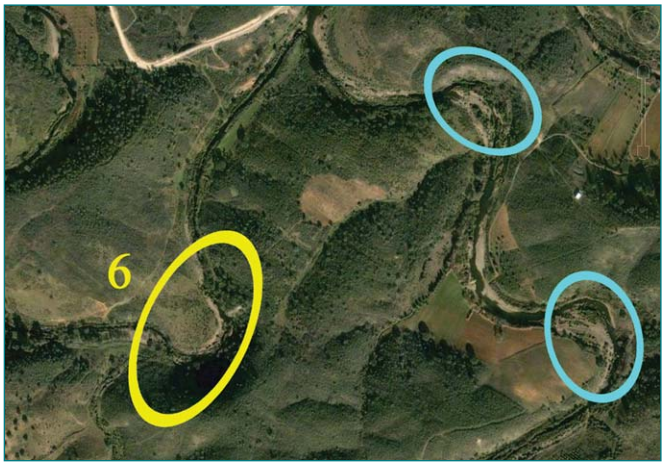
Port-5 Map.

Port-5 *Google* Image.

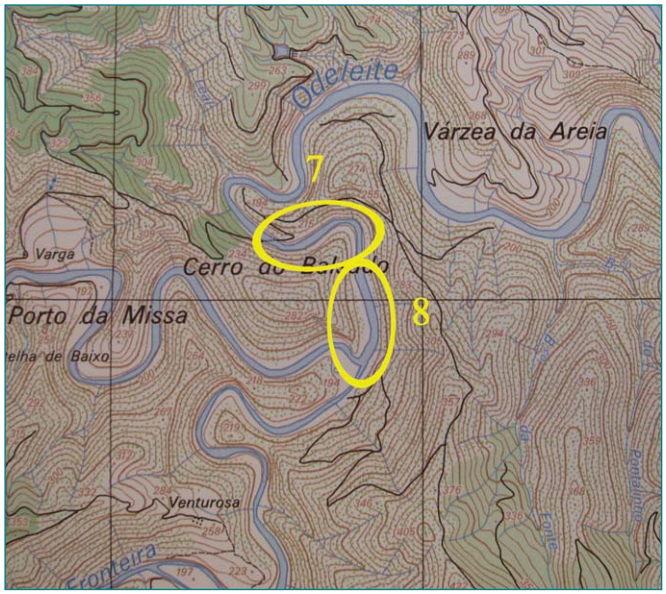
A large backwater feature; Port-5.



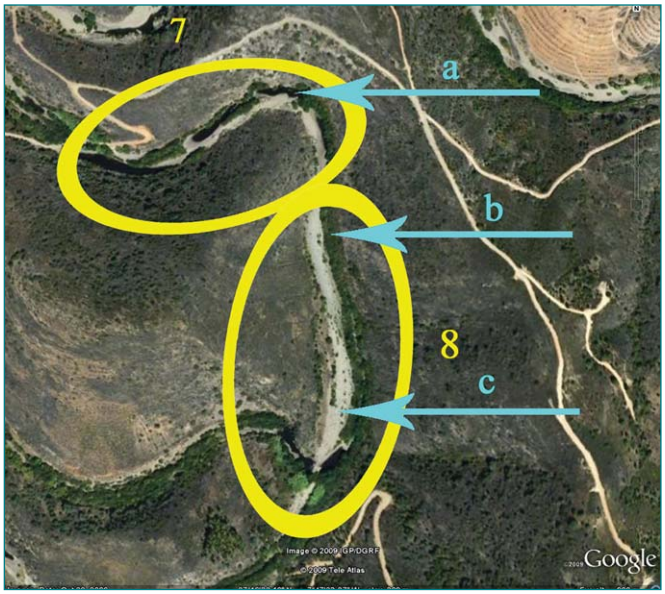
Port-6 Map.



Port-6 *Google* Image.



Port-7, 8 Map.



Port-7, 8 *Google* Image.

ANNEX B: Catchment geology. Percentage of catchment area upstream from our RHS sites.

	Grândola (Port-1- 4)	Vascão (Port-5)	Vascanito (Port-6)	Odeleite (Port-7, 8)
Carboniferous meta-sandstone shale/slate meta-limestone (Mértola formation)	100	8		
Late Devonian - Early Carboniferous meta-rhyolite meta-basalt group shale/slate quartzite	<1			
Carboniferous meta-sandstone shale/slate meta-limestone (Mira formation)		92	100	100

ANNEX C: Catchment land-use. Percentage of catchment area upstream from our RHS sites.

CLC2000 Class (level 2)	Grândola (Port-1- 4)	Vascão (Port-5)	Vascanito (Port-6)	Odeleite (Port-7, 8)
Mine, dump and construction sites		<1		<1
Arable land	1	1		
Permanent crops		<1		
Mixed agriculture	8	17	25	8
Forests, including cork oak	91	55	50	53
Shrub and/or herbaceous vegetation associations		27	25	39

ANNEX D: Characteristics of the rivers surveyed. Superscripts refer to site number.

	Grândola (Port-1- 4)	Vascão (Port-5)	Vascanito (Port-6)	Odeleite (Port-7, 8)
Predominant land-use	Managed cork oak and scrub	Woodland and scrub	Woodland and scrub	Woodland and scrub
Valley shape	Deep vee	Asymmetrical	Asymmetrical	Deep vee
Valley relief	100m	100m	60m	270m
Mid-site altitude	141m[1] 137m[2] 135m[3] 131m[4]	220m	280m	190m[7] 191m[8]
Channel slope	8.1m/km[1-4]	2.4m/km	4.1m/km	4.9m/km[7-8]
Distance from source (mid-point)	8.2km[1] 8.7km[2] 9.2km[3] 9.7km[4]	40.4km	20.5km	32.7km[8] 33.2km[7]
Height of source	248m	500m	409m	481m
Water width	3.5m[1] 5.5m[2] 3.5m[3] 2.0m[4]	23.0m	14.0m	12.5m[7] 7.0m[8]
Trashline channel width	Not applicable	Not applicable	Not applicable	28.0m[7] 35.0m[8]
Predominant channel substratum*	Pebble-cobble[1] cobble[2-4]	Cobble	Pebble-cobble	Cobble
Predominant flow type*	Smooth[1] unbroken wave[2] rippled[3] smooth[4]	Smooth	Smooth	Smooth
HQA	68[1, 2] 69[3] 81[4]	76	68	71[7] 73[8]
HMS (and class)	120(2)[1] 80(2)[2] 130(2)[3] 90(2)[4]	0(1)	0(1)	75(2)[7] 0(1)[8]
MTR score	61[1] 64[2] 54[3] 61[4]	60	65	60[7] 73[8]
Impacts on site	Minor fords	Negligible	Negligible	Ford immediately downstream from Port-7

* occurring in more than 3 or more spot-checks.

ANNEX E: HQA sub-scores and total scores for Port-1 to Port-8.

Site number (Port)	1	2	3	4	5	6	7	8
HQA sub-score category								
Flow-types	9	10	10	11	8	8	10	10
Channel substrata	8	7	9	10	8	7	11	12
Channel features	7	9	6	11	12	11	5	6
Bank features	7	7	8	10	9	9	6	4
Bank vegetation structure	12	12	12	12	12	12	12	12
In-stream vegetation	8	7	5	6	6	3	3	4
Land-use ‡	4	3	4	3	4	2	7	7
Trees and associated features	11	11	11	11	7	10	11	11
Special features ‡	2	2	4	7	10	6	6	7
Total HQA score	**68**	**68**	**69**	**81**	**76**	**68**	**71**	**73**

‡ Assumptions made on scoring land-use and special features.

ANNEX F: HMS and habitat modification class for Port-1 to Port-8.

Site number (Port)	1	2	3	4	5	6	7	8
HMS score	120	80	130	90	0	0	75	0
Habitat modification class	2	2	2	2	1	1	1	1

ANNEX G: Water chemistry. Data from nearest sampling point to RHS sites.

RHS site	River name	pH	Conductivity (µScm-1)	Total hardness (mg $CaCO_3$/l)	Total hardness class	Total phosphorus (µG/l)	Nitrate (mg NO_3/l)	Distance downstream from RHS site
Port-1 to 4	Grândola	8.80	328	118	Soft	70	0.5	1.6km
Port-5	Vascão	8.71	236	64	Very soft	30	0.5	2.5km
Port-7, 8	Odeleite	7.90	231	72	Soft	22	10.4	35.0km

Annex H: MTR survey results.

STR = Species Trophic Rank; SCV = Species Cover Value (scale 1-9); CVS – Cover Value Scores (STR x SCV)

Site Names			PORT-1		PORT-2		PORT-3		PORT-4		PORT-5		PORT-6		PORT-7		PORT-8	
Species \Trophic Rank\SpeciesCover Value\ Species Cover Score		**STR**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**
Hildenbrandia rivularis	Red alga	6		0	1	6		0		0		0		0		0		0
Lemanea fluviatilis	Wire alga	7	1	7	1	7		0	1	7	1	7		0	1	7	2	14
Cladophora agg.	Blanketweed	1	1	1	1	1	1	1		0		0		0	1	1		0
Vaucheria sp(p)	Mole-pelt alga	1		0		0		0	1	1		0		0		0		0
Bryum pseudotriquetrum	Moss	9		0		0		0		0		0		0	1	9	1	9
Cinclidotus fontinaloides	Moss	5		0	2	10	1	5	2	10		0		0		0		0
Fontinalis antipyretica	Moss	5		0	1	5		0	1	5		0		0		0		0
Fontinalis squamosa	Moss	8	5	40	7	56	6	48	7	56	2	16	3	24	1	8	7	56
Hygroamblystegium fluviatile/tenax	Moss	5	1	5	1	5	1	5	1	5		0		0		0	2	10
Hygrohypnum luridum	Moss	9	2	18	3	27	2	18	3	27		0		0		0		0
Leptodictyum riparium	Moss	1	1	1	1	1	1	1	1	1		0		0		0		0
Platyhypnidium riparioides	Moss	5	1	5	1	5	2	10	2	10		0		0		0	1	5
Equisetum palustre	Marsh Horsetail	5		0	1	5	1	5	1	5		0		0		0		0
Apium nodiflorum	Fool's Water-cress	4	1	4	1	4	1	4		0		0		0		0		0
Lotus pedunculatus	Marsh Trefoil	8	1	8	2	16	2	16	1	8	1	8		0	1	8	1	8
Oenanthe crocata	Hemlock Water-dropwort	7	3	21	4	28	3	21	3	21	2	14		0	1	7	2	14
Ranunculus peltatus	Pond Water-Crowfoot	4	1	4	1	4	1	4	1	4	5	20	1	4		0		0
Ranunculus flammula?	Lesser Spearwort	7		0		0		0		0	1	7		0		0		0
Eleocharis palustris	Common Spike-rush	6	1	6	2	12	3	18	2	12	2	12	1	6	1	6		0
Schoenoplectus lacustris	Common club-rush	3		0		0	6	18	2	6		0		0		0		0
Typha angustifolia	Bulrush	2	1	2		0	2	4		0		0	1	2	1	2		0
Sub-scores for calculating MTR Scores			20	122	30	192	33	178	29	178	14	84	6	36	8	48	16	116
MTR Scores			**61**		**64**		**54**		**61**		**60**		**60**		**60**		**73**	

Annex I: 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 present at edge/margin only.

Site Names	Common Names	PORT-1	PORT-2	PORT-3	PORT-4	PORT-5	PORT-6	PORT-7	PORT-8
Cladophora agg.	Blanketweed	1100	1100	1100	1100			1100	
Vaucheria sp(p.)	Mole-pelt alga			1100	1100				
	Filamentous algae not above	2200	2200	1100	2200	2200	3300	1100	3300
Hildenbrandia rivularis	Red encrusting alga		1100						
Lemanea fluviatile	Wire alga	1100	1100	1100	1100	1100		1100	2200
Nitella sp.	Stonewort	1100	1100	1100	1100				
	Encrusting lichen	2211	1111	1111	1111	1111	1111	1111	1111
	Foliose lichen		1100						
Lunularia cruciata	Liverwort	22	11	11	11	22	11		
Bryum pseudotriquetrum	Moss					1111	11	1111	1111
Cinclidotus fontinaloides	Moss		1122	1111	2211		1111		
Cratoneuron filicinum	Moss	1111							
Fontinalis antipyretica	Moss		1111	1111	1111				
Fontinalis squamosa	Moss	3311	3311	3311	3322	2211	3211	2211	3311
Hygroamblystegium fluviatile/tenax	Moss	1122	1122	1111	2233	1111	1111		1122
Leptodictyum riparium	Moss	1100	1111	1111	1111				
Octodiceras fontanum	Moss	1100	1100	2200	1100				
Platyhypnidium riparioides	Moss	1111	1111	1111	2211				1111
	Ferns	11	11	11	11				

Site Names	Common Names	PORT-1	PORT-2	PORT-3	PORT-4	PORT-5	PORT-6	PORT-7	PORT-8
Apium nodiflorum	Fool's water-cress	1111	1111	1111	1111				
Callitriche brutia var. *brutia*	Pedunculate water-starwort	1100	1100	2200	1100				
Callitriche stagnalis	Common water-starwort		1111	1100	1100				
Epilobium hirsutum	Great willowherb			11					
Lotus pedunculatus	Marsh trefoil	1111	1122	1122	1122	1111	1111	2122	1111
Lythrum salicaria	Purple loosestrife					11		2121	2122
Mentha aquatica	Water-mint	2222	2222	2222	2222	1111			
Myosotis scorpioides	Water for-get-me-not	1111	1122	1111	1111	1111	1111	11	11
Myriophyllum sp.	Milfoil						1100		
Oenanthe crocata	Hemlock water-dropwort	2222	3333	2233	2222	1122	2222	1121	1121
Pulicaria dysenterica	Fleabane					11			
Ranunculus flammula/ ophioglossifolius	Lesser Spearwort					1100			
Ranunculus peltatus	Pond water-crowfoot	2211	1111	2211	2211	3322			
Ranunculus sp.	Water-crowfoot					3222	2200		
Rorippa nasturtium-aquaticum agg.	Water-cress		1111	1111	1111				
Scrophularia auriculata	Water figwort	11	11	11	11				
Veronica anagallis/ catenata	Blue/pink water-speedwell		11						
	other dicotyledons	1122	1122	1122	1122	2222	1122	1111	1111
Alnus glutinosa	Alder							2122	2222
Salix sp(p.)	Willow	1111	1122	1122	1122			3222	3333
	Other trees and shrubs	1122	1122	2233	1133	1133	3333	3233	2222
Carex pendula	Pendulous sedge	11	11	11	11				
Deschampsia sp.	Tufted hair-grass	11	11	11	11				
Eleocharis palustris	Common spike-rush	1111	2222	2222	1111	2222		1111	1111
Glyceria fluitans/notata	Sweet-grass	1111							
Juncus acutiflorus/ articulatus	Sharp-flowered rush	1122	2222	1122	2222	1122	1111	1122	1111
Juncus effusus	Soft rush	2233	2233	2222	2222	2233	1122	1122	1111
Schoenoplectus lacustris	Common club-rush			2211	2211	2211	1111		
Scirpus sylvaticus	Wood club-rush							1111	1111
Typha angustifolia	Bulrush	1111		2211	1111	1111	2211	1111	1100
	other monocotyledons	2233	2222	1122	1122	3333	1122	1111	1111
NON JNCC CHECK-LIST TAXA									
Collema dichotomum	River jelly-lichen		1100						
Riccia beyrichiana	Liverwort			1111					
Bryum dichotomum	Moss	1122	1122	1111	2222	1111	1111	1111	1111
Didymodon insulanus	Moss		11	11					
Mnium undulatum	Moss		11	11	11				
Selaginella sp.	Clubmoss	33	22	22	22	11			11
Equisetum arvense	Creeping horse-tail		1111	1111	1111				
Isoetes echinospora	Quillwort					2211			
Callitriche sp.	unidentifiable starwort					2211			
Erica lusitanica	Heather							22	11
Illecebrum verticillatum	Coral necklace					1111			
Mentha sp(p.), inc. *M. Pulegium*	Mint	2222	2222	2222	2222	1111	1111	1111	1111
Myosotis sp.	Forget-me-not species					1111			
Nerium oleander	Oleander					11	2233	1111	11
Ranunculus ficaria	Lesser celandine								
Ranunculus trilobus		1111	1111	1111	1111	1122			
Saponaria officinalis	Soapwort						11	11	11
Gratiola officinalis		1111	1122	1122	2222	2222		1111	1111
Arundo donax	Giant reed						1111	1122	22
Baldellia repens/ ranunculoides	Lesser water-plantain		1111	1111		2222	1111		
Carex elata	Tufted-sedge							3233	2233
Cyperus longus		2222	2222	2222	2222	3322	2211	1111	1111
Scirpoides (Schoenus) holoschoenus		1122	1122	1122	1122	2233	1122	1122	1111

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

Key: habitat features; P = present; E = extensive; Wildlife observations • = species present.

Habitat features	Grândola (Port-1- 4)	Vascão (Port-5)	Vascanito (Port-6)	Odeleite (Port-7, 8)
Backwaters		P		
Mature mid-channel islands		E		
Natural terraces and berms	E	P		P
Sub-channels		E	P	P
Riparian scrub	E	E	E	E
Wildlife observations				
Azure-winged magpie (*Cyanopica cyana*)		•		
Bonelli's eagle (*Hieraaetus fasciatus*)		•		•
Common sandpiper (*Actitis hypoleucos*)		•		
Eagle owl (*Bubo bubo*)		•		
Grey Wagtail (*Motacilla cinerea*)	•		•	•
Hoopoe (*Upupa epops*)		•		
Kingfisher (*Alcedo atthis*)	•	•		
Montagu's harrier (*Circus pygargus*)		•		
Nightingale (*Luscinia megarhynchos*)	•	•		•
Sardinian warbler (*Sylvia melanocephala*)	•			
Western clubtail (*Gomphus pulchellus*)?			•	
Spanish feotoon (*Zerynthia rumina*)	•			
Marsh fritillary (*Euphydryas aurinia*)	•			
Otter (*Lutra lutra*) spraints*	•	•	•	•
Wild boar (*Sus scrofa*) uprooting of earth	•	•	•	•
Ladder snake (*Elaphe scalaris*)				•
Pond terrapin (*Emys orbicularis*)	•			•
Tree frog (*Hyla arborea*)	•			
Water snake (*Natrix* sp.)	•	•		

* several with crayfish (*Procambarus clarkii*) remains

Pond terrapin.

Marsh fritillary.

Newly emerged dragonfly – probably a female western clubtail; Port-6.

Backwaters were a prominent feature on the Vascão; Port-5.

ANNEX K: Portuguese RHS training course programme.

INAG, I.P., Environment Agency, UTAD, Vila Real; 20th to 23rd April 2009.

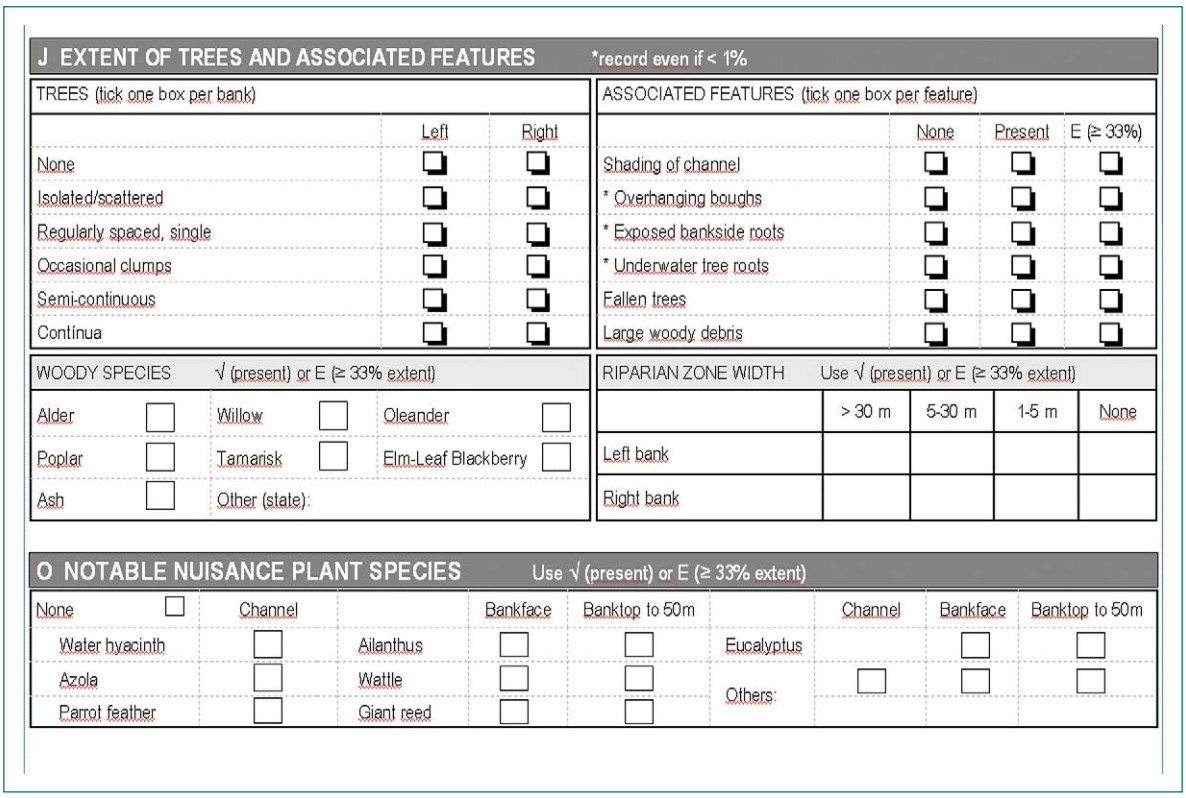
DAY 1 (20th April)			
10H00	Plenary session – Hydromorphology, WFD, RHS (briefing)	16H00	Tea/Coffee
13H00	Arrival and Lunch at Vila Real University (UTAD)		Video: Flow Types and geomorphology
14H00	Introductions; Health and Safety		Presentation: Bank and Channel Modifications
14H30	Presentation: Course Outline		Presentation: Bank, Channel and Valley Features
	Presentation: RHS Development & Applications	18H00	Summing up; Q&A Session
	Quiz: Highlights current knowledge and areas of weakness using		
	sample Accreditation Test Questions		
	Presentation: Introduction to Fluvial Geomorphology		

DAY 2 (21st April)			
8H30	Breakout Session: Channel modifications	13H15	Lunch at Vila Real University (UTAD)
10H00	Site Visit 1: River Tanha	14H00	Site Visit 2: Olo 2

DAY 3 (22nd April)			
8H30	Question and Answer Session (if Required)	14H00	Site Visit 4: River Pinhão
	Breakout Session: Channel features		Question and Answer Session
10H00	Site Visit 3: Corgo 1	20H00	Social dinner
13H15	Lunch at Vila Real University (UTAD)		

DAY 4 (23rd April)			
8H30	Spotting errors on form	14H30	Written assessment (1 hour)
9H30	Field assessment: Site Visit 5: Olo 1	17H00	Portuguese RHS adaptation – new elements
	Question and Answer Session (if Required)		
13H15	Lunch at Vila Real University (UTAD)		

ANNEX L: Modifications to the RHS form to account for riparian habitat in Portugal.



J EXTENT OF TREES AND ASSOCIATED FEATURES *record even if < 1%

TREES (tick one box per bank)

	Left	Right
None	❑	❑
Isolated/scattered	❑	❑
Regularly spaced, single	❑	❑
Occasional clumps	❑	❑
Semi-continuous	❑	❑
Contínua	❑	❑

ASSOCIATED FEATURES (tick one box per feature)

	None	Present	E (≥ 33%)
Shading of channel	❑	❑	❑
* Overhanging boughs	❑	❑	❑
* Exposed bankside roots	❑	❑	❑
* Underwater tree roots	❑	❑	❑
Fallen trees	❑	❑	❑
Large woody debris	❑	❑	❑

WOODY SPECIES √ (present) or E (≥ 33% extent)

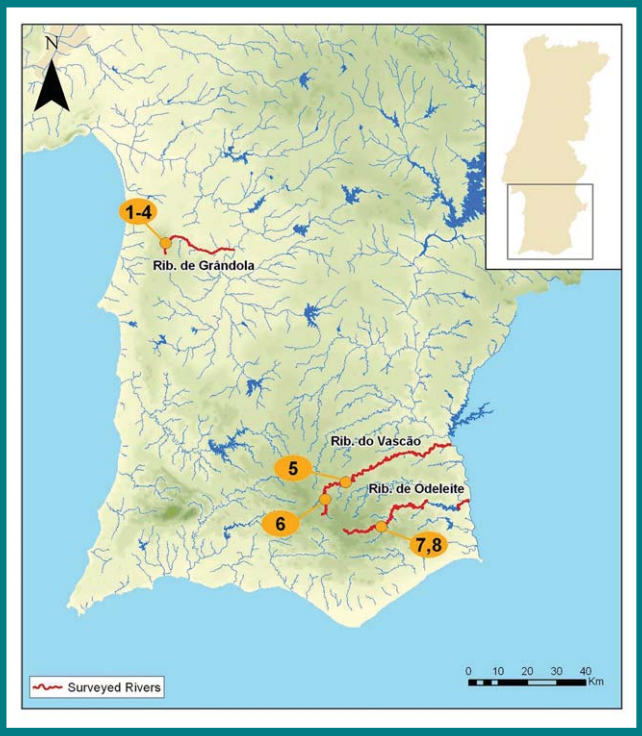
Alder ☐	Willow ☐	Oleander ☐
Poplar ☐	Tamarisk ☐	Elm-Leaf Blackberry ☐
Ash ☐	Other (state):	

RIPARIAN ZONE WIDTH Use √ (present) or E (≥ 33% extent)

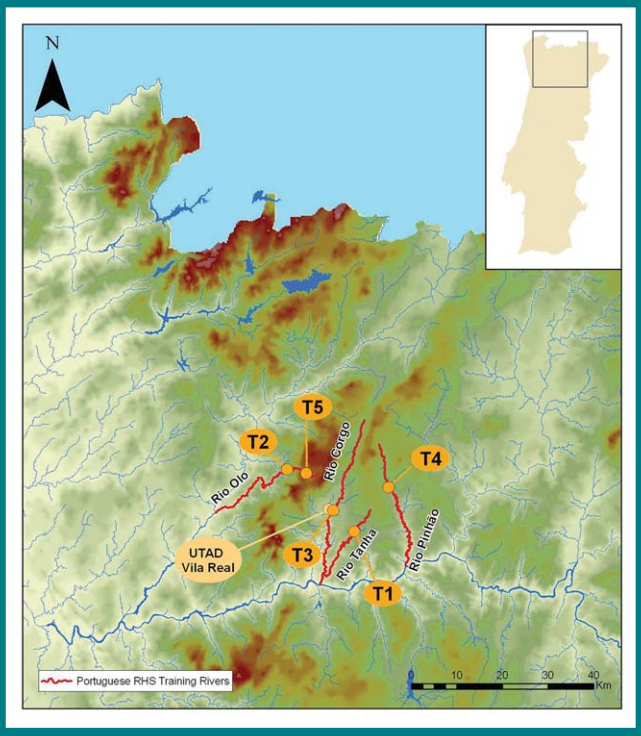
	> 30 m	5-30 m	1-5 m	None
Left bank				
Right bank				

O NOTABLE NUISANCE PLANT SPECIES Use √ (present) or E (≥ 33% extent)

None ☐	Channel		Bankface	Banktop to 50m		Channel	Bankface	Banktop to 50m
Water hyacinth	☐	Ailanthus	☐	☐	Eucalyptus		☐	☐
Azola	☐	Wattle	☐	☐	Others:	☐	☐	☐
Parrot feather	☐	Giant reed	☐	☐				



Location of benchmark sites



Location of RHS training sites

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Environment Agency

INSTITUTO DA ÁGUA, I.P.