




RIVER HABITAT SURVEY IN THE ARDÈCHE AND CÉVENNES AREAS OF SOUTH-EASTERN FRANCE

RESULTS FROM 2007

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WEB SITES

Cévennes National Park:
http://les.cévennes.free.fr/en/national-park.htm;
http://wwwcévennes-parcnational.fr
Floodsite: Flash Flood Basins:
http://www.floodsite.net/htm/pilot_site_flashflood.htm
Google Earth: http://earth.google.com/index.html
Life in UK Rivers: www.riverlife.org.uk
REBECCA project: www.environment.fi
RHS: www.rhs@environment-agency.gov.uk
Rhône-Mediterranean river basin:
www.rhône-méditerranée.eaufrance.fr
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
FRA	Unique acronym to identify sites from 2007 river survey on the RHS database
GPS	Global Positioning System
HER	Hydro-ecoregion
HMS	Habitat Modification Score
HMC	Habitat Modification Class
HQA	Habitat Quality Assessment
JNCC	Joint Nature Conservation Committee
MTR	Mean Trophic Rank
PCA	Principal Component Analysis
REBECCA	Relationships between ecological and chemical status of surface waters
RHS	River Habitat Survey
STAR	STAndardisation of River Classifications
WFD	Water Framework Directive
WISE	Water Information System for Europe

PURPOSE

The overall purpose of this visit was to undertake River Habitat Surveys (RHS)[1] on a selection of rivers in the Ardèche and Cévennes areas in Southern France to test the technique and for inter-calibration purposes under the EU Water Framework Directive (WFD).

Specific objectives were to:

- Locate and survey near-natural examples of different river types in the Ardèche and Cévennes districts using the RHS, Joint Nature Conservation Committee (JNCC)[2], and Mean Trophic Rank (MTR)[3] macrophyte survey methods.

- Collect RHS and macrophyte data for European inter-calibration purposes and add to the database established for the STAndardisation of River Classifications (STAR) project[4].

- Generate data for subsequent use in testing and refining the draft CEN standard on the morphological quality of European rivers.

- Recommend improvements to the RHS guidance manual for use on UK and European rivers.

- Share our experiences of river habitat survey and evaluation in the UK with the Ministère de l'Ecologie, du Développement Durables et de l'Aménagement and the Agence de l'Eau Rhône-Méditerranée et de Corse.

BACKGROUND TO METHODS

River Habitat Survey

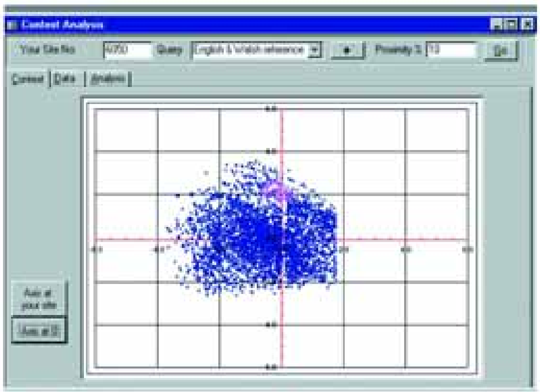
River Habitat Survey is a method developed in the UK to characterise and assess, in broad terms, the physical character of freshwater streams and rivers. It is carried out along a standard 500m length of river channel, with observations made at 10 equally spaced spot-checks along the channel. Other information on valley form, land use in the river corridor etc., is also collected. Field survey follows the strict protocols given in the 2003 RHS Manual[1].

RHS has been carried out in several European countries and the Manual has been adapted for local requirements and translated into Italian, French and Polish, whilst a Portuguese version is planned.

Training and accreditation for RHS is now standard practice in Poland.

Data are entered onto an RHS database. This now contains field observations, map-derived information and photographs from more than 17,000 surveys undertaken since 1994. During 1994-96 a stratified random network of sites established a geographically representative baseline cross-section of streams and rivers across the UK[5]. A second survey, to establish trends in habitat quality since the initial baseline, is being carried out in 2007 and 2008.

The RHS database allows sites of a similar nature to be grouped together for comparative purposes. For the UK, slope, distance from source, height of source and site altitude are used to cluster RHS sample sites for so-called "context analysis" based on principal component analysis (PCA) plots[6].



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

Indices of habitat quality and channel modification can be derived from RHS data, and these can be used as a basis for setting physical quality objectives for rivers[7].

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

Points are added together to provide the HQA. In contrast to HMS (*see below*), the higher the score, the more highly rated the site. The diversity and character of features at any site is influenced by natural variation and the extent of human intervention both in the channel and adjacent land. The RHS database allows HQA scores to be compared using sites with similar physical characteristics (e.g. slope, distance from source) and geology. Features determining habitat suitability for individual species such as European otter (*Lutra lutra*), or dipper (*Cinclus cinclus*) can also be selected, thereby providing a more ecologically-specific context for comparing sites[8]. Carrying out RHS and macrophyte surveys at specially selected good quality sites provides the necessary calibration of HQA for a range of river types in the UK. These special surveys have been extended to mainland Europe, including Finland, Norway, Poland, Slovenia, Bavaria and the Tyrolian Alps. This visit to south-eastern France represented another special survey. Comparison of various habitat assessment methods has also been part of this European-wide initiative[9].

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

Habitat Modification Score (HMS) is, by contrast, an indication of modification to the river channel morphology. To calculate HMS for sites, points are awarded for the presence of artificial features such as culverts, weirs, current deflectors, and bank revetments. Points are also awarded for modifications to the channel such as re-sectioned banks or heavily trampled margins. The more severe the modification, the higher the score. The cumulative points 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. In contrast to HQA, higher scores reflect more intervention and modification of the river channel within the site.

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

The STAR (STAndardisation of River Classifications) project. The STAR project was a research project funded by the European Commission under the Fifth Framework Programme and it links to the implementation of the Key Action "Sustainable Management and Quality of Water" within the Energy, Environment and Sustainable Development Programme. The project had a formal link to CEN and a key aim was to provide relevant CEN working groups with draft methods.

The project, completed in 2005, aimed to provide standard biological assessment methods compatible with the requirements of the WFD. 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' sites were chosen to reflect a gradient in habitat and morphology degradation. Results from the STAR project were published in a special issue of the journal *Hydrobiologia* in 2006[4].

Aquatic macrophyte surveys

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

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

The second type of macrophyte survey normally carried out is the Mean Trophic Rank (MTR). 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[3].

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

SURVEY AND ASSESSMENT

The study area was chosen because it is well-wooded, sparsely populated and contains land designated as national and regional park. This greatly increased the chances of finding near-natural watercourses. The area also differed in geology and landscape character from alpine areas previously surveyed in Slovenia[10] and the Austrian Tyrol[11].

Because rivers with good water quality were needed, the geographical clustering of Water Framework Directive reference sites was used as an initial guide. Preferred land-use, (i.e. native woodland) and access details were derived from 1:25,000 maps of the area (IGN-*Carte de Randonnée*) obtained in advance from Stanfords map store and verified by recent satellite images from *Google Earth* available on the Internet. Final selection of each site was made on the day of survey. For approximate locations, see the back cover page.

We were also fortunate to meet Pascal Laquet, a local environmental officer, on the first day. He was able to advise us about the characteristics of the northern Ardèche rivers and recommended the first two rivers we visited.

The strategy was to survey sites characteristic of the area, taking into account the pattern of geology (schist, granite, limestone) to establish if there were any differences in river channel character and macrophyte flora. We also specifically targeted a river heavily impacted by hydro-electric power generation, to confirm assessment of this pressure for the CEN standard on hydromorphology (see FRA-9).

Sites surveyed on the same day were located as close as possible together because of long journey times caused by the tortuous, narrow roads that have to negotiate the deeply-incised river valleys.

River Habitat Survey was undertaken by Paul Raven and Hugh Dawson, working closely together for quality assurance and for health and safety reasons. Nigel Holmes carried out the macrophyte surveys, using both the JNCC and MTR methods on all the rivers surveyed.

The RHS survey form entries were checked using digital photos taken in the field. Background information (altitude, geology, land use, water quality, climatic and hydrological regime), were derived from various publications and topographical 1:25,000 scale maps (Appendix 2).

Indicative water chemistry was determined from samples taken in the field by Hugh Dawson (pH: conductivity, hardness/colour) and subsequently analysed in the laboratory. This gives a broad indication of this important influence on river biology (Appendix 6). Water quality information was provided by Stephane Stroffek and also taken from the website http://www.ecologie.gouv.fr/Les-9es-programmes-sur-les-sites.html.

Incidental *ad hoc* wildlife observations were made by Paul Raven. Birds are good indicators of landscape character, so for contextual purposes, species seen close to the sites, but not necessarily within them were also included (Appendix 5).

The weather was unseasonably cold and wet for most of the survey week (27 May – 1 June 2007). Water levels were slightly elevated (especially in FRA-12 after heavy rain the previous day) but water clarity was excellent throughout. These conditions did not affect the RHS or macrophyte surveys but inevitably affected the wildlife sightings, particularly of insects.

Yellow-bellied toad – recorded on the Eyrieux River.

Peter Scarlett, at the Centre for Ecology and Hydrology (CEH), derived the PCA plot. Calculation of the RHS indices (HQA and HMS) was done by Paul Raven, using the 2005 version of these systems – in similar fashion to that done for Slovenia[10], Bavaria and the Tyrolian Alps[11]. MTR scores were calculated by Nigel Holmes. Identification of unknown bryophytes, or those where there was uncertainty, was done by Ben Averis.

Two-tailed pasha – seen near the Ardèche and Drobie Rivers.

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. The notes in Appendix 1 appear in Section P of the RHS database entry. The abbreviated site names, starting with "FRA" are unique acronyms to identify them in the RHS database.

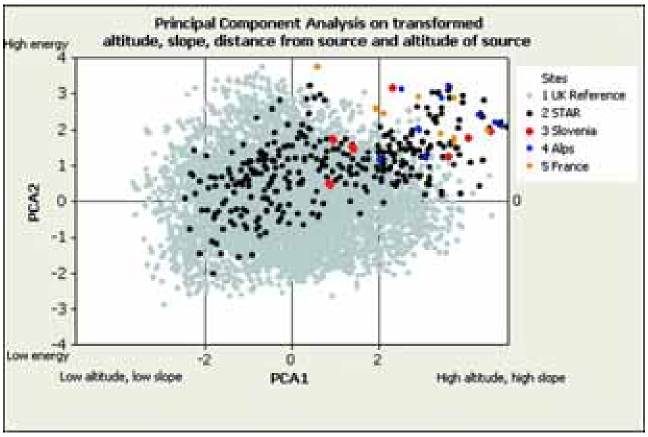


Figure 1. PCA plot showing UK, STAR and European benchmark sites.

Five of the eight rivers visited had obvious signs of beaver activity.

The eight streams and rivers visited in the Ardèche and Cévennes during 27 May – 1 June 2007 represented a variation on a landscape theme, namely heavily-wooded deep vee-shaped or gorge valleys. Variation was provided by differences in geology, channel bedslope and distance from source. In total, 13 RHS site surveys (500m lengths) JNCC and MTR surveys were completed. The RHS information comprises five single surveys and four double lengths (back-to-back 1 km) on four of the rivers (Appendix 1).

The Ardèche gorge – a spectacular wooded valley.

The similar valley form and channel character of FRA-1 to FRA-13 contrasts with the greater variety of landscape character we visited in Slovenia, Bavaria and the Tyrolian Alps where braided river channels and orchid-rich floodplain meadows featured at some of the sites[10, 11].

RESULTS

Context in relation to European hydro-ecoregions and UK rivers

The study area lies broadly within the Cévennes hydro-ecoregion (Table 1). The hydro-ecoregion concept provides a very useful framework for comparing river character on a European scale and has been developed as part of the European REBECCA project[12].

Figure 1 shows a PCA plot of the 2007 sites, compared with previous surveys [10, 11], STAR project sites [4] and UK baseline RHS sites. It confirms the high energy nature of rivers in the Ardèche and Cévennes.

TABLE 1: General characteristics of the Cévennes hydro-ecoregion as determined by REBECCA[12].

Altitude	450-750 m (medium)
Slope	2%-6% (medium)
Relief	Middle mountains
Lithology	Crystalline
Climate	Temperate mountain

Landscape and river character

The Ardèche and Cévennes are characterised by deeply dissected river valleys cut into the schist and limestone plateaux. The landscape differs in character from the Alps to the east, Central Massif to the north and Pyrenees to the south-west. The Cévennes form an important watershed for rivers draining (i) west and north to the Atlantic (e.g. the Loire and Tarn) and (ii) south and east to the Rhone valley and Mediterranean (e.g. the Gard, Ardèche and Herault).

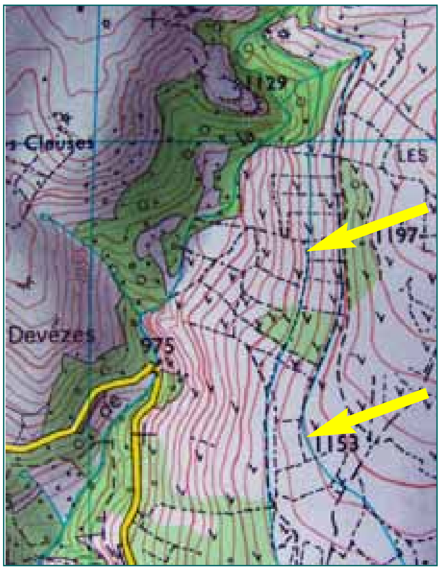
The rate of downward erosion by the rivers into the schists and limestone is impressive. Meanders have been maintained even in the 250 m deep gorge section of the Ardèche river, and oxbow channels are preserved as spectacular features.

Le Pont d'Arc on the Ardèche River.

The area is sparsely populated, with a few small hamlets and some bigger settlements in the more popular tourist areas (e.g. Vallon-Pont-d'Arc). There are few large towns (e.g. Aubenas, Alès), whilst agriculture is intensive only where river valleys are broad and relatively fertile, such as alongside the Ardèche River between Aubenas and Vogue.

Land use in the steep valleys is dense woodland or forest. Coniferous forestry occurs in several areas, but deciduous or mixed woodland, featuring beech (*Fagus sylvatica*) and

Vineyard terraces in the Drobie valley.



Levadas in the Brousse River catchment, shown by arrows.

A functioning levada in the Borne valley.

sweet chestnut (*Castanea sativa*) occurs extensively; these were the areas targeted. Terracing of favourably-positioned steep valley slopes, for vineyards using schist-stones for walls was widespread in the past , but in many cases the land has subsequently been abandoned and recolonised by shrubs and trees.

The streams and rivers flow in deeply-incised valleys and gorges, so they are all broadly of a similar character, with fast flow-types, coarse substrates and densely-wooded steep valley slopes. These characteristics, together with high rainfall (>1200 mm), mean that they are ideal for hydropower generation. Several river valleys (e.g. the Altier, Chassezac, Lignon) have hydropower dams and one of our sites (FRA-9, on the River Borne) was selected to assess the impact of hydropower modification on habitat character.

Another notable feature in several valleys was construction of levadas for irrigation purposes. Dilapidated and primitive irrigation in the Ardèches contrasted with well-functioning modern levadas in several catchments.

Morphological character

An overview of the landscape context, character and quality of the rivers visited is given in Tables 2 and 3, with more detailed information given in Appendices 2-4.

In bedrock channels the exposed rocks were often scoured bare up to the trashline, with some sapling alders (*Alnus glutinosa*) colonising cracks and crevices in boulder-sized vegetated bar material.

**TABLE 2: Basic landscape character of rivers surveyed in 2007.
Rivers are arranged in descending order of channel gradient.**

Site reference (ALP)	River Name	Channel slope (m/km)	Water width (m)	Trashline Level width (m)	Predominant valley form	Altitude of source (m)	Distance from source (km)
12	Brousse	100.0	7.0	7.5	Deep vee	1560	8.8
2, 3	Eyrieux	60.0[2], 35.0[3]	3.5[2], 5.5[3]	7.0[2], 6.0[3]	Deep vee	1100	13.2[2], 13.7[3]
1	Doux tributary	42.0	4.0	6.0	Deep vee	1190	8.0
13	Tarn	31.0	30.0	40.0	Deep vee	1650	21.7
9	Borne	12.5	18.0	40.0	Deep vee	1410	28.6
10, 11	Luech	8.0[10, 11]	9.0[10], 10.5[11]	28.0[10], 25.0[11]	Deep vee	1080	31.7[10], 32.2[11]
7, 8	Drobie	7.7[7, 8]	8.5[7], 11.0[8]	40.0[7], 45.0[8]	Deep vee	1180	21.0[7], 21.5[8]
4, 5, 6	Ardèche	1.45[4, 5, 6]	30m[5], 45m[6], 70.0[4]	85.0[5], 80.0[6], 120.0[4]	Deep vee/gorge	1280	96.2[5], 96.7[6], 97.7[4]

**TABLE 3: An overview of the habitat and water quality of rivers surveyed in 2007.
Rivers arranged in descending order of channel gradient.**

Site reference (FRA)	River name	Habitat quality (HQA)	Habitat modification score (and class)	MTR score	Chemical (and biological) water quality*
12	Brousse	70	0 (1)	64	[see Tarn, FRA-13]
2, 3	Eyrieux	81[2], 72[3]	0 (1)[2], 40 (2)[3]	68[2]; 66[3]	Very good (very good)
1	Doux tributary	68	0 (1)	70	[good (very good)]
13	Tarn	80	0 (1)	71	Good (very good)
9	Borne	76	350 (3)	73	Very good (very good)
10, 11	Luech	71[10], 66[11]	0 (1)[10], 0 (1)[11]	58[10]; 55[11]	Good (very good)
7, 8	Drobie	78[7], 74[8]	0(1)[7], 0(1)[8]	66[8]	Very good (good)
4, 5, 6	Ardèche	63[4], 61[5], 56[6]	0(1)[4, 5, 6]	48[4]	Very good (good)

* Data from nearest sampling point; biological classification based on macroinvertebrates and/or diatoms.

The scouring effect of flash floods leaves bedrock channels virtually without vegetation.

Cracks in the bedrock can provide footholds for some shrubs; Luech River.

Trashline at 40m – evidence of a spectacular flash flood; Ardèche gorge.

Most trashlines were at least 2-3 metres above dry weather flow, but the Ardèche gorge presented evidence of spectacular spate flows with several layers of debris, up to 40 metres above water level.

The HQA scores, not unexpectedly, were high throughout because of the near-natural character of the sites. The contributions that flow, channel and bank features make to the HQA scores vary locally and strongly depend on bedslope (Appendix 2 and 3). This pattern is consistent with wooded deep vee sites in the UK and elsewhere in Europe we have surveyed (Table 4).

Water quality

The chemical and biological water quality of most rivers in the Ardèche and Cévennes, including the ones we visited, is classified as good or very good (Table 3). Our own water chemistry and MTR results (Appendices 6 and 9) confirmed this.

TABLE 4: The characteristics of rivers in predominantly deep vee valleys in the UK, using selected features from the RHS baseline survey (1996 data).

Habitat feature	Percentage occurrence as extensive features in RHS baseline sites
Bankside trees	62
Shingle bars	89*
Woody debris	58*
Modifications	
Reprofiled banks	5
Protected banks	5
Impounded water	1
Land use	
Broadleaf woodland	48
Pasture land	23
Arable/tilled farmland	2
Wetland	4
Towns	9
Number of sites	331

* present, not extensive

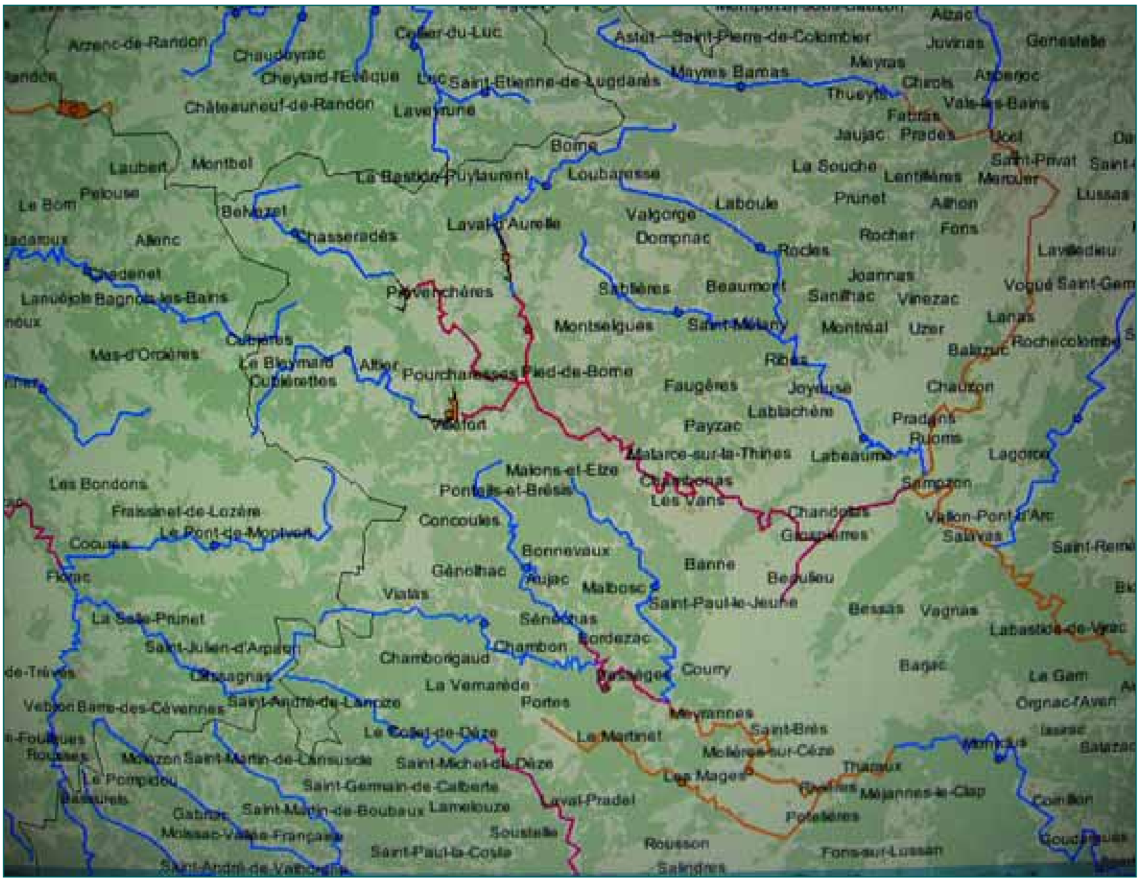


Figure 2. Rivers classified as at risk (red) or possibly at risk (yellow) of failing to achieve good ecological status.

TABLE 5: Water body categorisation of FRA-1 to FRA-13 under the Water Framework Directive.

	River (site)							
Category of water body	Doux tributary (1)	Eyrieux (2, 3)	Ardèche (4, 5, 6)	Drobie (7, 8)	Borne (9)	Luech (10, 11)	Brousse (12)	Tarn (13)
Natural or modified	Natural	Natural	Natural	Natural	Modified	Natural	Natural*	Natural
Risk of failing good status	No*	No	Possibly	No	Yes	No	No*	No

* Likely category (site not in a classified water body). Source: Water Information System for Europe (WISE).

Good ecological status

The Water Framework Directive requires Member States to identify water bodies, categorise them as either natural, heavily modified or artificial and assess the risk of them failing to achieve or maintain "good ecological status" by December 2015.

Preliminary analysis for England and Wales indicates that about 40% of riverine water bodies are either heavily modified or artificial. About 40% are at risk of failing to achieve good ecological status because of water quality factors, whilst 54% in England and 23% in Wales are at risk because of morphological pressures.

The main part of our study area is in the Rhône and Coastal Mediterranean River Basin District (http://www.rhône-méditerranée.eaufrance.fr). Eleven of our 13 sites are located in water bodies classified for WFD purposes. The Borne (at FRA-9) is confirmed as "modified" and is also at risk of failing good ecological status by 2015 (Table 5). The Ardèche (FRA-4 to 6) is possible at risk of failing good ecological status, presumably because of water quality pressures (Figure 2). FRA-12 and 13 are in the Adour-Garonne River Basin District.

Aquatic macrophytes

The flora recorded from the 13 sites varied significantly, with the shaded sites having rich bryophyte communities growing down the banks to the water's edge. Sites on the Ardèche River within the gorge had virtually nothing present due to either extreme bed instability, where pebbles, cobbles and boulders were the dominant components of the substrate, or where bedrock is scoured clean by the force of torrential floods. At the margins of the Ardèche, clinging in cracks in the rocks, were several non-native taxa, some of which do not have a great affinity to rivers.

The River Luech also had very sparse cover due to the erosive power of floods scouring smooth the dominant bedrock, but the number of bryophyte taxa present was much higher than on the Ardèche. In the three MTR sites surveyed in these rivers, only four check-list taxa were recorded, and in two sites the total cover was <0.1%, and in the other <1.0%. Generally total macrophyte cover was never extensive; it was greatest in the rivers with stable bedrock substrates and tree-shaded banks. Consequently, the greatest productivity was in the Doux tributary, Eyrieux and Brousse, where the communities were dominated by species similar to upland rivers on the UK, with *Rhynchostegium riparioides* dominant.

Macrophytes in the channel, and often the bank margins too, were generally dominated by bryophytes. *Bryum dichotomum* (*B. bicolour*) was a frequent colonizer of rock fissures in several of the rivers surveyed, extending down the inundation zone lower than where true aquatics such as *Fontinalis* or *Cinclidotus* were found. This vertical distribution has never been observed in UK rivers. Several sites contained bryophytes indicative of base-rich rock (e.g. Ardèche, Brousse).

Interestingly, the Brousse is in a granite catchment and the water chemistry suggests that a calcifuge taxa should dominate. However, the bryophytes indicate an outcrop of base-rich geology somewhere upstream, contrasting with the siliceous rock dominating the catchment as a whole. At some sites wetland or shade-loving bryophytes that are rare in the UK were found (e.g. *Riccia beyrichiana, Bryum gemmiparum*) and in the Eyrieux an unknown taxon was found that does not occur in the UK.

Sparse aquatic and bankside vegetation; Ardèche gorge.

Good macrophyte growth in the Doux tributary; FRA-1.

Bryum dichotomum growing in almost permanently submerged conditions; FRA-10.

Mosses such as *Cinclidotus* were rare and largely confined to rock fissures; FRA-6.

The presence of alien macrophytes was limited at the water's edge, but on the Ardèche and Luech several escapees were present on the bankface. Japanese knotweed (*Reynoutra japonica*) was common on the banks of the Luech, beggarticks (*Bidens frondosa*) and small balsam (*Impatiens parviflorum*) were common on the banks of the Ardèche, whilst the large American pokeweed (*Phytolacca americana*) was found on the gravel bars of the Drobie.

Ten MTR surveys were carried out on the eight rivers we visited but, as with sites surveyed in the mountains of Slovenia[10] and the Alps[11], too few UK taxa were found within the channel to give confidence in the results being a good indicator of water quality. In the Ardèche and Luech, taxa were exceptionally sparse, and the lowest MTR scores were noted for these rivers (48, 55, 58), but these do not reflect the near pristine water quality of these rivers. The other rivers had higher scores, but again, probably lower than would be expected given the purity of the water. Use of MTR using the UK check-list of taxa for water quality determination is therefore not recommended for such rivers, but may be adapted in the future if the taxa list is extended to include species more widespread in Europe as a whole. Even with an extended list, water quality cannot be assessed using macrophytes in sites such as the Ardèche and Luech were cover is so sparse, and the diversity so low.

Invasive non-native plants

Non-native species are recognised as a 'pressure' that could prevent water bodies achieving "good ecological status". Non-native plants, and Japanese knotweed in particular, are a problem along waterways in several parts of Europe. We recorded Japanese knotweed on the Ardèche and Luech (FRA-5, 10, 11) but it did not always extend down to the water's edge; Himalayan balsam (*Impatiens glandulifera*) was present in the Ardèche sites. In the UK, Japanese knotweed occurred at 8.6% of RHS baseline survey sites and Himalayan balsam at 14.4% of sites during 1994-96. Both have undoubtedly spread since then.

Himalayan balsam in the Ardèche; FRA-4.

Unstable substratum and bedrock scoured clean prevents macrophytes being used to assess water quality; FRA-11.

Japanese knotweed on the Luech River; FRA-10.

DISCUSSION

Hydro-ecoregions and hydromorphological assessment

The hydro-ecoregion framework, based on simple parameters such as altitude, slope, geology and climate is a much more useful tool for comparing river character than the original type A or B methods in the Water Framework Directive[12]. The approach has been used to derive a national and regional typology of rivers in France.

Assessment of habitat quality and hydromorphological pressures is however a more complex technical challenge, requiring detailed and careful interpretation of data[4, 9]. The current CEN work on a guidance standard is progressing slowly, not least because of the need to consider local and scale-related variation in river character when determining a set of generic rules that can be applied across Europe. Consequently, closer links between the CEN[13] and REBECCA[12] project work are needed. This is particularly important since the French method for hydromorphological assessment known as Système D'Evaluation de la Qualité du Milieu Physique (SEQ-MP) has been shelved.

Flood debris trashline on the Tarn River; FRA-13.

Flash floods in the Cévennes

The Cévennes-Ardèche mountain area is subject to intense 'deep convective' rainfall (>100mm/hr) in the autumn months . This can produce severe flash flooding; in the last 50 years there have been notable catastrophic events in 1958, 1999 and 2002.

In England, a comparable flash flood area, although many times smaller, occurs along the north Devon and Cornwall coasts where steep, deep valleys converge. The small coastal towns of Lynmouth (1952) and Boscastle (2004) have both suffered catastrophic flash floods after prolonged heavy rain inland.

On 8-9 September 2002, up to 600mm of rain fell in the mountains southwest of Alès[14]. The peak discharge in several tributaries of the Vidourle and Gard Rivers exceeded $10m^3/s/km^2$ (in some cases $20m^3/s/km^2$). The total peak discharge in the Vidourle catchment ($1700km^2$) was estimated at $6000m^3/s$; in the Gard catchment ($800km^2$) peak total discharge was $2000m^3/s$.

The steep valleys, high drainage density and very 'flashy' hydrological regime produce scoured bedrock channel and sparse aquatic macrophyte flora. The September 2002 event probably explains the extraordinary height of trashline debris 40m above the water in the Ardèche gorge (FRA-4) and the higher trashline on the Tarn River at FRA-13.

A survey strategy for hydromorphological assessment

Using the results from our small sample of sites, it should be relatively easy, using map-based information on valley form and land-use, to estimate the total length of good or high hydromorphological quality streams and rivers in the Cévennes and Ardèche. It is likely to be substantial because of the low population, land-use and sparse road network. Conversely, gently-sloping valley sides above spate flow levels are intensively managed, with significantly impoverished riparian habitat. Again this could be quantified using map or aerial photographs and simple rules.

Difficult terrain and access mean that aerial or satellite images are probably the most effective way of establishing the quality of river habitat, with assumptions verified and quality scores calibrated by a sample of ground-truth surveys such as RHS or similar methods.

This strategy could apply to any kind of terrain and land-use, provided the overall purpose and specific objectives were clear, and the supporting evidence for conclusions and subsequent actions are tested and verified.

The effect of scale is important. Localised bank reinforcement to protect roads and bridges may be obvious factors at an individual 500m survey site, but taken in the context of several kilometres of predominantly unaltered bedrock or boulder channel, this would have an insignificant impact on habitat character and disturbance of the hydrological regime. Decisions on boundaries and water body length for WFD purposes are therefore very influential on the consequent evaluation of whether high hydromorphological status is achieved or not. For example, the average riverine water body length in France is 124km, compared with 28km for the UK (WISE web-site).

Some gorge reaches are inaccessible by foot. Aerial photographs and canoes need to be used for river habitat assessment.

CONCLUSIONS

We achieved our main objectives and also discovered a complementary link with the Flash Flood Pilot of the Cévennes-Varias Hydrometeorological Observatory project. We will follow up with contacts with those involved in the REBECCA project regarding reference conditions in various hydro-ecoregions.

It is clear that most of the core and 'buffer' areas of the Cévennes National Park provide the necessary conditions for high quality riverine habitat and in many instances, natural or near-natural hydromorphological conditions needed for high ecological status under the Water Framework Directive.

The planning controls delivered through the National and Regional Park systems should help to protect the character of near-natural reaches of rivers within the Cévennes. In the context of climate change and extreme events, there will doubtless be mounting pressure to manage the problem of flash-flooding, possibly by regulating rivers with more flood control structures.

Care will therefore be needed to maintain the capacity of upland catchments to absorb intense rainfall; this means retaining woodland and heathlands and near-natural river channels. Additional intervention that alters natural flow or channel habitat would diminish further the very small proportion of near-natural rivers remaining in Europe. It would transgress the "no deterioration" principle enshrined in the Water Framework Directive, and also reduce the capacity for river networks to adapt to climate change in a natural and sustainable fashion.

Hummingbird hawkmoth; FRA-12.

Emerging club-tailed dragonfly; FRA-6.

Otter footprint on sandbar; FRA-10.

APPENDIX 1: NOTES FOR FRA-1 TO FRA-13

Tributary of the Doux River (FRA-1)
28 May 2007; HQA = 68; HMS = 0.
One survey (500m); 45° 06.524'N; 4° 28.096'E.

A small, tree-lined stream five km south-east of St-Bonnet-le-Froid; it is typical of many small watercourses in the northern Ardèche region. Here, the steep valleys are well-wooded with beech and Scots pine (*Pinus sylvestris*) giving way to traditional hay meadows on narrow river terraces in the valley bottom. Historically, these terraces were irrigated using simple leats, with rudimentary weirs providing a small head of water made by placing large boulders on natural bedrock controls.

FRA-1 is a good example of this landscape, with unimproved grassland on the narrow river terraces, and mixed woodland on valley sides abutting the channel.

Meadow in the valley floor; FRA-1.

The moss-dominated flora is typical of a community found in a shaded upland stream on slightly acidic rock in the UK. Indicators of acid rocks include *Racomitrium* and *Scapania* but the dominance of *Rhynchostegium*, with *Chiloscyphus* also common, clearly reflects a community type close to neutral rock chemistry. There is good moss productivity both below water level and at the margins where woodland taxa (e.g. *Plagiochila, Orthotrichum*) are present alongside the wetland and aquatic species.

Ascalaphid – spotted in the meadow; FRA-1.

Eyrieux River (FRA-2, 3)
28 May 2007; HQA = 81 and 72; HMS = 0 and 40.
Two back-to-back surveys (1km); 44° 59.677'N, 4° 21.390'E; 44° 59.400'N, 4° 21.430'E.

Located in the upper reaches of the Eyrieux, about four km south-west of St Agrève, this one km stretch typifies the steep watercourses flowing in deeply cut, forested valleys in the northern Ardèche. Dense beech-pine woodland gives way to alder-dominated fringes along the bedrock-boulder channel. There is a characteristic cascade-pool sequence, and, particularly in FRA-3 development of low river terraces (recorded as "natural berm" on the forms).

There is also a hint of historical (now abandoned) rudimentary irrigation, with large boulders being used to increase the head of water provided by natural bedrock controls to feed leats onto natural river terraces. About 10 km further upstream, near its source, the Eyrieux is dammed to form Lac de Devesset, a small (0.5km^2) lake which is used for swimming and sailing.

Good aquatic and water's edge bryophyte flora; FRA-1.

Distinctive step-cascade and pool sequence; FRA-2.

Dilapidated weir structure on the Eyrieux; FRA-2.

Good grey wagtail and dipper habitat on the Eyrieux; FRA-3.

The flora is very similar to that of the Doux tributary, reflecting close geographical proximity, a common river type, and broadly similar land-use. The MTR scores for all three sites (FRA 1-3) were all high (66-70), and due to the number of scoring taxa being at least seven, probably reflect the good, but not pristine water quality. The shaded nature of the river also resulted in a rich mix of woodland taxa extending down to the water's edge (not recorded), with an unidentified non-British taxon recorded. Calcicole taxa such as *Lejeunea cavifolia* occurred on some rocks, whilst calcifuges such as *Scapania undulata* occurred on others, indicating contrasting rock chemistry.

Plentiful bryophytes along the well-shaded Eyrieux; FRA-2.

Ardèche River
29 May 2007 (FRA-4, 5, 6); HQA = 63, 61 and 56; HMS = 0, 0, and 0.
One 500m survey (FRA-4), 44° 20.755'N; 4° 27.851'E; and two back-to-back surveys (FRA-5 and 6) 1.5 km further upstream; 44° 21.363'N, 4° 27.755'E; 44° 21.160'N, 4° 27.486'E.

The Ardèche River flows between Vallon Pont-D'Arc and St Martin d'Archèche in a spectacular 20km long gorge where it has cut extravagant meanders deep (300m) into the limestone plateau. The sites here were selected to illustrate erosion and deposition features in the gorge and to help improve guidance on surveys in gorge reaches.

The Ardèche River is very popular with canoeists.

The narrow gorge and bottleneck constrictions caused by tight meander bends mean that the erosive force during spate flows each year must be enormous. This has produced a complex bankface/banktop structure akin to a coastal wave-cut rock platform. There are several strandlines ranging between 15m and 40m above summer water level, the latter probably associated with a catastrophic flash flood in September 2002. Difficulties in determining the banktop/face are discussed in Appendix 7. There are point and side bars, riffles, pools and rapids, and the river is very popular with canoeists. Broadleaf woodland dominates the steep valley sides, with bare rock-face where the gorge-profile is sheer. The whole gorge is managed as a nature reserve.

Sheer gorge rock-face; FRA-5.

The Ardèche gorge is 20km long.

The virtual absence of plants in the submerged zone meant that only one MTR site was surveyed. In this, extremely sparse tufts of four taxa were recorded; the MTR score of 48 is not likely to be a true reflection of the water quality, which is expected to be considerably better than the score suggests. Apart from in crevices within bedrock, or at the tide-line of embedded huge boulders, virtually no macrophytes were present. The dominant bryophyte species in such habitats was *Cinclidotus*; together with taxa

Marginal macrophytes such a *Rorippa sylvestris* were confined to cracks in the limestone bedrock; FRA-5.

such as *Amblystegium fluviatile* and *A. tenax* this indicates base-rich rock. In some cracks higher plants were present, the commonest being creeping yellow-cress (*Rorippa sylvestris*) and yellow loosestrife (*Lysimachia vulgaris*). A glance at Appendix 10 shows that many taxa were present at this site that were absent from others, and vice versa. Notable species here, but not other surveyed sites, included water-crowfoot (*Ranunculus*) in the most stable parts of riffles, whilst water-milfoil (*Myriophyllum*) and curled pondweed (*Potamogeton crispus*) were found in rock pools and backwaters protected from the scouring force of flash floods.

River Drobie (FRA-7, 8)
30 May 2007; HQA = 78 and 74; HMS = 0 and 0.
Two, back-to-back surveys (1km); 44° 31.178'N, 4° 10.351'E; 44° 31.148'N, 4° 10.558'E.

Located on the River Drobie, about six km north-west of Joyeuse, FRA-7 and 8 represent a meandering bedrock channel in a deeply incised wooded valley. The upstream site (FRA-7) is dominated by bedrock platforms sculptured in the schist bedrock, whilst FRA-8 has a slightly greater channel gradient. Both sites have a diverse channel substrate and extensive vegetated shingle/cobble deposits forming vegetated side bars which support an alder-dominated riparian zone. A small summer house dwelling in FRA-8 is typical of the minor development in the river valley, whilst there is some terracing for vine-growing further upstream.

Club-tailed dragonfly, *Gomphus vulgatissimus*; FRA-6.

The bedrock channel and wooded valley of the Drobie River; FRA-8.

Sapling willows and alders colonising side bars; FRA-8.

Shaded bedrock with plenty of bryophytes; FRA-8.

The Drobie had the most macrophyte taxa recorded of any of the rivers surveyed, reflecting a rich bryophyte flora on some stable boulders, and in the fissures of the bedrock that was present in only some of the reach. The most abundant species indicated neutral, or slightly basic rock chemistry, but some rocks had *Racomitrium* present, suggesting that some more acidic boulders had been washed down from upstream. Several types of higher plants were recorded on shallow gravel margins, reflecting a diverse structure of the flora. On some gravel bars just away from the river, American pokeweed (*Phytolacca americana*) was found.

River Borne (FRA-9)
30 May 2007; HQA = 76; HMS = 350.
One site (500m); 44° 31.450'N, 3° 58.500'E.

The River Borne flows in a deep, steep-sided wooded valley. It is used for hydropower generation and also has levada systems down the valley. FRA-9, 10 km north-east of Villefort, was specially selected to investigate the impact of regulated flow (i.e. reduction of peak flows) on habitat features.

FRA-9 has the characteristics typical of a high energy mountain river, including very large boulders. What is unusual, compared with equivalent reaches not affected by hydropower, notably the Leuch River near Chamboredon, (see FRA-10 and 11), was the dense growth of alders along the margins, vegetated side bars and colonisation of rock crevices and boulders in mid-channel by saplings. The even-aged structure of the alders provides a clue to the timing of construction of the Barrage de Roujanel, a major dam 2 km upstream. Extensive coarse woody debris snagged by the alders in the channel also suggests that the peak flood event is artificially attenuated because elsewhere it would be scoured out and transported downstream, as in FRA-10 and 11.

Bar deposits in FRA-8 contrast with bedrock channel; FRA-7.

Valley slope terraced for vines; Drobie River.

Levada in the Borne valley; FRA-9.

Saplings colonising rock crevices and deposits; FRA-9.

Bridge arch indicates height of floods before dam construction 2km upstream; FRA-9.

Saplings and woody debris indicate infrequent scouring; FRA-9.

Additional impacts within the site are a major bridge with its associated rip-rap protecting the road, a functioning levada on the left bank and a dilapidated one on the right bank. A small (0.3m high) weir that feeds the levada is located about 100m upstream from the site, so this will further modify the hydrograph during low flows.

Despite flow regulation, true macrophytes were not common, probably due to the past instability of the boulder-strewn substrate. Long periods of low flow and buffering from the most severe effects of scouring floods have allowed shrubs and small bushes to colonize the river-bed, between the boulders. The flora generally was intermediate between the scoured rivers such as the Ardèche, and the moss-covered rivers such as the Eyrieux and Brousse. Remote sedge (*Carex remota*) was the only taxon uniquely noted for this site; this reflected the regulated nature of the river and the extension down the bank of woodland taxa.

River Luech (FRA-10,11)
31 May 2007, HQA = 71 and 66; HMS = 0 and 0.
Two back-to-back surveys (1km); 44° 18.139'N, 4° 02.181'E; 44° 18.278'N, 4° 02.294'E.

A meandering bedrock channel in a deeply incised (70m deep) valley about five km west of Bessèges. The bedrock bankface (defined by the trashline, and varying from 3.5m to 6.0m depending on channel profile) is predominantly bare, scoured clean by intense spate flows. The layered schist bedrock is angled and provides a diverse variety of crevices and 'rock pools' scoured into the surface. These crevices, pools and large deposits of sand and gravel provide a rich variety of temporary habitats. Rock pools are scored as a special HQA feature.

Barrage de Roujanel, 2km upstream from FRA-9.

Scoured bedrock and no woody debris on the Luech River; FRA-10.

Rock pools and crevices in the bedrock; FRA-10.

Crevices provide the only footholds for mosses in the scoured bedrock; FRA-11.

Numerous small alder saplings grow from crevices but do not grow higher than about 1m because of the scouring action and also beaver (*Castor fiber*) damage. There is virtually no coarse woody debris, again probably reflecting the force of spate flows. This contrasts with the regulated flow of FRA-9 (River Borne) which has abundant large woody debris and vegetated rock/boulder features (see FRA-9).

FRA-10 has a very diverse range of substrates, a good riffle-pool sequence and several bar deposits. The character of FRA-11 is different, reflecting a steeper gradient, and is dominated by a 300m long, narrow bedrock chute. Overall, there is a very diverse channel and bank habitat.

The immense scouring power of floods means that perennial aquatic taxa are rare. Cracks in the bedrock forming the rapids provide the only foothold for several bryophyte taxa, with *Cinclidotus and Bryum dichotomum*, the most hardy, found closest to the water level on the bankside. The total amount of perennial rooted vegetation was close to 0.1%, with the dominant in-channel taxon being the filamentous red alga *Lemanea*. Fissures in some flat pavements on one bank in FRA-10 provided suitable rooting habitat for marginal higher plants such as spike-rush (*Eleocharis*), common reed (*Phragmites*) and yellow loosestrife (*Lysimachia vulgaris*). A major concern is Japanese knotweed growing throughout the reach.

Brousse (FRA-12)
1 June 2007; HQA = 70; HMS = 0.
One survey (500m); 44° 21.994'N; 3° 41.151'E.

Marginal deadwater and gravel deposits add contrast to the scoured bedrock; FRA-10.

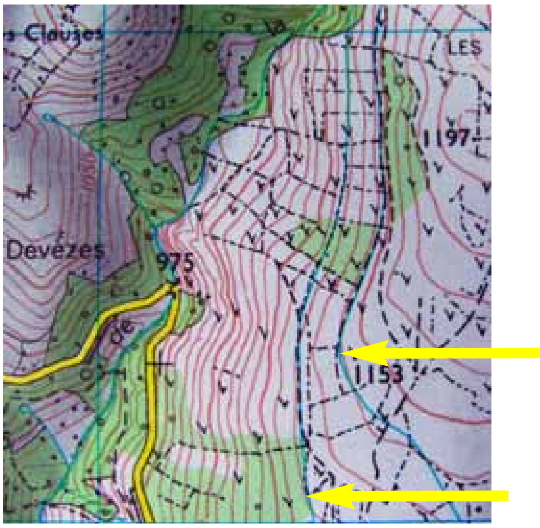
Discrete sand deposits are colonised by reeds; FRA-10.

Narrow bedrock chute; FRA-11.

Japanese knotweed – well-established along the Leuch; FRA-11.

One of several cascades and waterfalls; FRA-12.

The Brousse is a short (10 km), steep stream that rises two km west of Mont Lozère. FRA-12 is located in a deep wooded valley, about 750m from where it flows into the River Tarn (see FRA-13). The site is dominated by 14 substantial cascades and two large (>5m) waterfalls. It was specifically selected because of its granite catchment, so that the macrophyte flora could be compared with that in streams surveyed on schist geology. The excellent woodland is dominated by oak, (*Quercus*) and sweet chestnut, with alders frequent along the water's edge. Further upstream from the site, the habitat changes to sub-alpine heath. Two levadas have been constructed about 2.5 km upstream from the site.



Levadas upstream from FRA-12.

Heavy shade and torrent flow favour bryophyte growth; FRA-12.

The Brousse is a shaded stream with a very productive and species-rich bryophyte community, the majority of which comprises moisture and shade-loving woodland taxa that extend down the bank to colonize close to bed level. *Rhynchostegium riparioides* was by far the dominant taxon, both below the water surface, and at the frequently inundated zone. The site was selected to be representative of a very acid upland river flowing off siliceous rocks; however many of the taxa found on the rocks just above low water mark (e.g. *Porella platyphylla and Plagiochila porelloides*) are noted by Watson[15] as being more indicative of calcareous rocks. No alien taxa were found, but *Bryum gemmiparum*, a very rare taxon in the UK, was common here.

River Tarn (FRA-13)
1 June 2007; HQA = 80; HMS = 0.
One survey (500m); 44° 21.808'N, 3° 41.306'E.

Rhynchostegium dominates the channel and banks; FRA-12.

Boulder-strewn channel of the Tarn; FRA-13.

Diverse flow-types and channel habitat; FRA-13.

Large woody debris several metres above normal water level; FRA-13.

Bedrock bank, huge underwater boulders and sand bar deposit; FRA-13.

A typical bedrock-boulder dominated section of the upper Tarn, eight km east of Florac and flowing in a deeply-incised valley. There is granite geology on the north side (see FRA-12) and schist geology to the south, a geological mixture reflected in the different types of boulders, cobbles and pebbles comprising the side bars and discrete sand and gravel deposits which are notable features of the river margins. Trash lines at 2.5m and 3.5m above normal water level indicate the impact of flash floods.

Generally a very sparse flora, especially in the permanently inundated zone was noted. The vast majority of taxa, even the submerged ones, were confined to localised patches of stability afforded by marginal tree roots, rock fissures or protected small backwaters. *Riccia beyrichiana* was found on a sandy bar deposit; this species has a limited, and only western, distribution in the UK.

APPENDIX 2: Characteristics of rivers in the Ardèche and Cévennes surveyed in 2007.

	Doux tributary FRA-1	Eyrieux FRA-2, 3	Ardèche FRA-4, 5, 6	Drobie FRA-7, 8	Borne FRA-9	Luech FRA-10, 11	Brousse FRA-12	Tarn FRA-13
Geology	Schists	Schists	Limestone	Schists	Schists	Schists	Granite	Granite/schists
Predominant land use	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest
Valley shape	Deep vee	Deep vee	Deep vee/ gorge	Deep vee	Deep vee	Deep vee	Deep vee	Deep vee
Valley relief	200m	200m	220m	400m	350m	250m	250m	300m
Altitude (mid-site)	740m	795m; 770m	58m; 60m; 59m	225m; 221m	552m	228m; 224m	750m	690m
Slope (m/km)	42.0m/km	60.0m/km; 35.0m/km	1.45m/km	7.7m/km	12.5m/km	8.0m/km	100.0m/km	31.0m/km
Distance from source (midpoint)	8.0 km	13.2km; 13.7km	97.7km; 96.2km; 96.7km	21.0km; 21.5km	28.6km	31.7km; 32.3km	8.8km	21.7km
Height of source	1190m	1100m	1280m	1180m	1410m	1080m	1560m	1650m
Water width	4.0m	3.5m; 5.5m	70m; 30m; 45m	8.5m; 11.0m	18.0m	9.0m; 10.5m	7.0m	30.0m
Bankfull (trashline*) width	6.0m*	7.0m*; 6.0m*	120.0m*; 85.0m*; 80.0m*	40.0m*; 45.0m*	40.0m*	28.0m*; 25.0m*	7.5m*	40.0m*
Extent of braiding	None	None	None	None	None	None	None	None
Predominant channel substrate	Bedrock – boulders	Bedrock – boulders	Cobble	Bedrock – cobble; Cobble ; gravel-pebble	Boulder	Gravel – pebble; bedrock	Bedrock – boulders	Bedrock – boulders
Predominant flow type	Chute-rippled	Chute	Smooth	Smooth	Unbroken wave	Unbroken wave; chute	Chute	Chute
Biological water quality	Very good	Very good	Very good	Good	Very good	Very good	Very good	Very good
HQA	68	81; 72	63; 61; 56	78; 74	76	71; 66	70	80
HMS (and class)	0 (1)	0 (1); 40 (2)	0 (1); 0 (1); 0 (1)	0 (1); 0 (1)	350 (3)	0 (1); 0 (1)	0 (1)	0 (1)
MTR score	70	68; 66	48; n/a; n/a	n/a; 66	73	58; 55	64	71
Impacts on site	Negligible	None; Negligible	None	None; Negligible	Hydropower; bridge	None	None	None
Nature area	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Levadas nearby upstream?	No	No	No	No	Yes	No	Yes	No
Dams/weirs upstream?	No	Yes	Yes	No	Yes	No	No	No

* Quality assessed from nearest sample site. Classification based on macroinvertebrates and/or diatoms.

APPENDIX 3: HQA sub-scores and total scores for FRA-1 to FRA-13.

Site number (FRA)	1	2	3	4	5	6	7	8	9	10	11	12	13
HQA sub-score category													
Flow-types	12	10	10	10	10	9†	11	10	12	11	10	9	9
Channel substrates	11	11	11	7	7	7	9	11	9	10	11	7	10
Channel features	7	8	9	6	3	3	9	7	13	11	6	8	9
Bank features	2	3	4	1	5	5	7	10	5	3	1	0	6
Bank vegetation structure	11	12	12	12	10	8	12	12	12	8	9	12	12
In-stream vegetation	5	4	3	1	1	0	1	0	0	1	1	2	3
Land-use	4	14	6	14	14	14	14	10	6	14	14	14	14
Trees and associated features	11	11	11	7	6	6	10	10	15	8	7	11	11
Special features	5	8	6	5*	5*	4*	5	4	4	7	7	7	6
Total HQA score	68	81	72	63	61	56	78	74	76	71	66	70	80

* limestone pavement (extensive) scored 4.

† assumptions made regarding "not visible" entries.

APPENDIX 4: HMS scores and habitat modification class for FRA-1 to FRA-13.

Site number (FRA)	1	2	3	4	5	6	7	8	9	10	11	12	13
HMS score	0	0	40	0	0	0	0	0	350	0	0	0	0
Habitat modification class	1	1	2	1	1	1	1	1	3	1	1	1	1

APPENDIX 5: Selected habitat features and *ad hoc* observations of wildlife associated with FRA-1 to FRA-13.

Habitat Features: P: present; E: extensive. Species presence indicated by •.

Habitat features	Doux tributary FRA-1	Eyrieux FRA-2, 3	Ardèche FRA-4, 5, 6	Drobie FRA-7, 8	Borne FRA-9	Luech FRA-10, 11	Brousse FRA-12	Tarn FRA-13
Rock pools			P	E[7]	P	E[10]		
Natural cascades		P		P	P	P	E	•
Waterfalls		P					P	
Rock platform			E					
Wildlife observations	*	*			*	*		*
Beaver (chewed saplings) (*Castor fiber*)			•	•	•	•		•
Otter (footprints) (*Lutra lutra*)						•		
Edible frog (*Pelophylax esculentus*)			•	•		•		
Yellow-bellied toad (*Bombina variegata*)		•						
Grey wagtail (*Motacilla cinerea*)		•		•	•	•		
Dipper (*Cinclus cinclus*)			•	•	•	•	•	•
Kingfisher (*Alcedo atthis*)				•				
Grey heron (*Ardea cinerea*)		•				•		•
Alpine swift (*Apus melba*)			•					
Crag martin (*Ptyonoprogne rupestris*)			•					
Black kite (*Milvus nigrans*)			•			•		
Short-toed eagle (*Circaetus gallicus*)			•					•
Ascalaphid (*Libelloides longicornis*)	•							•
Scarce swallowtail (*Iphiclides podalirius*)			•	•				
Two-tailed pasha (*Charaxus jasius*)			•	•				
Banded demoiselle (*Calopteryx splendens*)				•				
Splendid demoiselle (*Calopteryx virgo*)								•
Club-tailed dragonfly (*Gomphus vulgatissimus*)			•					

*Rain during survey

APPENDIX 6: Indicative values for water chemistry at FRA-1 to FRA-13.

Indicative values of pH (±0.2 units), calcium and magnesium hardness and nitrate were made in the field using test papers.

Single spot samples were collected in full and sealed containers subsequently tested for more precise analyses at 19-21° C within 3-7 days with calibrated conductivity and pH meters, and for calcium and carbonate hardness by titration.

Key: Nitrate tr = trace, <5mg/l; Total hardness scale as calcium carbonate: 'very soft' = <70 mg/l, 'soft' = 70-125mg/l or low hardness, 'medium' = 125 – 250 mg/l or medium hardness, 'hard' = >250 mg/l or high hardness.

Site reference	Acidity (value after 3-7 days, if changed)	Conductivity (µS cm $^{-1}$)	Total hardness (Ca & Mg as $CaCO_3$)	Calcium mg/l	Carbonate mg/l $CaCO_3$	Nitrate mg/l	Water colour
FRA-1Trib. of Doux	6.3 (7.0)	68	Trace	2	15	0	Slightly brown
FRA-2, 3 Eyrieux	6.3 (7.0)	85	Trace	5	20	0	Slightly-mid brown
FRA-4, 5, 6 Ardèche	7.0 (7.3)	171	Very soft	15	105	Trace	Clear
FRA-7, 8 Drobie	6.4 (7.1)	52	Trace	Trace	<10	0	Clear
FRA-9 Borne	6.6 (7.2)	42	0	Trace	<10	0	Clear
FRA-10, 11 Luech	7.0 (7.2)	102	0	5	28	0	Clear
FRA-12 Brousse	6.0 (7.3)	38	0	Trace	<10	0	Slightly brown
FRA-13 Tarn	6.2 (7.3)	30	Trace	Trace	<10	0	Clear

APPENDIX 7: Recommendations for improving the RHS manual.

The following recommendations, reaffirmations and considerations follow on from those made during previous visits to Slovenia[10] and Bavaria[11].

Recommendations

Recommend that the health and safety form has a 'residual risk' column added to demonstrate dynamic risk assessment actions, and also an opportunity to feed back after the survey is completed – or abandoned because of safety reasons.

Recommend putting a circle round SM (smooth flow) in spot-check records if it is the more powerful flow type (typical of large deep rivers) to differentiate it from the low energy smooth flow (Section E).

Recommend putting a circle round the 'R' of RD (rock/dune land-use) in the spot-check or sweep-up records to confirm rock and scree, as opposed to sand dunes (Sections E and H).

Scale will determine whether large discrete deposits are side bars; FRA-13.

Point bar deposit covering the bank face (not visible).

Composite bank profile in bedrock provides variety of habitat niches; FRA-11.

Coincident trashline and scoured bedrock
mark the 'banktop' in deep vee valley; FRA-10.

Determining tree distribution in vee-shaped valleys can be difficult.

Recommend requiring an explanation where not visible ('NV') is to be used as an entry for bank material when side or point bar material entirely covers the bankface (Section E). The manual needs to be more explicit about how to record this.

Recommend a better explanation in the RHS manual over the difference between side bars and discrete silt/sand/gravel deposits and how to record them.

Recommend more explicit explanation that the filamentous algae category of in-channel vegetation excludes diatom films growing on pebbles.

Recommend an explanation that composite bank profile (Section I) includes bedrock platforms scoured by the force of water.

Recommend that in deep vee valleys, an obvious scour-level coincident with trashline height is used as the surrogate "bankface/banktop" boundary for recording vegetation structure at spot-checks.

Recommend a more explicit definition of how to record bankface/banktop tree cover in deep vee and gorge valleys.

Recommend an analysis of 'other' special features and impacts recorded to update the current list in Section M. For example, bedrock platform, and "rock pools" as special features and levadas as a modifying feature were generated by this survey visit.

Rock pool in limestone bedrock pavement, Ardèche River.

Discrete sand deposit – more of a bank
associated feature? FRA-13.

Comparison of map-derived and GPS-derived altitudes

GPS and 1:25,000 scale map derived mid-point altitudes (m) for FRA-1 to FRA-13								
Site	GPS	Map	Difference		Site	GPS	Map	Difference
1	770	740	+30		7	205	225	-20
2	800	795	+5		8	227	221	+6
3	750	770	-20		9	570	552	+18
4	62	58	+4		10	237	228	+9
5	60	60	0		11	220	224	-4
6	60	59	+1		12	728	750	-22
					13	650	690	-40

Discrete sand deposits on side bar; FRA-8.

Reaffirmations

Reaffirm that deep vee definitions for bankface/banktop are used in predominantly gorge-like valleys – bearing in mind that true gorge profiles (>80° slope) are unlikely to be surveyed because of safety reasons.

Reaffirm the need to use 1:25,000 scale maps (GPS referenced, if possible) to cross-check GPS readings and bedslope estimates, since GPS readings for altitude are not reliable.

Considerations

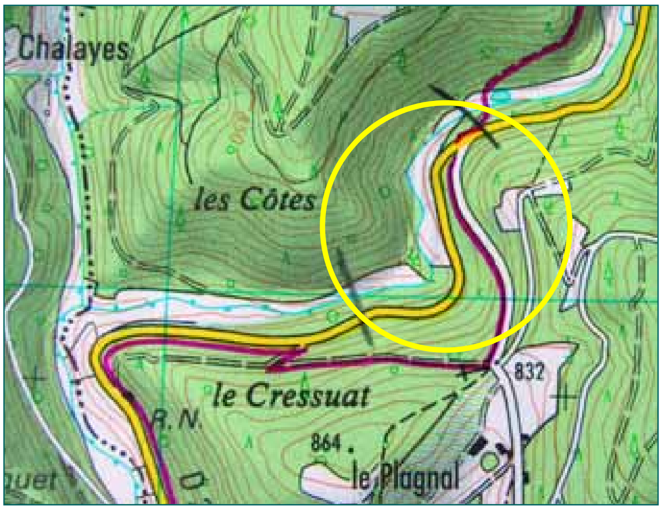
Consider including discrete deposits in the bank feature element of the HQA calculation, rather than the channel element, as is currently done.

Consider encouraging surveyors to note the occurrence of natural shade (such as caused by narrow gorge profile) in addition to tree-related shade (Section J).

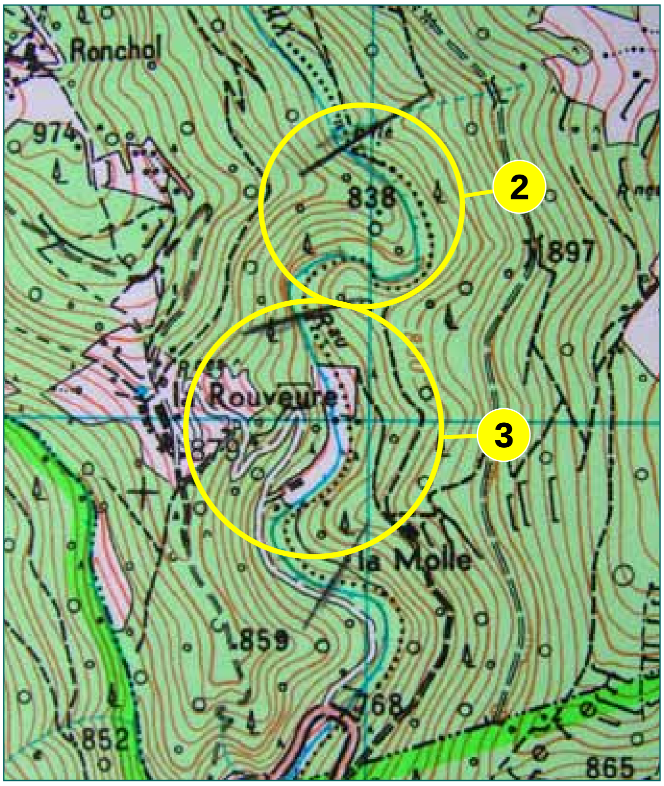
Consider whether to include the phrase 'almost continuous' tree cover to avoid confusion over 'semi-continuous' (particularly in various translations from English).

Shading in deep, gorge-like valleys could influence channel vegetation; FRA-10.

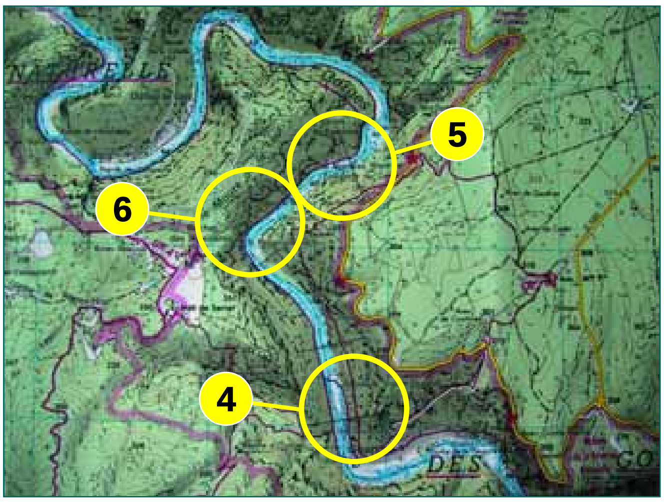
APPENDIX 8: Maps showing FRA-1-13. Source: IGN-Carte de Randonnée



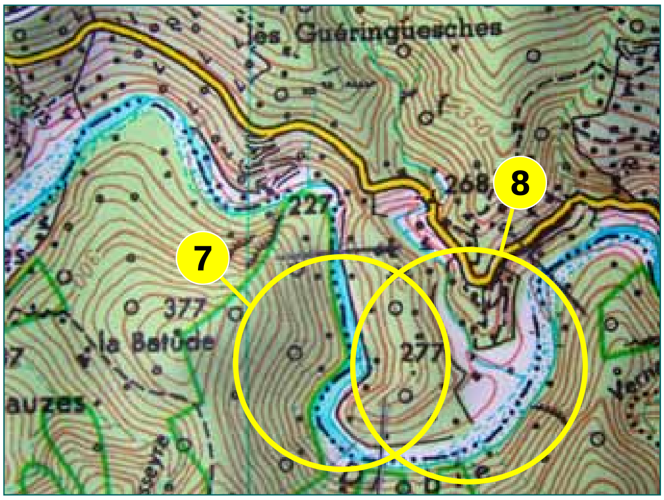
FRA-1



FRA-2/3

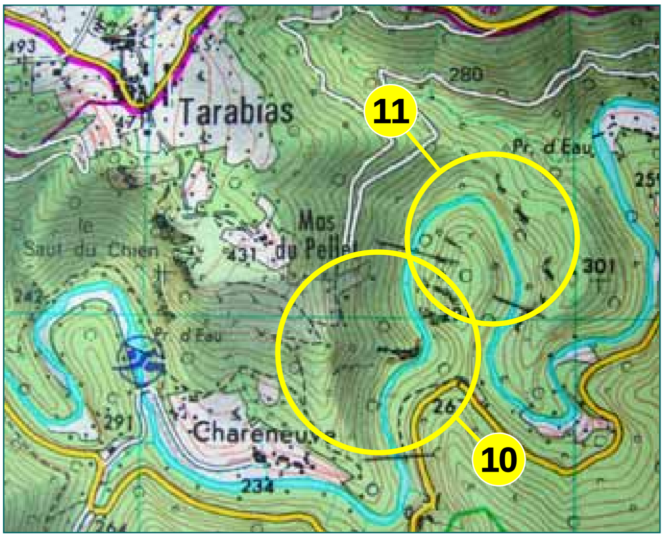


FRA-4-6

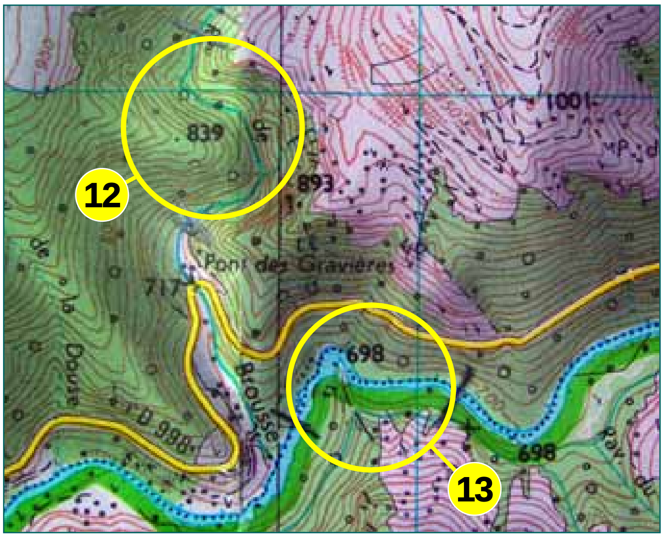


FRA-7/8

FRA-9



FRA-10/11



FRA-12/13

APPENDIX 9: MTR survey results.

STR = Species Tropic Rank; SCV = Species Cover Value (one scale; 1-9); CVS – Cover Value Score (STR x SCV).

MTR Sites		1		2		3		4		8		9		10		11		12		13	
Species\Codes	**STR**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**
Lemanea fluviatilis	7	1	7	2	14	2	14		0	0	0		0	2	14	1	7	2	14	1	7
Chiloscyphus polyanthos	8	3	24	2	16	3	24		0		0		0		0		0	2	16	1	8
Jungermannia atrovirens	8		0		0		0		0	1	8		0		0		0		0		0
Marsupella emarginata var. *aquatica*	10		0	1	10		0		0		0		0		0		0		0		0
Pellia epiphylla	7		0		0		0		0		0	1	7		0		0		0		0
Amblystegium fluviatile	5		0		0		0		0	2	10	1	5	1	5	1	5	1	5		0
Brachythecium plumosum	9	3	27	1	9	1	9		0		0	1	9		0		0	1	9		0
Brachythecium rivulare	8	2	16	2	16	0	0		0	1	8	1	8		0		0	1	8	1	8
Bryum pseudotriquetrum	9		0		0		0		0	1	9	1	9		0		0		0		0
Calliergon cuspidatum	8		0		0		0		0	1	8		0		0		0		0		0
Cinclidotus fontinaloides	5		0		0		0	1	5	1	5		0	1	5	1	5		0		0
Dichodontium sp.	9		0	1	9	1	9		0		0		0		0		0		0		0
Fontinalis antipyretica	5	1	5	1	5	1	5		0		0		0	1	5		0	2	10	1	5
Fontinalis squamosa	8	1	8		0		0		0		0		0		0		0	1	8	1	8
Philonotis fontana	9				0		0		0		0		0		0		0		0	1	9
Racomitrium aciculare	10		0		0		0		0	1	10	1	10		0		0		0		0
Rhynchostegium riparioides	5	5	25	6	30	5	25		0	4	20	2	10		0	1	5	5	25	1	5
Thamnobryum alopecurum	7		0	1	7	1	7		0	1	7		0		0		0	1	7		0
Lotus pedunculatus	8		0		0		0		0	1	8		0		0		0		0		0
Ranunculus penicillatus subsp. *pseudo*	5		0		0		0	1	5		0		0		0		0		0		0
Rorippa nasturtium aquaticum	5		0		0		0	1	5		0		0		0		0		0		0
Veronica anagallis aquatica	4		0		0		0	1	4		0		0		0		0		0		0
Sub-score for calculation of MTR		**16**	**112**	**17**	**116**	**14**	**93**	**4**	**19**	**14**	**93**	**8**	**58**	**5**	**29**	**4**	**22**	**16**	**102**	**7**	**50**
MTR SITE SCORES		**70**		**68**		**66**		**48**		**66**		**73**		**58**		**55**		**64**		**71**	

APPENDIX 10: JNCC macrophyte survey results.

Figures (scale 1-5) 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].

Species name\Site (FRA 1-13)	1	2	3	4	5	6	7	8	9	10	11	12	13
Lemanea fluviatilis	2200	2200	2200				2100	2200	1100	3200	3200	2200	1100
Filamentous green algae (other)				2100	1100	1100			3300	1100	1100		3100
Encrusting lichens	2211	1111	2211									1122	1111
Foliose lichen	2211	1111	1122		11	11	1111	1111	2222			1122	1111
Chiloscyphus polyanthos	2222	2222	2222									1122	1111
Conocephalum conicum					11		11	11	11	11	11		11
Jungermannia sp(p).		11	11	11	11			11					
Marchantia polymorpha		11	11								11		
Marsupella emarginata (var. *aquatica*)		11											
Pellia epiphylla		1122	1111						11				
Porella sp.												1122	
Scapania undulata	1111	1122	1111									11	
Amblystegium fluviatile		11	1111	1111			1122	1122		1121	1111	1111	1111
Brachythecium plumosum	2222	2222	2222					11	11			22	11
Brachythecium rivulare	1122	1122	1122					1111				22	11
Bryum pseudotriquetrum				11		11	1111	1111	1111			1111	1111
Calliergon cuspidatum							1122	1122	1111				
Cinclidotus fontinaloides				2132	3131	3131	2122	2222		1132	1131		1121
Cratoneuron filicinum					11								
Dichodontium pellucidum/flavescens		11	11				1111	11	11				
Fontinalis antipyretica	1111	2211	2211				1111	1111	1111	1111		1111	1111
Fontinalis squamosa	2200											1111	1121
Philonotis fontana													11
Polytrichum commune		11	11				11	11					
Racomitrium aciculare	1122	1122	1122				1111	1111	1122	11	1111	11	
Rhynchostegium riparioides	3322	3333	3333				1111	2222	2211		1111	3333	1111
Schistidium rivulare		11	11				1122	11	11	21	11	1122	1121
Thammnobryum alopecurum	1122	22	1122				1122	1122				1122	
Osmunda regalis							1111	1111		1111	1111		
ferns	22	11	1122						1122			22	11
Angelica sylvestris												11	
Caltha palustris	1111	11	11					11				11	
Eupatorium cannibinum							11	11	1122			11	11
Filipendula ulmaria	1122	11	1122						1111			11	11
Impatiens glandulifera				21	11	11							
Lotus uliginosum	1122	1111	1111				1111	1111	1111	1111	11	1111	1111
Lycopus europaeus		11					1111	1111	1111	11			11
Lysimachia vulgaris				2121	1111	1121	2122	2122	1111	2121	1121		3121
Lythrum salicaria				1111	1111	1111							
Mentha aquatica				11			1111	1111	1111	11	11	1111	
Myosotis scorpioides	1122	1111					11	11					
Myriophyllum spicatum					1100								
Myosoton aquaticum	11												
Persicaria amphibia							11	11					
Persicaria hydropiper										11	11		
Ranunculus pen. subsp. *pseudofluitans*				2100		1100							
Rorippa sylvestris				1131	1121	1121	1122	1122					
Rorippa nasturtium-aquaticum agg.				1111						11			
Sagina procumbens		11	11				11	11	11	11	11	11	11
Solanum dulcamara							11	11					
Valeriana officinalis	11	1122	1122									11	11
Veronica anagallis-aquatica hybrid				1111		11							
Veronica anagallis-aquatica				1111		1111							
Viola palustris		1111	1111					11	11	11	11		11
other dicots.	1122	1122	1122	1121	1111	1111	11	11	1122	11	11	1122	1121
Alnus	1133	1122	1133				1133	1133	2233	2132	1131	1122	3132
Salix	11	1122	1111	1121		1111	1133	1133	3333	2132	1131	1111	2132
other trees & shrubs	1122	1122	1122	21		11	1111	1122	2222	1121	1121	1111	1121
Carex disticha				1121	1121	1121							1111
Carex remota									11				
Carex ovalis	11												
Carex sp.		11											

APPENDIX 10: continued

Species name \ Site (FRA 1-13)	1	2	3	4	5	6	7	8	9	10	11	12	13
Carex viridula								1111	1111	11	11		
Deschampsia cespitosa	11	11	1111									11	11
Eleocharis palustris				1121	2121	1121				1111			
Glyceria declinata												11	
Glyceria fluitans	1122	1111											
Juncus acutiflorus		1111	1111				1111	1111	1111	1121	1111	1111	1111
Juncus effusus	1111	11	1111				11	11	11			1111	
Phalaris arundinacea				1121	11	1111							2121
Phragmites australis										11			
Potamogeton crispus						1100							
Scirpus sylvaticus		1111								1111			
other monocots	1122	1111	1122	1121	1121	1121	22	22	1122	1121	1121	1111	1121
Non-JNCC Database Check-list Taxa	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Diatom film	2111	1100	1100	3200	3100	3100	2100	2200	1100				
Encrusting algae							3200	3300	2200	1100	1100		
Dermatocarpon fluviatilis	2211	1111	1111					1111				1111	1111
Jungermannia gracillima				11									11
Jungermannia hyalina		1111	11										
Lejeunea cavifolia			11										
Lophocolea bidentata												11	
Plagiochila aspleniodes												11	
Plagiochila porelloides	11											11	
Porella platyphylla												1122	
Riccia beyrichiana													11
Amblystegium tenax				11	11	11							
Bryum dichotomum	1111						2122	1122	1111	2121	2131	1111	1111
Bryum gemmiparum												1111	
Bryum capillare		11	11							11	11	11	
Climaceum dendroides	11							11					
Didymodon insulanus										11	11		
Mnium hornum	22	22	22									11	22
Orthotrichum rupestre	11								1111			11	
Oxyrhynchium hians												11	
Philonotis caespitosa					11		1122	1122	1122	1121	1121		11
Plagiomnium undulatum	11	22	11									22	11
Plagiomnium punctatum	11	11	11										
Rhizomnium rostratum	11	22	22										
Equisetum arvense				1111	1111	1111	1111	1111	1111				1111
Artemisia sp.				21	11	21							
Bidens frondosa				11		11	11	11					
Cardamine hirsuta	11	11											
Cardamine pratensis									11				
Chrysanthemum sp.							22	11					
Chrysosplenium oppositifolium	1111	1111	1111									1122	
Galium sp.	11	11											
Geranium robertianum												11	
Impatiens sp.								11					
Lamiastrum galeobdolon	11	11	11										
Mentha (not *aquatica*)							1122	1122	1111				
Melampyrum sp.							11	11	11				
Ononis spinosa					11								
Prunella vulgaris							11						
Persicaria persicaria				1132	1111	1121	22	22					
Persicaria bistorta	11												
Reynoutra japonica				11									
Potentilla arvense				1111		11							
Ranunculus acris		11											
Ranunculus aconitifolium	11	1122	1111										
Rumex acetosella			11										
Saponaria officinalis							22	22					
Saxifraga granulata												11	
Scrophularia nodosa	11	11	11	11	11	11							
Sedum sp.												11	11
Stellaria neglecta	11												
Succisa pratensis	11												
Agrostis stolonifera				1111	1111	1111							
Allium sp.					11								
Juncus bufonius				11									
Juncus sp.	11	11	11		11					11			
Luzula sp.				1111		1111							

Source: Encarta

APPROXIMATE LOCATIONS OF SITES SURVEYED

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