




RIVER HABITAT AND MACROPHYTE SURVEYS ON THE DRAWA RIVER, NORTH-WEST POLAND

Results from 2008 and 2009

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PURPOSE

The main objective of our study of the River Drawa (30 August to 1 September 2008; 30 August to 1 September 2009) was to characterise the habitats and aquatic macrophyte flora of a high quality lowland river and to use the results for benchmarking purposes.

Specific objectives were to:

- Assess the habitat character of several 500m lengths of river, using River Habitat Survey (RHS) [1], and the macrophyte flora in these sites and over longer reaches of river, using the Joint Nature Conservation Committee (JNCC)[2] and Mean Trophic Ranking (MTR)[3] methods;
- Establish a baseline dataset of RHS and macrophyte results for the Drawa River and add this information to the database already established for the Standardisation of River Classifications (STAR) project[4];
- Test and refine the draft CEN guidance standard on the hydromorphological assessment of rivers[5] and recommend improvements to the RHS manual used in Poland[6];
- Compare results with previous RHS and macrophyte surveys carried out in Poland[7] and on the River Itchen in southern England;
- Assess the effect of different survey lengths by comparing results from consecutive RHS surveys, and establish the optimum sample strategy.

Results are presented in Tables and Figures, with supporting material in Appendix 1 and Annexes A-K. Recommendations for improving the RHS Manual are set out in Appendix 2.

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

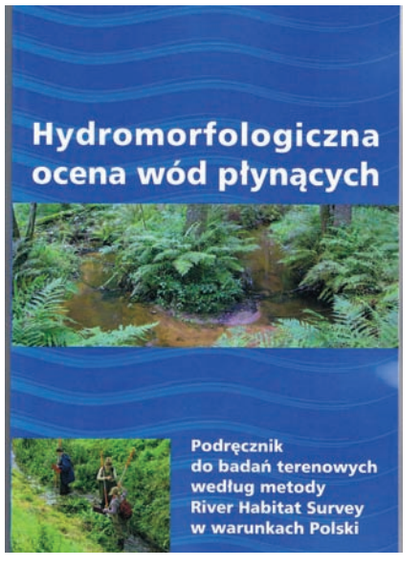
Beyond the UK, RHS has also been carried out in several other European countries. For instance, more than 200 RHS surveys were included during the STAR project[4] (Figure 1); in addition, 200 sites have been surveyed in Italy; more than 600 in Poland, more than 700 in Portugal, 400 in the Cantabrian Region of northern Spain, whilst a further 600 surveys planned for 2010. The RHS Manual has been adapted and translated into Italian, French and Polish[6], whilst Portuguese and Spanish versions have also been developed.

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 24,000 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 habitat quality across England and Wales and trends since the initial baseline will be published on the Environment Agency web-site in June 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 RHS database allows detailed investigation of the relationships between physical variables (e.g. gradient, geology), channel modifications and habitat features at spot-check and site level. These investigations can make use of available water chemistry and hydrological data, plus biological information such as benthic macroinvertebrate, macrophyte, fish or breeding bird survey results where additional sampling has been done in or near RHS sites[11].

Assessment of habitat quality and extent of channel modification can be derived from RHS data, and these indices can be used as a basis for setting physical quality objectives for rivers[12]. For example, **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 bankside trees and the extent of near-natural land-use adjacent to the river. Points are added together to provide the HQA score.



The 2009 Polish RHS manual.

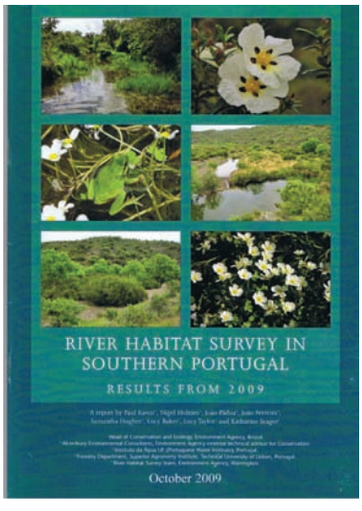
Wet woodland contributes to a high HQA score.

In contrast to HMS *(see below)*, the higher the score, the more highly rated the site. The diversity and character of features at any site is influenced by natural variation and also the extent of human intervention both in the channel and adjacent land. The RHS database allows HQA scores to be compared using sites with similar physical characteristics (e.g. gradient, 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 used as attributes, 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[14]. 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, the Picos de Europa, northern Spain and Mediterranean rivers in southern Portugal[7, 15-19]. The Drawa River study represents a further component in 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[20].

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 re-profiling and reinforcement of banks. Greater and more severe modifications result in a higher score. The cumulative points total provides the Habitat Modification Score (HMS) for the site. A Habitat Modification Class (HMC) protocol 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 guidance standard for assessing the hydromorphological features of rivers [21]. It is a recommended method for the agreed protocol for field survey and recording of morphological features. RHS was also used to help develop and test the associated CEN guidance standard on determining the degree of modification on river hydromorphology[22]. In the UK, RHS has been used for several WFD purposes such as identifying water bodies in hydromorphological reference condition, and those classified as "heavily modified" and assessing morphological pressures affecting river catchments.



A previous report in this series.

A severely modified channel in Poland.

Only aquatic taxa are scored for MTR, but the JNCC method includes marginal plants as well.

The STAR (STAndardisation of River Classifications) project was a research initiative funded by the European Commission and was completed in 2005. The main aim was to provide standard biological assessment methods compatible with WFD requirements. It also set out 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

Wherever possible, two macrophyte survey methods are used at benchmark RHS sites, for calibration purposes and an assessment of water quality. 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 MTR survey[3] 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.

The Makrofitowy Indeks Rzeczny (MIR) method is a Polish adaptation of MTR. Data collection is identical but the system uses slightly different species for scoring and a different score weighting for selected taxa[23]. A comparison of MTR and MIR results was made during previous survey work in Poland[7].

Inter-calibration

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.

In this report, we use RHS and macrophyte results from the River Itchen with those on the Drawa to demonstrate the use of these data across different European countries and also the application of the CEN standard[5] in determining the naturalness of river hydro-morphology.

Cowbane *Cicuta virosa* is common in Poland and is included in the MIR scoring system.

STUDY AREAS

THE DRAWA RIVER – CHARACTER AND HISTORY

The following information has been derived from the Drawa National Park website (www.dnp.pol) and *Rivers of Europe* (pages 564-570)[24].

The Drawa is considered to be one of the most beautiful rivers in Poland. It rises in the Drawa lake district 160m above sea-level and flows for 199 km, joining the Noteć River, which in turn feeds the Warta and then the Elbe. The catchment area is almost 3300km^2, containing 472 lakes (total area 156km^2), of which 390 are inter-connected by streams and rivers. The upper reaches (north of Drawno) flow through 18 lakes (accounting for 38.5km of its length), whilst the lower reaches flow along a valley deeply incised (up to 30m) in a vast outwash plain (sandur) formed in the Weischel Glacial Period (17,000 years ago). The Quaternary siliceous sandy deposits are 140-180m deep and contain large aquifers and complex sub-surface drainage. There are three main tributaries, most notably the Płociczna, which is 51 km long, drains a catchment area of 477km^2 and flows through three lakes, joining the Drawa near Głusko.

The river is predominantly groundwater-fed, so it has a very stable hydrological regime and a relatively small, ice-free, range in water temperature. Annual variation in water levels is modest (0.4-0.5m); however, upstream from Drawno, abundant growth of submerged aquatic macrophytes can cause an increase in water levels by up to 1.2m in the summer. Mean annual discharge is 9.3 m^3/s at Drawno and 21.5 m^3/s at Drawina (near the confluence with the Noteć), whilst the Płocicnza has an annual discharge of 3.0 m^3/s where it joins the Drawa.

Human activity associated with the river is first documented in the 14th Century, when Cistercian monks began clearing the parts of the primary forest, draining marshes and building mills. Since then the Drawa has been used as a regional boundary and for water transport. In 1662 parts of the river were deepened, banks protected and fallen trees removed to aid boat passage. In 1700 the

river was used to transport honey from Drawsko to Frankfurt, whilst from medieval times until 1979 it was used for rafting timber felled in the adjacent forest. Examples of the roll-way systems used to launch timber into the river have been preserved as historical monuments of the old forestry practices. Since timber rafting ceased in 1979, fallen trees have once again become a feature of the river downstream from Drawno. They represent an important factor shaping the channel morphology as well as providing an exciting challenge for canoeists.

In the second half of the 19th Century, drainage and irrigation were undertaken to create meadows. Marked down-cutting of the channel in the lower reaches was associated with extensive channelization and straightening of the Noteć River during 1891-96. Soil shrinkage and subsequent inundation led to abandonment of many of the meadows. This and a general population shift from rural settlements to towns and cities have resulted in meadowland reverting once again to woodland in many areas. Today, 59% of the Drawa catchment (including 62% of the Płociczna catchment) comprises forest and other semi-natural land-use, 4% is water and wetland and 33% agriculture (Table 1).

The Drawa has two small (1Megawatt) hydro-electric power-generating stations. One is at Borowo, located in the Prostinyia channel (built in 1917-storage height, 9m); the other is 60km (check) downstream at Kamienna, near the confluence of the Płociczna (built in 1899-storage height 8m). Several ambitious plans to create a series of hydropower stations and navigation schemes have been proposed in the past, but subsequently abandoned. In the Drawa National Park (DNP) boundaries the Drawa and Płociczna are managed for ecological purposes because they still retain natural morphological function and features- a rarity for lowland rivers in northern and western Europe[24].

Water quality has improved markedly since the early 1990s, but does not meet the highest standard because nutrient enrichment associated with domestic sewage effluent and agricultural run-off is still a problem. Large parts of the catchment are now designated as landscape or wildlife protection areas to help reduce diffuse pollution problems[24].

Drawa National Park

The National Park (DNP) is approximately 114 km^2 in area and features and Drawska Forest beech woods *Fagus sylvatica*, 20 lakes, the Drawa River and its tributary the Płociczna. Several if its habitats and species are designated under the European Habitats Directive[25]. The lakes and rivers in DNP contain good fish populations, represented by 42 species. However, salmon *Salmo salar* became extinct in the 1980s and there is a re-introduction programme on the Drawa, using fish from Latvia. A reintroduction programme for Baltic sturgeon *Acipenser oxyrinchus* began in 2007, to re-establish a breeding population on the Drawa last recorded in 1936. European otter *Lutra lutra* (which is the DNP symbol) and beaver *Castor fiber* are both common. The best example of beech woodlands are along the Drawa, whilst alders *Alnus glutinosa* dominate marshy areas of wet woodland in the valley floor. Pine trees *Pinus* spp. planted as coniferous forestry in the past are now being felled selectively as part of a re-naturalisation programme for the woodland. There are more than 100km of marked tourist trails in the woodland. Canoeing is very popular on the Drawa and there are several campsites for canoeists along the river. The DNP has strict controls to protect the native wildlife and habitats.

The River Itchen is a Special Area of Conservation in the UK.

THE RIVER ITCHEN

The River Itchen is a world-renowned chalk stream in southern England, famed for its trout fishing and designated as a Special Area for Conservation (SAC) under the European Habitats Directive[25]. In common with the Drawa, the Itchen has a very stable flow regime typical of groundwater spring-fed rivers *(see Figure 3)*. Rainfall in autumn and winter swells the groundwater reservoirs, giving rise to highest average flows in winter and spring. Factors affecting the stability of discharge are more complicated in the Drawa resulting in peak discharges in late spring and early summer.

TABLE 1: Catchment land-use upstream from selected RHS sites on the Drawa and Płociczna.

Site number and river	Percentage catchment area					
	Forestry and semi-natural	Wetland and water	Agriculture	Urban	Other	Area (km2)
Drawa						
Drawa-1	52	6	34	1	7	1107
Drawa-2	53	6	34	1	6	1255
Drawa-9	57	5	33	1	5	1736
Drawa-17	57	5	32	1	5	1756
Drawa total	*59*	*4*	*33*	*1*	*4*	*3288*
Płociczna						
Ploc-2	59	3	36	0	2	440
Płociczna total	*62*	*3*	*34*	*0*	*2*	*477*

SURVEY AND ASSESSMENT

Location of study sites and conditions during survey work

The river lengths we surveyed are shown in Figure 1. We completed 19 RHS surveys during 31 August-1 September 2008 and 30 August-1 September 2009, comprising 17 on the Drawa River and two on the Płociczna (Appendix 1; Annex A). Canoe-based observations on the Drawa were also made:(i) an 'upper reach', representing 12.5 km of river between Prostinyia and Drewiany Most on 30 August 2008;(ii) a 'lower reach', comprising a 24km length of river between Bogdanka and Sitnica (Figure 1). Two back-to back RHS sites were carried out on the Płociczna near Most Karolinka on 1 September 2009 (Annex A). The weather during survey work was dry and warm in both 2008 and 2009 and water levels similar with good flow.

River Habitat Survey

Surveys were undertaken by Paul Raven and Hugh Dawson, with assistance at various sites from Agnieska Ławniczak, Tomas Zgoła and Marta Swabinska. There were two single (500m) surveys, two paired surveys (1km), one set of three (1.5km) a set of four (2km) and a set of five (2.5km) survey units (Annex A). 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. Site numbers were determined chronologically in 2008 and 2009, but results are presented in downstream sequence (Table 2;Appendix 1;Annexes B-H,J,K). Results from canoe and bank-based surveys carried out at Drawa-1 are also presented.

Calculation of HQA and HMS scores was based on the 2005 version (2.1) of these systems – with HQA adapted for local conditions similar to the approach for sites surveyed in Slovenia, the Bavarian and the Tyrolean Alps, the Cévennes, Poland, Picos de Europa and southern

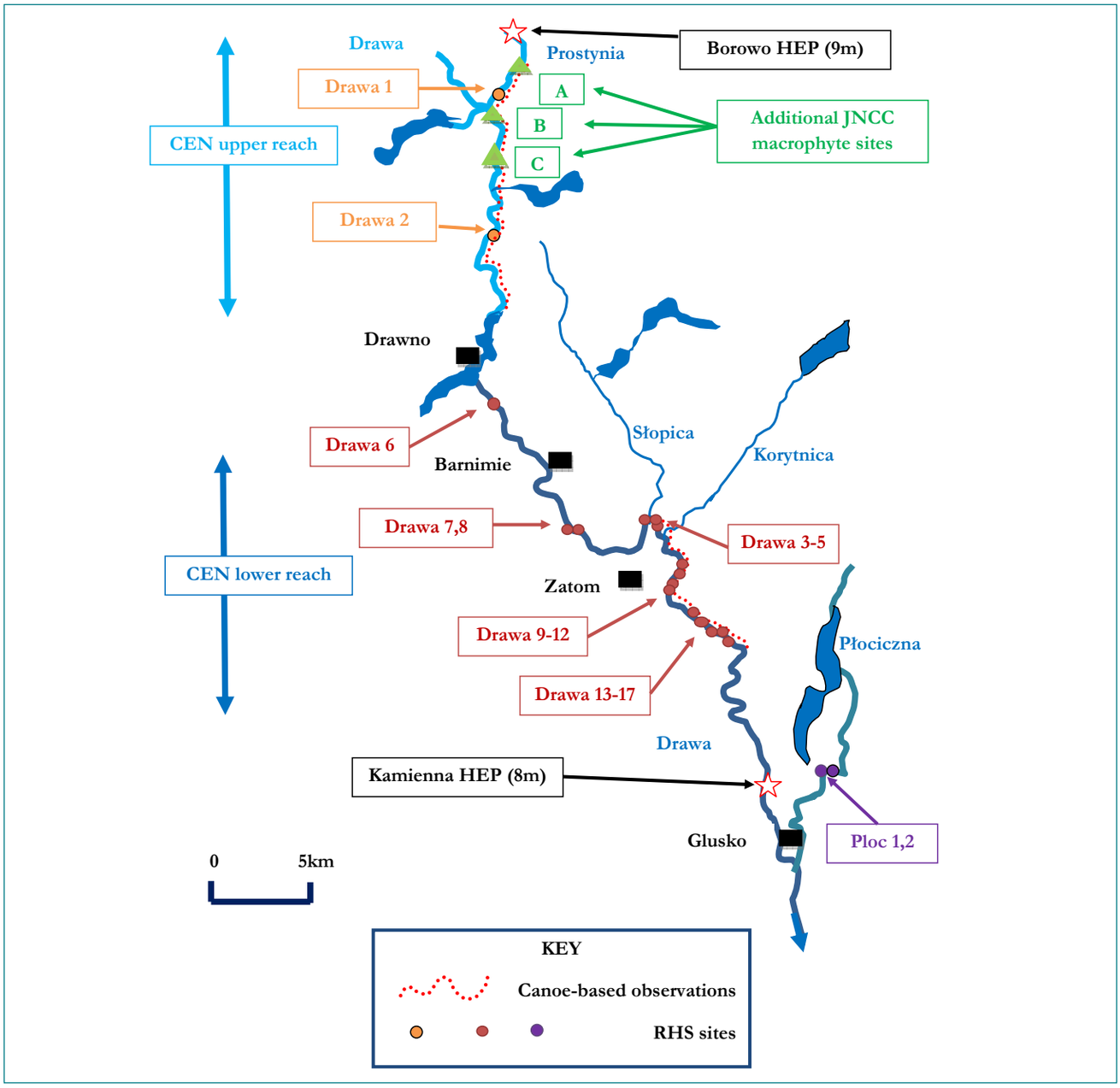


Figure 1. Simplified map of the Drawa, showing the location of our study reaches and RHS sites.

Moss growth and dragonfly exuvia provide clues to hydrological regime.

Portugal[7, 15-19]. This means that several assumptions were made about the inclusion and scoring of special features and 'semi-natural' land-use. Additional special features and generous interpretation of semi-natural land-use mean that HQA scores can be 10 points or more than those automatically generated using the UK scoring system. For example, small remnant areas of coniferous plantation (CP) occurring in broadleaf woodland along the Drawa was discounted and a score of 7 (natural land-use) for that bank given. This is because we know these trees are not managed for forestry and are being replaced as part of a long-term re-naturalisation of the woodland landscape. The effect of including additional special features and generous interpretation of semi-natural land-use on HQA scores is illustrated by comparing the Drawa results in Figures 9 and 10.

A complete set of RHS survey forms, a CD-Rom with digital photographs, maps showing locations, sketches and macrophyte lists for each site visited have been produced and these are available on request. Site numbers, prefixed with "Drawa" and "Ploc" are unique codes that identify individual survey sites for the Drawa and Płociczna in the STAR database.

Map-based information needed for PCA contextual purposes, such as distance from source of individual survey sites was calculated from 1:100,000 scale topographic maps in the *Mapa topograficzna Polski* series. Water-level spot heights marked on these maps were interpolated to calculate channel slope (gradient) and mid-site altitude. Surface geology of the river valley was determined from the 1:200,000 scale map of Gorzów Wielkopolski (Instytut Geologiczny). Land management information was derived from CORINE land-use cover data for the catchment (Table 1).

Wildlife sightings are recorded during our surveys because they provide useful additional *ad hoc* information. They appear in Annex K.

Aquatic macrophytes and water chemistry

Nigel Holmes carried out macrophyte surveys on all the rivers visited, using the JNCC[2] and MTR methods[3] at all 19 RHS sites respectively. Three additional sites (A-C) in the upper study reach were also surveyed (Figure 1). MIR results were calculated by Agnes Ławniczak for comparison with MTR scores. Water samples were collected in full, sealed containers at selected sites and analysed in the laboratory within 20 days, using calibrated equipment.

Signs of wildlife, such as beaver activity, are recorded as additional information during RHS surveys.

European guidance standard on hydromorphological modification

The European (CEN) guidance standard[5] is based on a set attributes representing hydrological and morphological character, with a scoring protocol that assesses departure from near-natural conditions within a given reach. The attributes are scored on a 1-5 scale, with 1 representing near-natural conditions and 5 severely modified state. A 1* classification is achieved when the attribute is assessed to be in pristine, or near-pristine condition. Some attributes are assessed quantitatively, and others qualitatively (Annex I). Various sources of data derived from surveys such as RHS can be used to score relevant attributes separately in a quantitative or semi-quantitative manner, with the overall score for a reach calculated using the best available information that qualifies for assessment purposes. We used a combination of quantitative site-based and qualitative canoe-based observations to assess modifications to river hydromorphology in our 'upper' and lower' reaches (Figure 1;Annex J). For comparison with the River Itchen, RHS data and qualitative assessment based on local knowledge were used in similar fashion.

Near-natural channel and riparian habitat.

RESULTS

Context in relation to European hydro-ecoregions and UK rivers

Figure 2 shows the PCA plots of the Drawa and Płociczna sites (averaged to simplify presentation), compared with our previous Polish surveys[7], the STAR project sites[4] and the 1994-96 stratified random baseline network of sites in the UK[8].

Hydrology

The Drawa is located in the "Central Baltic Plain" hydro-ecoregion, which is in the same broad grouping as "Southern England – Channel coast" [26]. This suggests that rivers in both locations should be broadly similar in character. The very stable groundwater-fed hydrological characteristics of the Drawa closely match those of groundwater-fed rivers of southern England, notably the River Itchen which we use for comparison in this report (Figure 3).

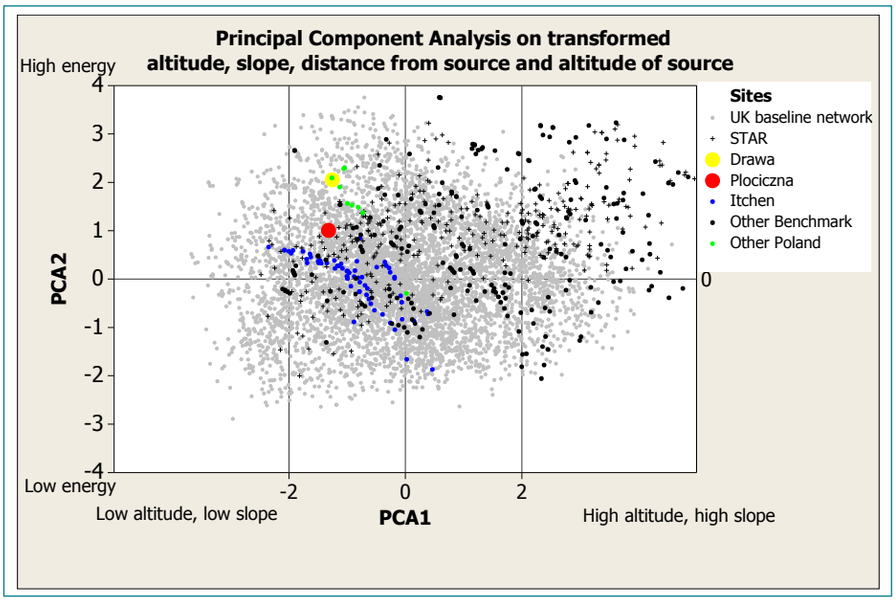


Figure 2. PCA plot showing the Drawa and Plociczna in relation to baseline UK, STAR and other European benchmark sites.

River landscape character

Table 2 summarises the main characteristics of the sites we surveyed, with Appendix 1, Annex A, B, C and D providing more detail on location, features and HQA and HMS scores. There were two distinct river valley landscape types in our study area: (i) reed-swamp alongside the upper reach and (ii) wet woodland alongside the lower reach. Channel and riparian floodplain habitat varies little over long distances in both upper and lower study reaches.

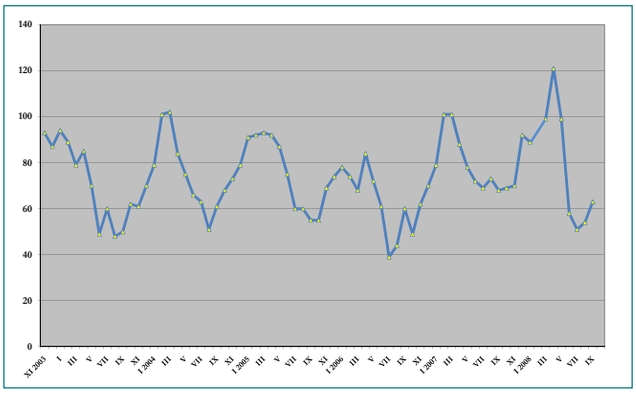


Figure 3. Hydrographs from the Drawa (left) and Itchen (right) for 2003-2008, showing similar stable flow regimes. The former shows mean monthly water levels and the latter mean monthly discharge in cumecs.

Two landscapes predominate: reed-swamp in the upper study reach; wet woodland in the lower reach.

Tree-less banks along a widened channel; Drawa-1.

Reed-lined channel with abundant macrophytes is typical of the upper reach.

TABLE 2: The occurrence of selected habitat features at RHS sites on the Drawa and Płociczna, in downstream sequence.

	Drawa							Płociczna
	1	2	6	7-8	3-5	9-12	13-17	1-2
Eroding cliffs	None	Present	Present	Present	Present	Present	Present	Present
Depositional bars	None	Present	Present	Present	Present	None	Present	Present
Mature mid-channel island	None	None	None	None	None	Present	None	Extensive
Floodplain reed swamp	Present	Extensive	None	None	None	None	None	Extensive
Fringing reeds	Extensive	Extensive	Present	None	None	None	Present	Extensive
Bankside trees	Isolated	Semi-continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Semi-continuous
Fallen trees	None	Present	Present	Extensive	Extensive	Extensive	Present	Extensive
Wet woodland	None	Present	Present	Extensive	Extensive	Extensive	Extensive	Extensive
RHS in-stream vegetation types*	8	8	8	5	3-4	5-9	6-8	7-8
Total HQA score	**34**	**70**	**76**	**74-81**	**65-73**	**63-74**	**72-81**	**68-91**

** excludes filamentous algae.*

Reed-swamp along the upper reach

For the majority of our upper study reach, between Prostynia and Drawno, the river is unconstrained by glacial moraines on one or both banks and there is extensive floodplain, typically 1-1.5km wide (Annex A). This floodplain is dominated by extensive reed-swamp and contains several large relic side channels and ox-bows, resulting from channel movement and realignment, with drainage ditches present. There are very few bankside trees, aquatic macrophytes grow abundantly and reeds dominate the channel margins.

The HQA score (34) for Drawa-1, located in a straightened and widened channel, with uniform bankside vegetation structure and virtually treeless banks is in stark contrast with the remaining survey sites, all of which have semi-continuous or continuous tree cover (HQA = 63-91) (Table 2).

Wet woodland along the lower reach

Between Barnimie and Sitnica (including sites Drawa-3 to 17), the river is deeply incised in glacial moraines and the valley has a distinct terraced profile. The river channel meanders across a valley floor that typically is 80-100m wide. The meanders are 'fixed' by an extensive network of alder tree roots that form a natural lattice revetment. The river channel is heavily-shaded, fallen trees are frequent (Annex E) and the predominant substratum mix is gravel-pebble and sand. Flow is predominantly smooth or rippled and the groundwater-fed hydrological regime means that there are few erosion and deposition features. Local variation in channel character is provided by the frequency of fallen trees, some wider, shallower stretches (e.g. in Drawa-13), a noticeably steeper stretch in Drawa-16 and a huge glacial erratic boulder (Wydrzy Głaz) in Drawa-17. Aquatic plant growth is abundant only where breaks in the shade allow full sunlight to the channel.

Exposed alder roots form a natural revetment protecting the bank from erosion.

Huge glacial erratic in the channel; Drawa-17.

Unstable sandy slopes with beech trees.

Macrophytes thrive in un-shaded parts of the river.

Where sedge is cut on the riparian floodplain alder regeneration is prevented.

The valley floor (riparian floodplain) has peaty soil and is dominated by wet woodland (predominantly alder and sedge *Carex* spp.). This contrasts with beech and pine woodland on the dry, sandy terrace slopes. In a few places (e.g. Drawa-13 and 17) cropping of sedges indicated continuing management of parts of the valley floor for hay. The even-aged nature of many alders suggests reversion to wet woodland from previously managed meadows (see 'character and history' text above).

Other than occasional wooden platforms for canoe access and landing points, plus short lengths of bank reinforcement and a road crossing, the impact on channel and riparian floodplain habitat was negligible on the Drawa between Barnimie and Sitnica (Annex B).

Wet woodland with even-aged alders.

The Płociczna

The Płociczna is a smaller-scale version of the Drawa, but with a mixture of wet woodland and reed-swamp within the 1000m stretch we surveyed (Ploc-1, 2). Extreme meanders, an ox-bow and presence of point bars, mature island and backwaters provided more channel diversity than the Drawa, suggesting more active river processes in operation. The river bed is entirely sand, with some silt in the channel margins. Habitat diversity and therefore HQA scores are high because of the mixture of wet woodland and reed-swamp habitats found in both sites.

Morphological assessment using the European (CEN) guidance standard

Assessment of our two study reaches on the Drawa, the Płociczna and the River Itchen appears in Annex J. The upper Drawa reach scores 1 (near-natural category) for only 4 of the 16 qualifying attributes and has seven scores of 3-4 (moderately-extensively modified categories). Overall this produces a 'moderately modified' classification for the reach. In contrast, the lower reach consistently scores 1*, indicating near-natural hydro-morphological conditions. The Płociczna also scores 1 or 1* for all attributes.

An ox-bow adds to habitat diversity on the Plociczna.

Mature mid-channel island on the Plociczna.

The cumulative occurrence of features

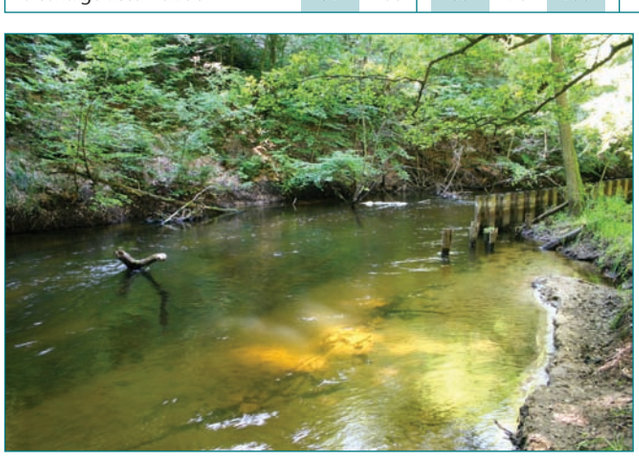
Table 3 shows the number of flow-type, channel substratum and RHS features recorded in successive sites (Drawa-3, 4, 5; 9-12 and 13-17). For the Drawa between 83% and 100% of features were captured within a 1000m length, depending on the precise location. The cumulative pattern is similar to results from consecutive RHS benchmark surveys elsewhere in Europe[14] and reaffirms that for near-natural channels, two or more consecutive sites should be carried out.

Comparison between canoe and bank RHS survey results

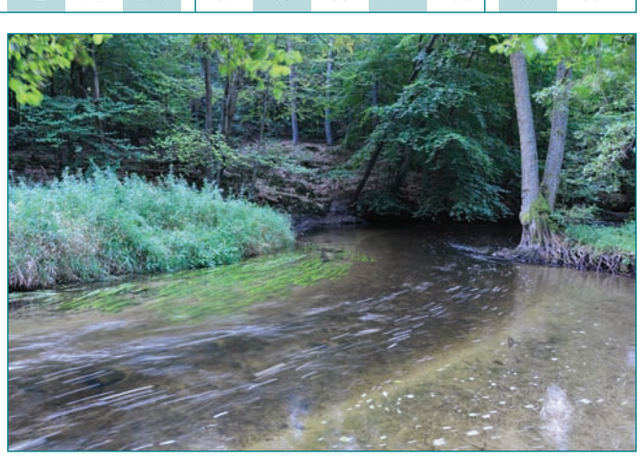
Parallel RHS surveys, from the left bank and a canoe, were carried out at Drawa-1. The site was relatively uniform in habitat diversity terms, but dense fringing reeds made observations of the channel difficult from the bank; the opposite problem, poor visibility of bank-top vegetation and land-use, was encountered when surveying from the canoe. Furthermore, estimating 50m distances from the canoe in the reed-lined channel was virtually impossible because of the lack of obvious landmark features such as trees to use a reference points for a range-finder, so spot-check locations were determined from the bank. Despite difficult access and visibility through the reeds, the bank survey was quicker to complete than the canoe. However, the canoe had the advantage of manoeuvrability and much easier assessment of channel substratum, aquatic vegetation and water depth. It was also invaluable for surveillance between sites and access downstream.

TABLE 3: The occurrence of flow-types, substrata and habitat features in consecutive RHS sites, indicating the cumulative appearance of new features.

River	Drawa															Płociczna	
Site number (downstream sequence)	7	8	3	4	5	9	10	11	12	13	14	15	16	17		1	2
Predominant channel substrata	2	3	2	1	2	2	2	2	2	2	2	2	3	3		1	1
Flow-types	4	5	5	5	6	4	5	5	4	4	4	4	5	4		4	5
Channel and bank features	7	6	6	10	8	5	5	5	7	5	8	5	8	6		9	10
Tree and riparian habitat features	8	8	7	7	6	9	9	8	9	9	9	9	8	9		6	9
Total per site	21	22	20	23	22	20	21	20	22	20	23	20	24	21		20	25
Cumulative total	21	26	20	24	25	20	22	22	24	20	24	24	28	29		20	25
Percentage accumulation	81	100	80	96	100	83	92	92	100	69	83	83	97	100		80	100



Occasional bank modifications represent a very minor departure from natural river form and fluvial processes in the lower study reach; Drawa-3.



Flow patterns influence substrata and depositional features. [Korytnica River, shortly before it joins the Drawa.]

A lack of distinctive landmarks or trees creates problems when using range-finders in canoes.

Assessing mid-channel substratum and submerged macrophytes is more effective from a canoe.

Overall, results were very consistent with only 12 differences in the 392 data entries (3%), but this figure is misleading because it includes 40 (albeit correct) assumptions about bank-top vegetation structure and land-use made from the canoe. Key differences were associated with observations of submerged vegetation types, mainly the assessment of cover abundance (Table 4).

Our conclusions, albeit from one experimental comparative survey, are that where a canoe-based survey is carried out (e.g. where a channel that is too deep to wade flows through dense reeds, swamp, scrub and shrubs, therefore making access by foot difficult or unsafe) two key factors must be resolved: (i) an accurate way of estimating 50m, using a range-finder to determine 50m spot-check intervals, and (ii) validation of bank-top and floodplain features using aerial photographs.

TABLE 4: In-channel vegetation types recorded by bank and canoe-based RHS surveys at Drawa-1. Numbers indicate presence at spot-checks (n = 10), with extensive cover in brackets.

Vegetation type	Bank RHS	Canoe RHS
Emergent, broad leaved herbs	7	7
Emergent, reeds/sedges/rushes	10	10
Floating-leaved	7	7
Free-floating	9	9
Amphibious	2	3
Submerged, broad-leaved	10 (4)	10 (6)
Submerged, linear-leaved	8 (3)	10 (9)
Submerged, fine-leaved	9	9

AQUATIC MACROPHYTES

The Drawa is dominated by higher plant species, but not exclusively so (Annex G and H). There are significant differences between the upper and lower reaches, primarily in response to variations in water depth and velocity, and bankside tree cover. Water velocity directly influences which macrophytes grow and also has a major indirect effect by determining the channel substratum. Bank-face tree roots provide footholds for bryophytes which cannot thrive in unsuitable marginal habitats dominated by reeds and sedges.

The extent of tree shade is a major factor for macrophyte growth. In the upper study reach (A-2; Figure 4-chart A) trees are sparse or absent but in the lower reach tree cover is semi-continuous or continuous. Alder is the overwhelming dominant species, or sometimes co-dominant with reeds and sedges. Where trees are absent or sparse, common reed *Phragmites australis* and lesser pond-sedge *Carex acutiformis* dominate the banks, the latter also being common in abandoned wet meadows in the floodplain. Unlike many rivers surveyed in Poland, reed sweet-grass *Glyceria maxima*, and most notably, reed canary-grass *Phalaris arundinacea*, are much less common on the Drawa.

Whilst there was major variation in the distribution pattern of some species downstream, two taxa (unbranched bur-reed *Sparganium emersum* and arrowhead *Sagittaria sagittifolia*) were abundant throughout. Both these species have the ability to grow different leaf-forms; in the Drawa their predominant leaf-shape is strap-shaped and linear. Two other locally abundant and widespread taxa were fennel pondweed *Potamogeton pectinatus* and perfoliate pondweed *Potamogeton perfoliatus*. All four taxa have a low MTR trophic rank, indicating tolerance to nutrient enrichment (Figure 5-chart B).

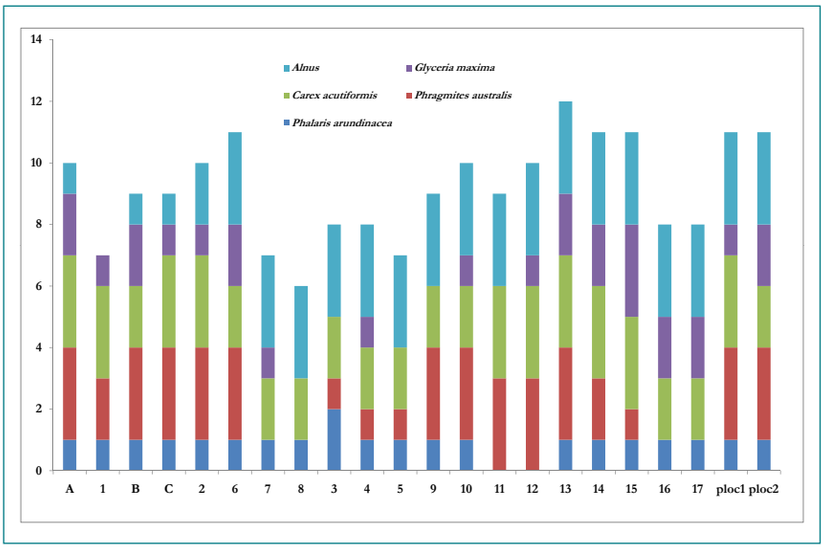


Figure 4. The distribution pattern of bankside trees and fringing reeds in our study areas.

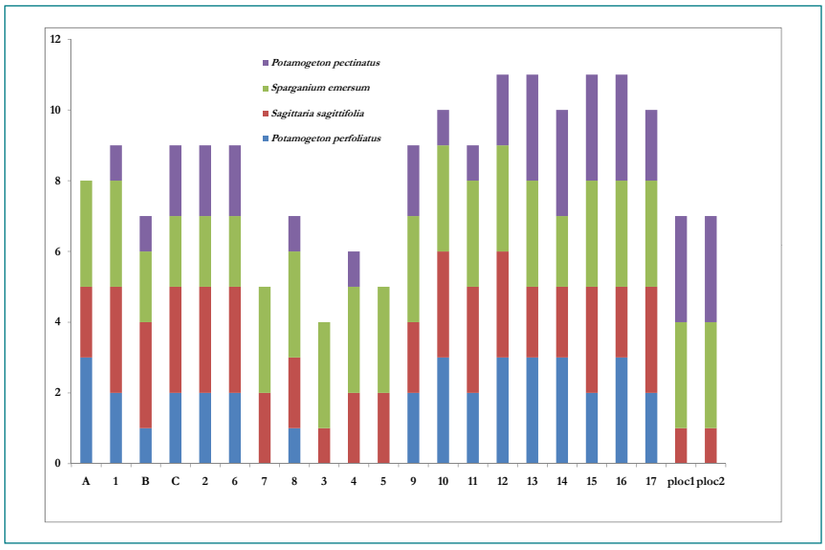


Figure 5. The distribution and abundance patterns of four widespread macrophyte taxa.

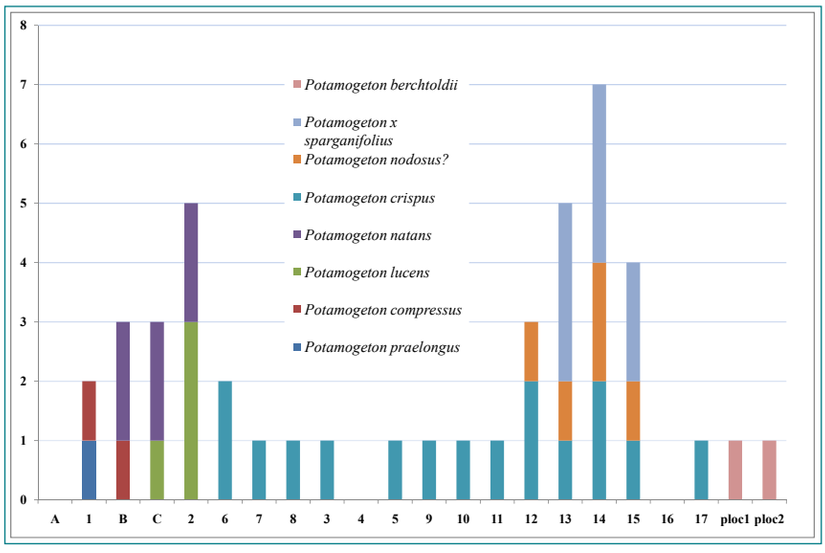


Figure 6. The distribution and abundance of pondweed species.

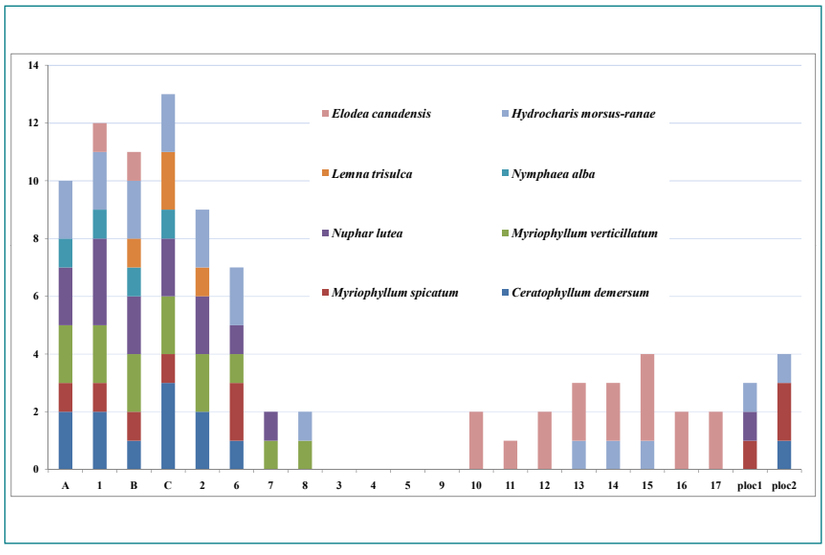


Figure 7. Variation in the distribution of eight macrophyte taxa.

Changes in channel morphology, notably water depth, velocity and substratum, are reflected by the distribution patterns of several taxa. Pondweeds (genus: *Potamogeton*) are a good example. In the upper reach, characterised by sluggish, deep water, finer substratum and virtually no shade, four taxa were present that were not observed downstream. They included long-stalked pondweed *Potamogeton praelongus* and grass-wrack pondweed and *P. compressus* which are both relatively rare in Poland. The other taxa confined to the upper study reaches were floating-leaved pondweed *Potamogeton natans* and shining pondweed *P. lucens.* The former is one of the parent species of a rare hybrid found in the downstream study reach (Drawa-13-15). Generally, the lower reach had a more limited pondweed community, although in Drawa 12-15 where shallow, faster-flowing gravel-bed areas were interspersed with more sluggish areas with sand substratum, there was a very rich assemblage. Faster-flowing sections had a mixed community that included the hybrid *Potamogeton x sparganifolius*, whilst Loddon pondweed *Potamogeton nodosus* occurred in the slower-flowing areas (Figure 6).

Other aquatic higher plants also showed significant variation in distribution patterns down the Drawa. The upper reach had a far greater range of taxa that prefer, or even demand, sluggish or stable flows. These included whorled water-milfoil *Myriophyllum verticillatum*, common hornwort *Ceratophyllum demersum*, and free-floating species such as water soldier *Stratiotes aloides*, ivy-leaved duckweed *Lemna trisula* and frogbit *Hydrocharis morsus-ranae*. White and yellow water lilies *Nuphar lutea* and *Nymphaea alba* were also confined to the upper reach. Although the alien species Canadian water-weed *Elodea canadensis* was recorded upstream, it was more common downstream where all the taxa cited above, except frogbit, were absent (Figure 7).

Many bryophytes and some other higher plant taxa thrive best where there are firm substrata in the channel or banks to grow on. A good example is water-crowfoot *Ranunculus*, which flourishes on coarse substrata and in turbulent water flow. Most crowfoot observed in the Drawa was small and sparse, and has been tentatively determined as river water-crowfoot *Ranunculus fluitans*. Mosses were locally abundant in stretches where cobbles or pebbles formed a firm substratum for attachment. In sluggish conditions *Fontinalis antipyretica* was dominant, whilst in faster-flowing sections *Platyhypnidium* and *Hygroamblystegium* dominated.

Acorus calamus

Butomus umbellatus

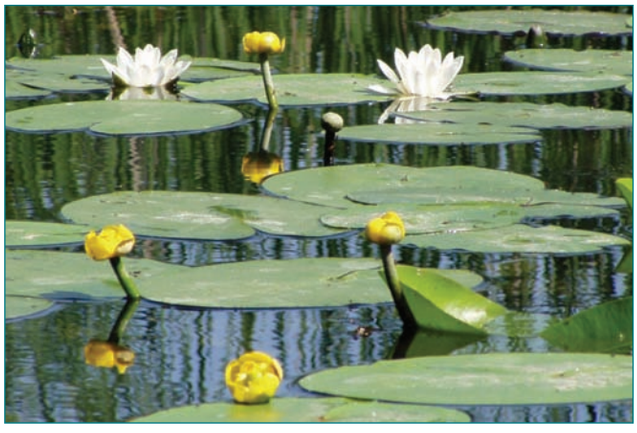
Caltha palustris

Sparganium emersum

Ranunculus fluitans

Pulicaria dysinterica

Iris psuedacorus



Nuphar lutea and *Nymphaea alba*

Typical macrophytes recorded from rivers in Poland during our surveys.

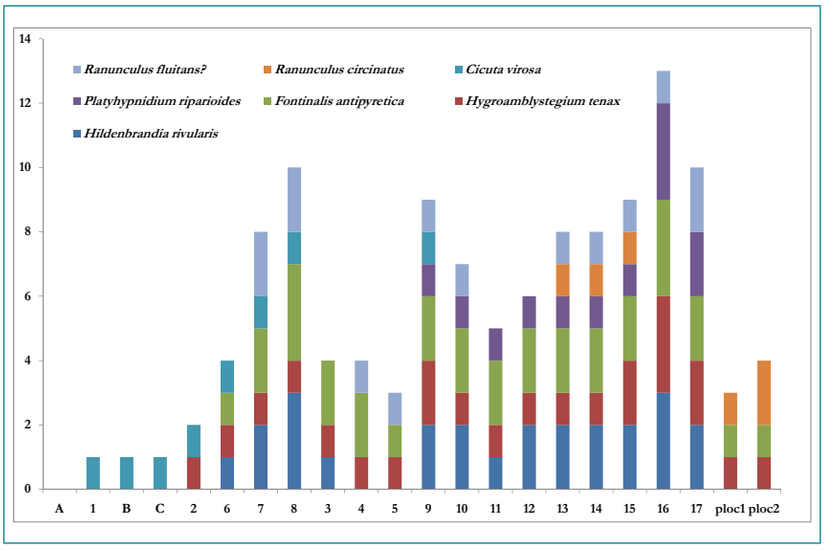


Figure 8. The distribution of macrophyte taxa that require firm substratum.

Firmly embedded cobbles and pebbles were also frequently covered by the encrusting red alga *Hildenbrandia*. As this species can thrive in low light intensity, it was especially common where bankside trees cast very heavy shade. River sponge *Ephydatia* is also very shade-tolerant, and occurred in similar habitats (Figure 8).

The flora of the Płociczna generally has more in common with the upper reach of the Drawa. Algae were not recorded and most aquatic bryophytes were present only on submerged tree roots. Hornwort, spiked water-milfoil *Myriophyllum spicatum* and yellow water-lily, which were confined to the upper Drawa reach were also found in the Płociczna. In contrast, species that were common the lower Drawa reach, such as Canadian waterweed, curled pondweed and perfoliate pondweed, were not found. Small pondweed *Potamogeton berchtoldii*, common spike-rush *Eleocharis palustris* and lake sponge *Spongilla lacustris* were present in the Płociczna but not found in the Drawa.

A notable feature along the lower study reach of the Drawa was a distinct 'bryophyte cut-off' line at the base of bankside trees, about 30cm above the riparian floodplain level. Above this level woodland mosses coated the trunk, but below it was completely bare. The reason would appear to be related to the very constant water level in winter and spring (*cf.* Figure 3). The bare area marks the zone where the period of inundation is too long to enable terrestrial woodland species to thrive, yet is not inundated sufficiently in the growing season to enable aquatic mosses to grow.

River sponge and *Hildenbrandia* encrust cobbles and pebbles in shaded parts of the lower reach.

WATER QUALITY

Our water chemistry results suggest little variation in pH (7.24-7.41) and conductivity (325-390 uScm-1) within the study area (Annex D). Whilst nitrate levels are very low, there was evidence of elevated phosphorus levels, confirming that there are still water quality problems associated with domestic sewage effluent and agricultural run-off[24].

The MTR method[3] uses macrophyte communities to assess nutrient status. MTR scores for all sites on the Drawa, and also the Płociczna, were in the range 32-39, indicating at least moderate enrichment (Annex G). The MIR range was 32-45. The UK river classification[2] would classify the Drawa and Płociczna as River Community Type I rivers. In the UK, river types have mean MTR scores of 34[27] with the highest quality 10% having an average score of just 41. This suggests that for the vegetation community type, the Drawa is of at least average, and possibly slightly above average, water quality when compared with UK river systems of a similar river type.

DISCUSSION

Overall, diversity of channel substrata, flow-types and both erosion and deposition features is relatively low throughout the Drawa, reflecting the very stable hydrological regime. The biggest contribution to habitat diversity and therefore HQA scores were bankside tree features (notably fallen trees), wet woodland on the riparian floodplain terraces, fringing reeds and in-channel vegetation.

A key objective of our study was to compare our results with other hydrologically similar sites we had surveyed in Poland[7] and also the River Itchen in southern England. This would establish if the Drawa and Płociczna were good examples of 'reference condition' lowland, groundwater-fed rivers.

High spring water level is marked by the lower limit of terrestrial moss growth on riverside tree trunks.

Comparing RHS results with other lowland Polish rivers and the River Itchen

Table 5 summarises the main characteristics of the Drawa and Płociczna compared with eight other lowland groundwater-fed rivers we surveyed as 'benchmark' sites in previous study visits to Poland in 2003 and 2008[7]. Wet woodland was present or extensive at the Pilawa, Dobrzyca and Pisa benchmark sites, which all have high HQA scores and little or no on-site impacts. The Krynica is affected by forestry, whilst the Narew, Biebrza, Elk and Jegrizna sites were largely tree-less and have hydrological or livestock grazing impacts that significantly reduce riparian habitat diversity and consequently the HQA score. Differences in the overall character, features and HQA scores vividly demonstrate the contrast in naturalness and morphological functioning.

Observations also suggest that the Płociczna in our study area is a naturally-functioning river and represents a good 'reference' benchmark for small, lowland sandy rivers in Poland. It contrasts markedly with the Jegrznia and Elk rivers in the Biebrza catchment we surveyed in 2007[7]. Although an extravagant meander pattern remains on the Jegrznia and Elk they are hydromorphologically moribund because most of their flow is diverted into major drainage channels.

Figure 9 compares the HQA scores of the Drawa and Plociczna sites compared with those from RHS surveys undertaken on the River Itchen. For direct comparison the HQA scores have been calculated using the UK scoring protocol. The contrast between the Drawa and Itchen is striking and reflects the extensive wet woodland riparian floodplain habitat along the lower Drawa reach, compared with the absence of this habitat along most of the Itchen. Figure 10 illustrates the HQA scores for all the sites we have surveyed in Poland using RHS[7], reaffirming the importance of the Drawa as a true lowland river benchmark within Poland and also other European countries.

CEN assessment of the Drawa and River Itchen

Another objective of our survey of the Drawa was to test and refine the draft CEN guidance standard on the hydromorphological assessment of rivers[5] with a view to demonstrating the identification and use of near-natural reaches for quality assessment purposes. Within the UK

Fallen trees are a major feature along the lower study reach.

there are very few reaches of river more than 10km long than can be considered 'totally' or 'nearly totally undisturbed', and therefore qualify as being in 'reference condition' as defined by the WFD[27]. No medium or large lowland rivers in the UK remain in a near-natural condition for more than 2-3 kms, so these do not qualify for 'reference condition' status. A similar picture occurs across the majority of lowland European countries with intensively farmed or urbanised landscapes[24]. We can therefore usefully compare the Drawa results with other Polish rivers and also the Itchen, using RHS and CEN guidance standard information.

The difference between the lower reach of the Drawa, which can be classified as near-natural and the River Itchen, which, in an undisturbed state, should broadly be hydro-morphologically equivalent, is striking. The Itchen is morphologically degraded for a large part of its length (see HQA scores in Figure 9) and as a result is classified as 'moderately to extensively modified' using the CEN guidance standard protocol (Annex J)[5]. The lower Drawa reach is therefore a good example of a hydro-morphologically un-impacted (reference) condition lowland river that is extremely rare or absent from several European countries, notably the UK. It is also important in the context of the Drawa downstream from Sitnica. Here, CEN assessment would reflect the effects of the major impacts on hydrology and morphology caused by the Kamienna HEP and historical channel re-alignment downstream to the Noteć River.

The River Itchen has very little or no woody debris or fallen trees in the channel.

The Dobrzyca is very similar in character to the Drawa.

Our observations, linked to documented land-use changes in the Drawa valley also suggest that natural regeneration of wet woodland habitat from previous hay meadow management can be relatively quick, given favourable conditions. This provides encouraging evidence for the protection of existing wet woodland habitat and its restoration wherever possible to maintain morphological and nature conservation interest within and outside protected areas for wildlife-on the Drawa and elsewhere.

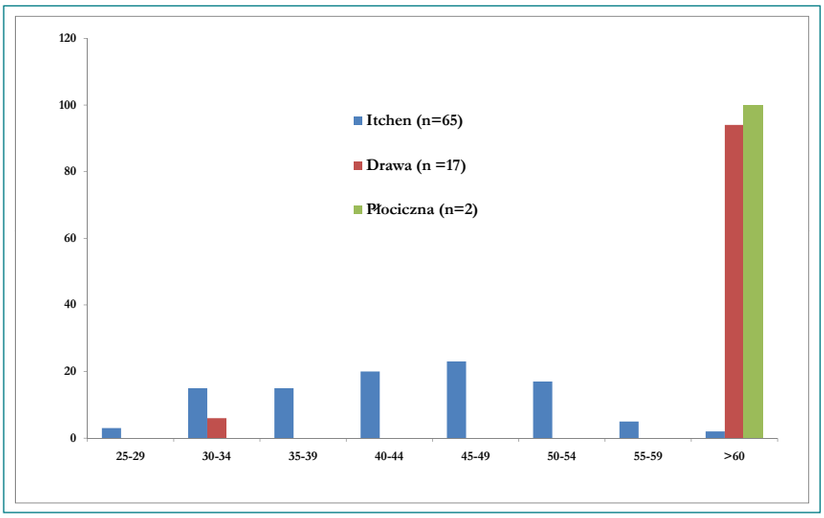


Figure 9. HQA scores from the Drawa and the Itchen, expressed as percentage of sites surveyed.

Macrophytes

The macrophyte communities found in the Drawa and Płociczna had much in common with the communities in most of the other rivers surveyed previously[7]. These surveys included 11 JNCC sites on eight rivers.

Marsh cinquefoil *Potentilla palustris*, fine-leaved water-dropwort *Oenanthe aquatica* and water soldier *Stratiotes aloides* were the only aquatic species that were recorded in two or more of the previous survey sites but were absent from the sites surveyed on the Drawa. There were several taxa of interest such as bladderwort *Utricularia* sp., blunt-leaved and flat-stalked pondweeds *Potamogeton obtusifolius* and *P. friesii*, and thread-leaved water-crowfoot *Ranunculus trichophyllus* that were present in previous surveys but not found in the Drawa. In contrast the Drawa was especially noteworthy for presence of the hybrid pondweed *Potamogeton x sparganifolius*.

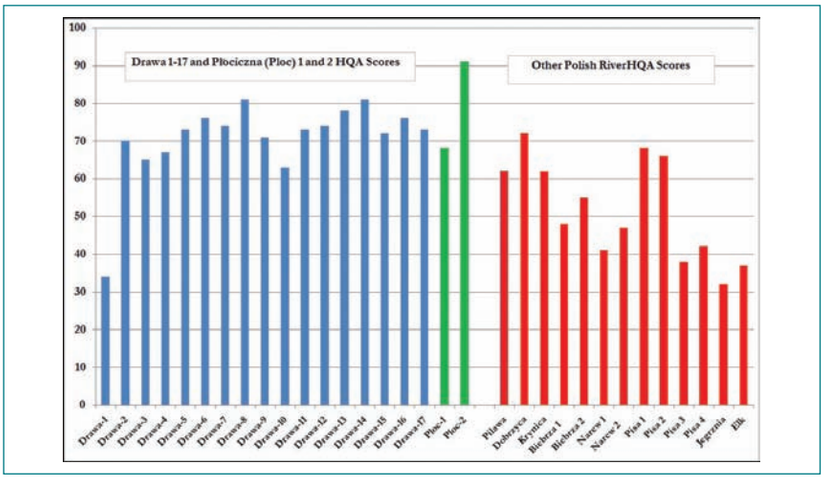


Figure 10. HQA scores from the Drawa and other Polish rivers used for benchmarking purposes.

Species such as arrowhead *Sagittaria sagittifolia* appear to be widespread and often dominant in many lowland Polish rivers. Pondweeds such as *Potamogeton pectinatus* and *Potamogeton perfoliatus* were more widespread, and more abundant, than in rivers previously surveyed. Both common bur-reed species were present in the Drawa, with *Sparganium emersum* far more abundant than recorded in other Polish rivers, and *Sparganium erectum*, whilst widespread, was much less abundant than recorded in previous surveys.

The MTR scores for the Drawa and Płociczna were very similar to those scores derived from previous surveys. Scores from the previous surveys ranged from 33-41[7] (mean, 36) and for the Drawa scores ranged from 32-39 (mean, 35.5), with MTR scores for the Płociczna being 32 and 34.

TABLE 5: A comparison of HQA and MTR scores, selected features and physical attributes of rivers surveyed in Poland. Ranked by descending HQA score. Extensively modified sites are excluded (see back cover for locations).

River	HQA score	MTR score	Reedswamp/ marsh/ wetland	Fringing reeds	Fallen trees	Wet woodland	Gradient (m/km)	Bankfull width (m)	Impacts
Płociczna (n = 2)	68-91	32-34	Extensive	Extensive	Present/ extensive	Extensive	0.55	8.0-9.0	None
Drawa (n = 16)	63-81	34-39	Present/ extensive	Present/ extensive	Present/ extensive	Extensive	0.31-0.89	18.0-42.0	None
Dobrzyca (n = 1)	72	35-37	Extensive	Present	Present	Extensive	0.74	11.0	None
Pisa (n = 2)	66-68	34	Extensive	Extensive	Present	Extensive	0.16	38.0-45.0	None
Krynica (n = 1)	62	33	None	None	Extensive	Present	1.0	4.0	Forestry
Pilawa (n = 1)	62	33	Extensive	Extensive	Present	Present	0.98	9.0	None
Biebrza (n = 2)	48-55	36-37	Extensive	Extensive	None	None	0.14	23.0-26.0	Cattle grazing
Narew (n = 2)	41-47	38	Extensive	Extensive	None	None	0.4	13.0	Reservoir downstream
Elk (n = 1)	37	38	Extensive	Extensive	None	None	0.12	30.0	By-pass channel
Jegrznia (n = 1)	32	34	Extensive	Extensive	None	None	0.13	18.0	By-pass channel

The Jegrznia is moribund because most of its flow has been diverted into a large by-pass channel.

CONCLUSIONS

We fulfilled all our objectives and the results, including comparison with other rivers we surveyed, confirm the following:

- the Drawa between Barnminie and Sitnica is characterised for long distances by the near-natural morphological conditions of an unimpacted lowland groundwater-fed river;
- this reach should therefore be used as a 'reference condition' location for morphology under the WFD in Poland and as a surrogate reference condition location marker for lowland groundwater-fed rivers in the UK;
- a combination of canoe and bank-based field survey and surveillance, together with supporting map information and local knowledge is an effective way of assessing the morphological character of the Drawa for CEN standard purposes[5];
- two or more consecutive RHS surveys are required to capture variation in near-natural river channel and riparian habitat such as that along the Drawa and Płociczna.

Our RHS and macrophyte results have added considerably to the STAR and benchmarking database, increasing our knowledge about the character of a variety of rivers across Europe[14]. We have also made recommendations for improving the RHS manual and HQA scoring protocol (Appendix 2) which build on previous suggestions that can be found in our previous reports[7, 15-19]. This should further improve the relevance and quality of RHS training in Poland, as well as helping to improve the assessment and management of rivers across Europe.

We hope that our results will help to develop a European-wide network of expertise that shares data and knowledge and training material. This is particularly relevant in relation to identifying and protecting near-natural river reaches in 'reference condition' and also determining morphological measures needed to achieve and maintain 'good ecological status' in water bodies as required by the Water Framework Directive.

A modified stretch of the River Itchen.

'Reference' conditions for channel and riparian floodplain habitats along the Drawa.

Hybrid pondweed *Potamogeton x sparganifolius* in the Drawa.

APPENDIX 1: Notes for survey sites on the Drawa and Płociczna, in downstream sequence.

Drawa-1. 30 August 2008. HQA = 34 HMS = 1340(A). One 500m survey. 53° 18′ 55.4″ N; 15° 46′ 29.1″ E.

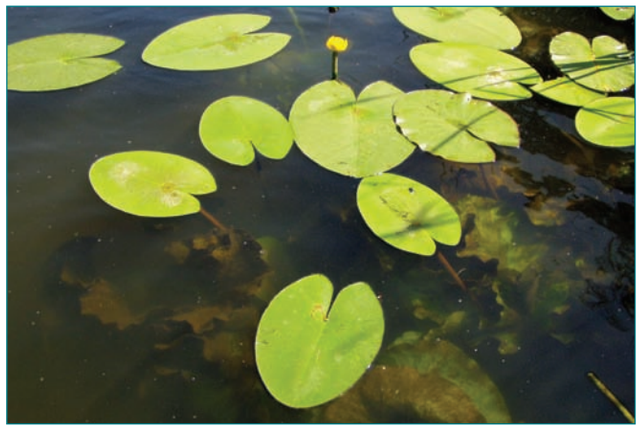
Drawa-1 is located at the downstream end of an artificial channel (the Prostynia) that is 9km long compared with 21km of the meandering old Drawa channel that it bypasses. There is little variety in channel substratum, flow-type or bank vegetation structure. There are virtually no bankside trees, but extensive fringing reeds and fen alongside. Submerged macrophyte growth is abundant, with taxa that prefer sluggish flow and often associated with lakes, dominant. Whorled water-milfoil and yellow water-lily were abundant here, but not elsewhere in our study area. The open banks are dominated by lesser pond-sedge.

Drawa-2. 30 August 2008. HQA = 70; HMS = 0(1). One 500m survey. 53° 15′ 46.9″ N; 15° 46′ 01.8″ E.

Drawa-2 is located at the transition between wetland floodplain and wet woodland. Starting as a meandering channel in a wide floodplain, fringed with extensive reedbeds and fens, it changes at the downstream end where the channel cuts into a moraine terrace and wet woodland replaces wetland. The site is characterised by deep, powerful smooth flow and sand substratum.

Submerged macrophyte growth is abundant in the largely un-shaded channel, with shining pondweed one of the dominant species, although it was not found in the study reach from this point downstream. Free-floating species such as gibbous duckweed *Lemna gibba*, ivy-leaved duckweed *Lemna trisulca* and common hornwort *Ceratophyllum demersum* which favour sluggish flow were present here but largely absent further downstream.

Little variety in habitat; Drawa-1.

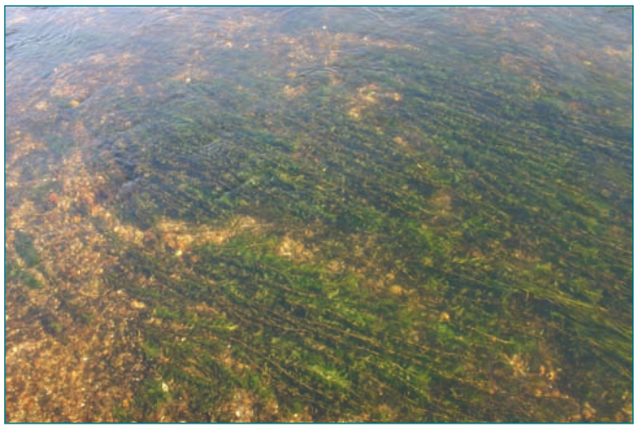


Whorled water-milfoil and yellow water lily - common only in the upper study reach.

Shining pondweed – common in Drawa-2.

A transition between fringing reeds and wet woodland occurs in Drawa-2.

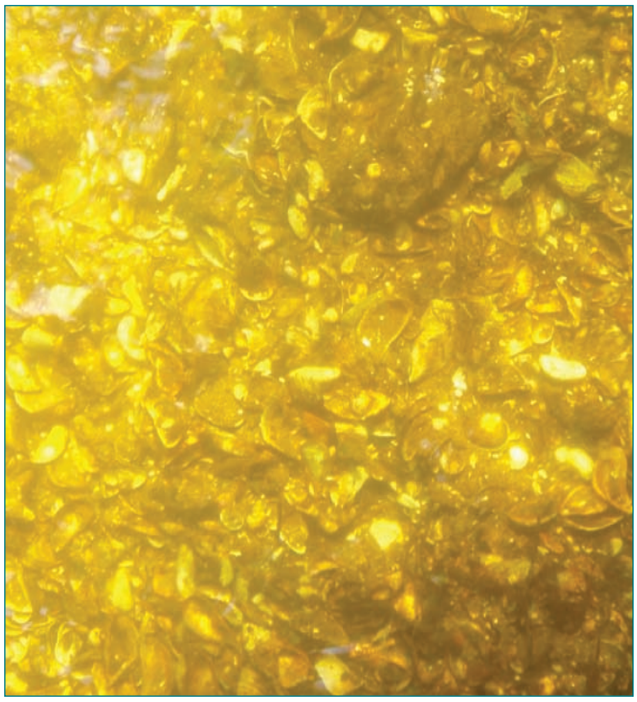
Abundant macrophytes, including arrow-head; Drawa-6.



Submerged macrophytes (*Potamogeton perfoliatus*) on gravel-pebble substratum; Drawa-6.

Drawa-6. 1 September 2008. HQA = 76; HMS = 0(1). One 500m survey. 53° 11′ 18.7″ N, 15° 46′ 31.0″ E.

A partly-shaded, relatively straight and wide section, mid-way between Drawno and Barnimie. Wet woodland occurs on the riparian floodplain along the right bank but there is scrub/grassland on the left bank and there were very few fallen trees in the channel. Parts of the channel were dominated by a deep layer of bivalve shell fragments (*Anodonta* spp.) Macrophyte growth is abundant, with a great variety of physiognomic forms, reflecting the range of water depths, velocity and substratum. Several species that were absent in the upper reach, including algae (e.g. *Hildenbrandia*) and mosses (e.g. *Fontinalis antipyretica*) were recorded here and further downstream. Arrowhead grows as an emergent plant in sluggish backwater areas and has only linear strap-shaped leaves where the current is greater.



Bivalve shells as a substratum; Drawa-6.

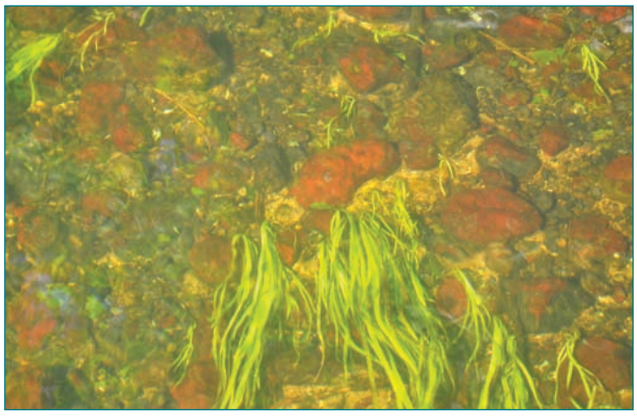
Drawa-7, 8. 1 September 2008. HQA = 74, 81. HMS = 60(2), 10(1). Back-to-back surveys (1 km). 53° 09′ 16.6″ N, 15° 48′ 42.0″ E; 53° 09′ 17.8″ N, 15° 48′ 54.5″ E.

A heavily-shaded, meandering channel, cutting into high moraine deposits and with riparian floodplain dominated by wet woodland. Fallen trees (55 in Drawa-8) are a particular feature, creating localised erosion on the opposite bank, although extensive alder roots stabilise the bank face generally. Macrophyte growth is limited by the extensive shading. However, shade-tolerant taxa thrive, notably *Fontinalis* and *Hildenbrandia* with tree roots and stable, coarse substratum providing the ideal surfaces for attachment respectively.

Fallen trees and wet woodland; Drawa-7.

Sandy moraine terraces are easily eroded and trees undermined; Drawa-7.

Fontinalis is locally common on exposed alder roots and fallen trunks; Drawa-7.



Hildenbrandia on pebble substratum; Drawa-16.

Drawa-3, 4, 5. 31 August 2008. HQA = 65, 76, 73. HMS = 40(2), 0(1), 0(1). Three back-to-back surveys (1.5km). 53° 09′ 01.6″ N, 15° 52′ 09.4″ E; 53° 08′ 56.6″ N, 15° 52′ 17.6″ E; 53° 08′ 52.2″ N, 15° 52′ 13.5″ E.

Here the river is a heavily-shaded meandering channel with sand substratum, cutting through 10m high glacial moraine terraces. Extensive riparian floodplain occurs alongside the channel, which is fixed in position by alder trees and their extensive root network. Wet woodland (alder-sedge) is extensive. There is one 50m section of sheet piling in Drawa-3 which currently serves no obvious purpose. As in Drawa 7-8, macrophyte growth is sparse, restricted by dense shade from bank-side trees. Species that were dominant or co-dominant in several other sites, such as perfoliate pondweed, fennel pondweed and arrowhead, were absent or scarce along this 1.5km of river channel.

Dense shade and riverside alders; Drawa-5.

Sand substratum and eroding cliff; Drawa-4.

Wet woodland with even-aged alders; Drawa-9.

Smooth flow and exposed bankside alder roots; Drawa-9.

Although gravel-pebble dominates the mid-stream substratum, sand characterises the channel margins; Drawa-10.

Drawa-9, 10, 11, 12. 30 August 2009. HQA 71, 63, 73, 74; HMS = 0(1), 0(1), 0(1), 0(1). Four back-to-back surveys (2km). 53° 08.474′ N, 15° 52.414′ E; 53° 08.369′ N, 15° 52.751′ E; 53° 08.231′ N, 15° 52.887′ E; 53° 08.044′ N, 15° 52.788′ E.

The heavily-shaded meandering channel with well-developed floodplain and wet woodland habitat is very similar in character to Drawa 3,4, 5 and 7-8. Rippled flow is predominant at first but replaced by smooth flow in Drawa-12. Gravel-pebble substratum is predominant in mid-channel, but sand dominates towards the edges where back eddies and marginal dead-water are characteristic features. The variety of faster-flowing shallows and deeper sluggish sections, together with alternating open and shaded areas, results in a high diversity of macrophytes. Arrowhead and unbranched bur-reed are co-dominant throughout, but other taxa such as perfoliate pondweed are also locally dominant. In heavily-shaded parts with stable substratum, the algae *Hildenbrandia* occurs alongside river sponge *Ephydatia*. In places where the riparian floodplain is slightly higher and drier, alders are replaced by sedges (*Carex* spp.), and some areas have been cut.

Drawa-13, 14, 15, 16, 17. 31 August 2009. HQA = 78, 81, 72, 76, 73; HMS = 0(1), 0(1), 0(1), 0(1), 0(1). Five back-to-back surveys (2.5km). 53° 07.041′ N, 15° 53.275′ E; 53° 06.884′ N, 15° 53.424′ E; 53° 06.665′N, 15° 53.766′ E; 53° 06.503′ N, 15° 53, 974′ E; 53° 06.484′ N, 15° 54.372′ E.

Another heavily-shaded, meandering 2.5km stretch, with well-developed riparian floodplain and wet woodland habitat, very similar in character to Drawa 3-5, 7-8 and 9-12. River 'bluffs' occur where the channel has cut into the glacial moraine, sometimes resulting in steep unstable sandy slopes up to 30m high. Locally, (especially in Drawa-13 and 15), reed *Phragmites* and sedges *Carex* spp. rather than alder woodland dominate some of the drier riparian floodplain suggesting hay meadow management. Extensive sedge-cutting on the drier riparian floodplain at the downstream end of Drawa-17 and further downstream towards Sitnica marks a significant change in riparian landscape character.

Drawa-16 is noticeably different in character, with faster flow-type (the only three riffles recorded over the 2.5km occur in this site), coarser substrata and abundant liverworts and mosses. There are fewer fallen trees than in Drawa-8 and 9-12.

Abundant macrophytes grow in un-shaded reaches, particularly in Drawa-13 where the channel widens to more than 50m in places. Here the dominant taxa are pondweeds, with specific species thriving best in different conditions. In sluggish water perfoliate pondweed occurs with Loddon pondweed; where flow is faster the hybrid pondweed *Potamogeton x sparganifolius* occurs alongside fennel pondweed. Mosses such as *Platyhypnidium* and the alga *Hildenbrandia* are co-dominant with higher plants where cobbles are common and boulders occur, notably in Drawa-16.

Perfoliate pondweed; Drawa-11.

Abundant linear-leaved arrowhead and unbranched bur-reed; Drawa-12.

Sandy river 'bluffs' reach 30m high: Drawa-15.

Heavily-shaded channel; Drawa-15.

Some riparian floodplain is still cropped for sedge; Drawa-13.

Faster flow and cobble substratum; Drawa-16.

Ploc-1 and 2. 1 September 2009. HQA = 68, 91; HMS = 0(1), 0(1). Two back-to-back surveys (1 km). 53° 03.369'N, 15° 58.635' E; 53° 03.372' N, 15° 58.397' E.

A small, deep, sand-bed river with extravagant meanders, flowing through extensive *Phragmites* reedbeds and wet woodland in 50-100m wide valley floor. Water flow is powerfully smooth (i.e. with upwellings) and in Ploc-1 an ox-bow channel has been recently created. Unlike the relatively featureless channel structure of the Drawa, there are mature islands, distinct pools, point bars and backwaters. Half-way along Ploc-2 there is a narrow cut-through channel which has been formed at right angles to the old channel which we continued along to survey as the second half of the site. Fallen trees are more prominent in Ploc-2 (17 compared with 3 in Ploc-1, excluding the ox-bow) and floodplain terraces that are so prominent in Drawa 3-17 are only obvious for a short distance in Ploc-1. The macrophyte flora was similar to parts of the Drawa, but not identical. Algae were not recorded on the predominantly sandy substratum, and most aquatic bryophytes were present only on the submerged tree roots. Hornwort, spiked water-milfoil and yellow water-lily, found in Drawa reach 1 but not in reach 2, were found in the Płociczna. Similarly, Canadian waterweed, curled pondweed and perfoliate pondweed, all common in the lower Drawa, were also not found in the Płociczna. In contrast, small pondweed *Potamogeton berchtoldii* was present in the Płociczna but not found in the Drawa

There is a short section of very old dilapidated log pile revetment of the left bank in Ploc-1, presumably an historical attempt to protect the forestry track that briefly skirts the river channel and was not considered to be a functioning bank reinforcement for HMS purposes.

Wet woodland was extensive on the floodplains of both the Drawa and the Płociczna.

Sand substratum and fallen trees; Ploc-2.

Sandy mid-channel bars add to habitat diversity; Ploc-2.

Cut-through channel; Ploc-2.

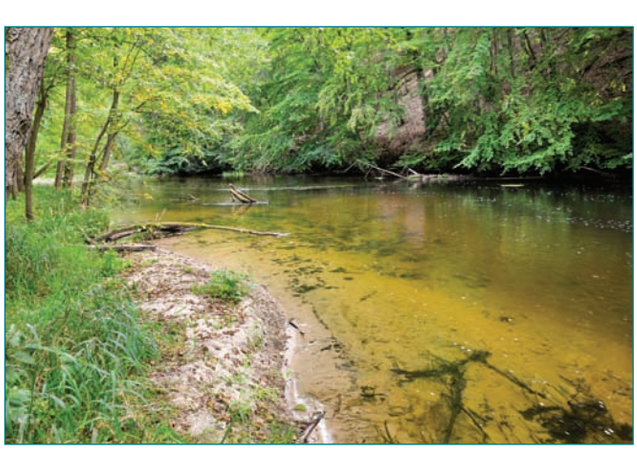
A mixture of wet woodland and reed-swamp typifies Ploc-1 and 2.

APPENDIX 2: Recommendations for improving the RHS manual.

The following recommendations and suggestions are additional to those made in the reports for Slovenia, Bavaria and Tyrolean Alps, the Cévennes, Poland, Picos de Europa and southern Portugal[7, 15-19]. **A generic recommendation** is that all these are consolidated into one document that is made available so that RHS manuals can be updated and relevant recommendations adopted for specific hydro-ecological regions and individual countries, as appropriate.

Additional channel substrata: *recommendation* that where a substratum is recorded as additional in Section E (i.e. it is not predominant in any spot-check), but occurs extensively (33% or more of the channel-bed area in the site), it should be circled (e.g. SA).

Bankside tree roots: *reaffirm* that tree roots on the bank-face should be recorded as 'simple' vegetation structure (Section E) because of the woody nature and erosion-resistant character *(see recommendation 18 in the Picos de Europa report[18])*.



Sand can be extensively sub-dominant and needs to be recorded as such when an additional substratum.

Tree roots represent simple bankface vegetation structure.

Counting fallen trees would help to determine 'extensive' occurrence in a site.

Underwater tree-roots are already specifically recorded. There is a case for recording extensive underwater roots and stolons of reeds and sedges as well.

Fallen trees: *recommendation* that these should be counted and a simple, scale-related rule about numbers that represent 'extensive' within the site is agreed. For this report (see Annex E), 10 or more fallen trees were used to determine 'extensive' occurrence in Section J and qualify for an HQA score of 5. A similar approach needs to be developed for 'overhanging boughs'.

Gallery/riparian woodland: *suggestion* that 'gallery woodland' is considered a special feature in Section M, depending on bio-geographical region and rarity.

Riparian floodplain: *recommendation* that this should be recorded as an additional natural bank profile in Section I, to differentiate it from 'natural berm'. Wet woodland would be a characteristic diagnostic attribute. *(See recommendation 13 regarding better terminology for natural berm/terrace/riparian floodplain in the Picos de Europa report 18).*

Semi-natural land-use: *suggestion* that the HQA 'bonus' score of 7 for a bank with semi-natural land-use is based on local knowledge, provided a clear explanation is provided and cross-referenced to Section H in notes for the site. For this report we used local knowledge and a generous interpretation of re-naturalising woodland and meadow for this purpose (see Figures 9 and 10).

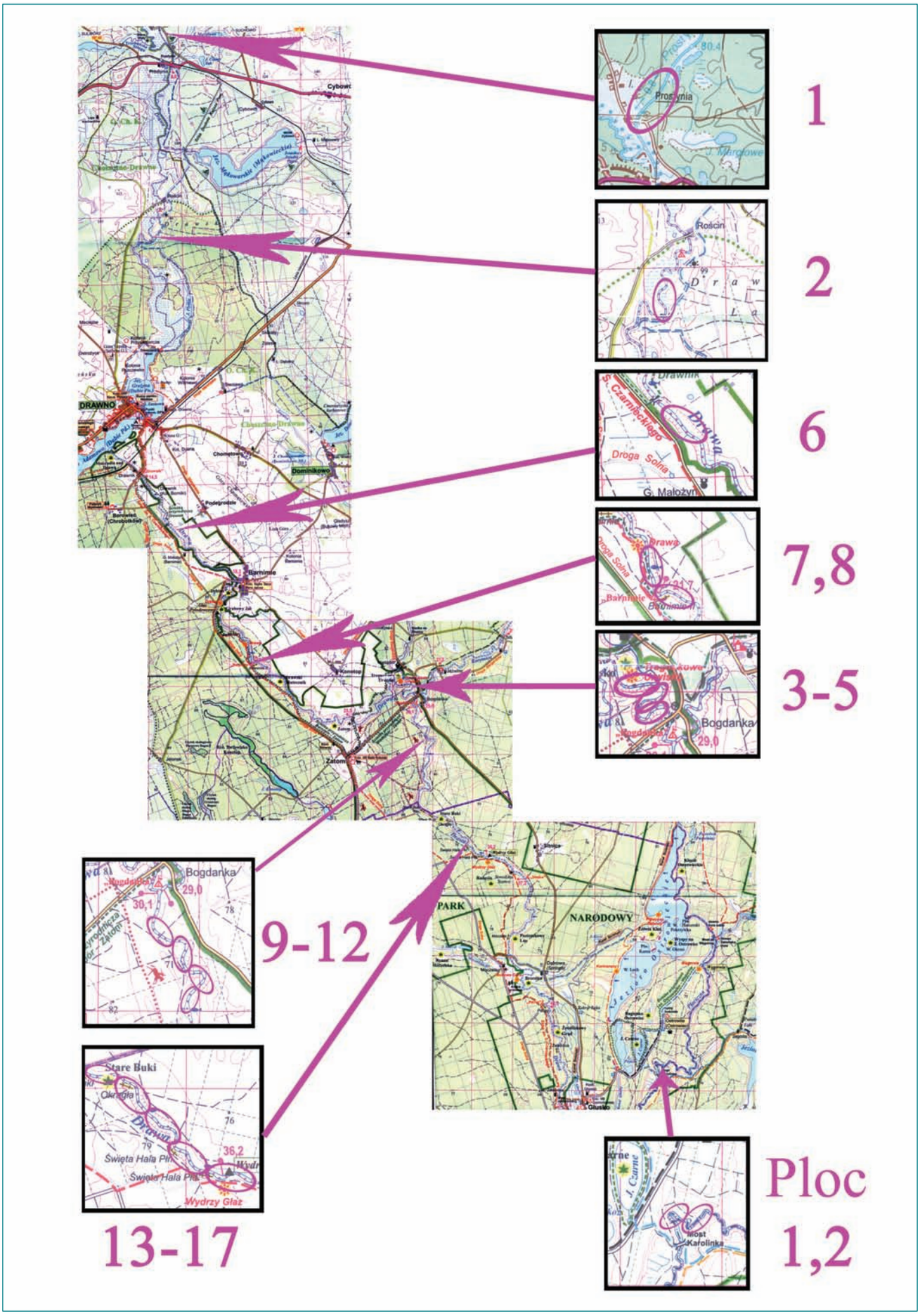
Underwater (tree) roots: *recommendation* that a literature search is carried out to establish whether exposed submerged roots and stolons associated with extensive fringing reedbeds (reeds and sedges) provides equivalent habitat as underwater tree roots of alder and willow. If so, consideration should be given to scoring extensive submerged reed roots/stolons as a special feature in Section M.

Wet woodland: *reaffirm* recommendation 14 in the Picos de Europa[18] report that wet woodland should be recorded as a land-use category at spot-checks.

Natural bank profile merging with wet woodland (not natural berm).

Areas of lightly managed riparian wetland occupying what would naturally be wet woodland can be considered as 'semi-natural' land-use if local knowledge is applied logically.

ANNEX A: Location maps for the Drawa and Płociczna sites.



ANNEX B: Characteristics of the Drawa and Płociczna sites, in downstream sequence. Superscripts refer to site number.

	Drawa-1	Drawa-2	Drawa-6	Drawa-7/8	Drawa-3/4/5	Drawa-9/10/11/12	Drawa-13/14/15/16/17	Płoc-1/2
Predominant valley form	Floodplain	Floodplain	Concave	Asymmetrical	Asymmetrical	Asymmetrical	Asymmetrical	Floodplain
Surface geology	Riverine silts and sands	Riverine silts and sands	Riverine silts and sands	Riverine silts and sands	Riverine silts and sands	Riverine silts, sands and gravels	Riverine silts, sands and gravels	Riverine silts and sands
Location (latitude/longitude)	53° 18′ 55.4′ N 15° 46′ 29.1′ E	53° 15′ 46.9′ N 15° 46′ 01.8′ E	53° 11′ 18.7′ N 15° 46′ 31.0′ E	53° 09′ 19.5′ N 15° 48′ 38.2′ E	53° 08′ 56.6′ N 15° 52′ 17.6′ E	53° 08.260′ N 15° 52.521′ E	53° 06.665′ N 15° 53.766′ E	53° 03.353′ N 15° 58.544′ E
Distance from source*	114.0km	124.0km	136.0km	142.0-142.5km	149.5-150.5km	152.0-153.5km	155.8-157.8km	40-41km
Altitude	80.0m	78.0m	74.0m	68.0-68.5m	61.0-62.0m	58.5-60.0m	54.0-56.0m	43.5-44.0m
Channel slope	0.45m/km	0.31m/km	0.89m/km	0.89m/km	0.89m/km	0.89m/km	0.89m/km	0.55m/km
Bankfull width (m)	25.0	22.0	42.0	23.0[7] 18.0[8]	16.5[3,5] 28.0[4]	22.0[9] 28.0[10], 21.0[11] 22.0[12]	23.0[13] 30.0[14], 29.0[15] 26[16,17]	8.0[1], 9.0[2]
Predominant flow-types†	Smooth	Smooth	Smooth	Smooth-rippled[7,8]	Smooth-rippled[3,5] Rippled-smooth[4]	Rippled[9-11] Smooth-rippled[12]	Smooth[13,15,17] Smooth-rippled[14] Smooth-rippled-unbroken wave[16]	Smooth
Predominant substratum†	Sand	Sand	Gravel/pebble-sand	Gravel/pebble-sand[7,8]	Sand-gravel/pebble[3] Sand[4,5]	Gravel/pebble-sand[9-12]	Gravel/pebble-sand[13,14,15,17] Cobble-pebble-sand[16]	Sand
HQA score	34	70	76	74[7] 81[8]	65[3] 67[4] 73[5]	71[9] 63[10] 73[11] 74[12]	78[13] 81[14] 72[15] 76[16] 73[17]	68[1] 91[2]
HMS and class	1340 (4)	0(1)	0(1)	60(2)[7] 0(1)[8]	40(2)[3] 0(1)[4,5]	0(1)[9-12]	0(1)[13-17]	0(1)[1,2]
MTR score	35	34	34	38[7] 36[8]	36[3] 32[4] 34[5]	34[9] 38[10] 37[11] 35[12]	34[13] 35[14] 38[15] 39[16] 34[17]	32[1] 34[2]
MIR score	39	32	37	44[7] 42[8]	44[3] 37[4] 43[5]	40[9] 45[10] 39[11] 39[12]	40[13] 40[14] 41[15] 42[16] 41[17]	37[1] 37[2]

Height of source: Drawa 160m; Płociczna 120m. * calculated as main channel, except for Drawa-1 (on the Prostynia). † recorded at 3 or more spot-checks.

ANNEX C: HQA sub-scores and total scores for the Drawa and Płociczna sites, in downstream sequence.

River	Drawa																	Płociczna	
Site number	1	2	6	7	8	3	4	5	9	10	11	12	13	14	15	16	17	1	2
Flow types	4	5	5	8	9	8	7	10	6	7	7	6	6	7	6	9	6	6	7
Channel substrata	3	3	5	7	7	6	5	5	6	7	7	8	6	6	7	9	9	4	4
Channel features	0	0	2	2	2	1	1	1	0	0	1	2	0	1	1	2	1	3	7
Bank features	0	2	6	7	6	3	6	7	2	4	2	2	4	4	3	3	3	5	8
Bank vegetation structure	1	10	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	9	12
In-stream vegetation	15	16	15	6	6	4	5	4	8	10	8	7	16	14	9	9	8	12	12
Land-use‡	4	14	9	14	14	14	14	14	14	1 4	14	14	14	14	14	14	11	11	14
Trees and associated features	1	9	12	12	18	12	12	16	16	12	16	16	12	16	12	12	16	8	16
Special features‡	6	11	10	6	7	5	5	4	7	7	6	7	8	7	8	6	7	10	11
Total HQA score	34	70	76	74	81	65	67	73	71	63	73	74	78	81	72	76	73	68	91

‡ assumptions made regarding near-natural land-use and special features (see text).

ANNEX D: HMS and habitat modification class for the Drawa and Płociczna sites, in downstream sequence.

River	Drawa																	Płociczna	
Site number	1	2	6	7	8	3	4	5	9	10	11	12	13	14	15	16	17	1	2
HMS score	1340	0	0	60	10	40	0	0	0	0	0	0	0	0	0	0	0	0	0
Habitat modification class	4*	1	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1

* widened by-pass channel, with major bridge.

ANNEX E: Fallen tree count at sites in downstream sequence.

River	Drawa																	Płociczna	
Site number	1*	2*	6*	7*	8*	3*	4*	5*	9	10	11	12	13	14	15	16	17	1	2
Across the whole channel	0	2	5	3	14	1	0	8	2	1	1	0	0	1	0	0	1	1	4
Across part of the channel	0	0	0	27	41	11	19	30	13	8	18	10	8	17	4	7	10	2	13
Total	0	2	5	30	55	12	19	38	15	9	19	10	8	18	4	7	11	3	17

* estimated from photographs.

ANNEX F: Water chemistry results.

Water samples were collected in full, sealed containers for laboratory analysis, undertake at 16-18°C within 20 days with calibrated conductivity and calibrated pH meter. Duplicate semi-quantitative titration undertaken for calcium, chloride and carbonate hardness. Total hardness determined on site using test papers:low hardness = 70-125 mgl^{-1}.

Site number	pH	Conductivity (µ Scm^{-1})	Total hardness (Ca and Mg as carbonate)	Calcium (mgl^{-1})	Carbonate CaCO3 (mgl^{-1})	Nitrate	Chloride
Drawa-1	7.31	325	Low	63	71	n/d	n/d
Drawa-6	7.33	333	Low	62	77	n/d	n/d
Drawa-4	7.33	334	Low	64	72	n/d	n/d
Drawa-11	7.25	384	Low	62	83	Trace	5-12
Drawa-16	7.24	390	Low	62	87	Trace	15-18
Ploc-1	7.41	354	Low	56	81	Trace	15-18

Drawa-1, 6 and 4 samples taken on 30 August – 1 September 2008. Drawa-11, 16 and Ploc-1 samples taken on 30 August – 1 September 2009.
n/d: not determined.

ANNEX I: Descriptions of CEN scoring attributes.

1. Channel geometry

1a: Planform (reach-based change in sinuosity)

1b: Channel section (changes to long-section and cross-section)

2. Substrata

2a: Extent of artificial material (e.g. concrete, rubble, gabion baskets)

2b: *'Natural' substrate mix or character altered*

3a. *Aquatic vegetation management*

3b. *Extent of woody debris if expected*

4. ***Erosion/deposition character***
Presence of in-channel features such as gravel bars, etc.

5. Flow

5a: Impacts of artificial in-channel structures within the reach

5b: Effects of catchment-wide modifications to natural flow character (upstream of the reach evaluated) (e.g. by hydropower dams, abstractions, etc.)

5c: Effects of daily flow alteration (e.g. hydro-peaking)

6. Longitudinal continuity as affected by artificial structures - Reach-based and local impacts of sluices and weirs on ability of biota (e.g. migratory fish) to travel through reach, and sediment to be transported naturally.

7. Bank structure and modifications - Extent of reach affected by artificial bank material (% of bank length)

7. Vegetation type/structure on banks and adjacent land - Land cover in riparian zone (% of bank length)

8. Adjacent land-use and associated features - Land cover beyond the riparian zone

10. Channel-floodplain interactions

10a. Degree of lateral connectivity of river and floodplain (Extent of floodplain not allowed to flood regularly due to engineering - based on hydromorphological surveys)

10b. Degree of lateral movement of river channel (Capacity of river to migrate naturally within its floodplain)

Attributes shaded can only be assessed qualitatively.

ANNEX J: CEN scores for sites and reaches on the Drawa and Płociczna, with an overall assessment for the Itchen.

	1	2	UR	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	LR	PL1	PL2	PLR	Itchen
1a	5	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1*	1	1	1	5
1b	5	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1*	1	1	1	5
2a	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1*	1	1	1	1
2b	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1*	1	1	1	1
3a	!		3							!									1*		!	1	5
3b	!		4							!									1*		!	1	5
4	!		3							!									1*		!	1	3
5a	!		1							!									1*		!	1	5
5b	!		3							!									1*		!	1	3
5c	!		3							!									1*		!	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1*	1	1	1	3
7	3	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1*	1	1	1	3
8	3/4	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1*	1	1	1*	3
9	2/3	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1*	1	1	1*	3
10a	5	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1*	1	1	1*	3
10b	5	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1*	1	1	1*	5

Overall reach assessments

Qualitative assessments only

! Attributes only assessed at 'reach' scale, not for individual RHS sites. UR = upper reach; LR = lower reach. PLR = Płociczna reach (1km).

Annex G: MTR survey results.

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

Site Names			1		2		6A		6B		7		8		3		4		5		9		10		11		12		13		14		15		16		17		P1		P2	
Check-list of taxa and Species Trophic Rank		**STR**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**	**SCV**	**CVS**
Hildenbrandia rivularis	Red encrusting alga	6					1	6	1	6	2	12	2	12	1	6		0		0		0	1	6	2	12	1	6		0	2	12	5	30	6	36	1	6		0		0
Cladophora glomerata agg.	Blanketweed	1		0	2	2	1	1	1	1	1	1	1	1		0		0		0		0		0	1	1	1	1	1	1	1	1	2	2	1	1	1	1		0		0
Vaucheria sp.	Mole-pelt alga	1		0				0		0		0		0		0	1	1	1	1		0		0		0	1	1	1	1	1	1	1	1	1	1	1	1		0		0
Pellia endiviifolia	Liverwort	6				0		0		0	1	6	1	6		0		0		0	1	6	1	6	1	6	1	6	1	6	1	6	2	12	1	6	1	6		0		0
Amblystegium tenax	Moss	5		0	1	5	1	5	1	5	1	5	1	5	1	5	1	5		0		0		0	1	5	1	5	1	5	1	5	1	5	5	25	1	5		0		0
Brachythecium rutabulum	Moss	3						0		0						0		0		0		0		0		0		0		0		0		0	1	3	1	3	1	3
Bryum pseudotriquetrum	Moss	9						0		0						0		0		0		0		0	1	9		0		0		0	1	9	1	9		0		0	1	9
Fontinalis antipyretica	Willow-moss	5		0		0	1	5	1	5	2	10	2	10	2	10	2	10	2	10	1	5	2	10	1	5	1	5	2	10	2	10	4	20	5	25	1	5	1	5	1	5
Leptodictyum riparium	moss	1		0			1	1	1	1	1	1	1	1	1	1	1	1		0	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1
Platyhypnidium riparioides	Moss	5																		0		0	1	5	1	5		0		0		0	1	5	5	25	1	5		0		0
Equisetum fluviatile	Water Horsetail	5		0		0		0	1	5		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0
Berula erecta	Lesser Water-parsnip	5		0	2	10		0		0		0		0		0		0		0	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	4	20	4	20
Callitriche obtusangula	Blunt-fruited Water-starwort																					0		0		0		0	1	0		0	1	0		0		0		0		0
Ceratophyllum demersum	Common Hornwort	3	3	9	5	15	2	6	1	3		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0
Myriophyllum spicatum	Spiked Water-milfoil	3	1	3		0	4	12		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	2	6	3	9
Nuphar lutea	Yellow Water-lily	3	6	18	3	9	2	6	1	3		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0
Nymphaea alba	White Water-lily	6	1	6		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0
Persicaria amphibia	Amphibious bistort	4	1	4		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0
Ranunculus circinatus	Fan-leaved Water-crowfoot	4		0		0		0		0		0		0		0		0		0		0		0		0	1	4	2	8		0		0		0	1	4	1	4		
Ranunculus fluitans	River Water-crowfoot	5		0		0		0		0	3	15	2	10		0	1	5		0		0	2	10		0	2	10	2	10		0		0		0		0		0		0
Ranunculus sceleratus	Celery-leaved Buttercup	2		0		0		0	1	2	1	2	1	2		0	1	2	1	2		0		0		0		0		0		0	1	2		0		0		0		0
Rorippa amphibia	Great Yellow-cress	3	1	3	2	6	2	6	1	3	1	3	1	3		0		0		0		0		0		0		0		0		0		0		0	2	6	1	3		
Rorippa nasturtium-aquaticum	Water-cress	5		0	2	10		0		0		0		0		0		0		0		0		0		0		0		0	1	5	1	5		0		0		0		0
Rumex hydrolapathum	Great Water-dock	3	2	6	1	3	1	3	1	3		0	1	3		0		0		0		0		0		0	1	3	1	3		0	2	6		0	1	3	1	3		
Veronica anagallis/cat indet.	Blue Water-speedwell	4		0		0	1	4		0	1	4	1	4		0	1	4	1	4		0	1	4	1	4		0	1	4	2	8	1	4	2	8	1	4	2	8	3	12
Acorus calamus	Sweet-flag	2		0	2	4		0	1	2		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0
Alisma plantago-aquatica	Common Water-plantain	3		0		0		0	1	3		0		0		0		0	1	3		0		0		0		0		0		0		0		0	1	3	1	3		
Butomus umbellatus	Flowering Rush	5	4	20	1	5	2	10	3	15		0		0		0		0	1	5	1	5	1	5		0		0	3	15	3	15	4	20	3	15	2	10		0		0
Carex acuta	Slender-tufted Sedge	5		0	2	10		0	1	5	1	5	1	5		0	1	5		0		0		0		0		0		0		0		0		0		0		0		0
Carex acutiformis	Lesser Pond-sedge	3	5	15	3	9	2	6	3	9	2	6	2	6	1	3	1	3	1	3		0	1	3	1	3	1	3	3	9	3	9	2	6	1	3	3	9	2	6	3	9
Elodea canadensis	Canadian pondweed	5	1	5		0		0		0		0		0		0		0		0		0		0		0		0	4	20	6	30	5	25	4	20	4	20		0		0
Eleocharis palustris	Common Spike-rush	5		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	1	5
Glyceria maxima	Reed Sweet-grass	3	1	3	1	3	2	6	3	9	1	3		0		0	1	3		0		0	1	3		0	1	3	3	9	2	6	1	3	1	3	1	3		0	2	6
Hydrocharis morsus-ranae	Frogbit	6	2	12	2	12	2	12	2	12		0		0		0		0		0		0		0		0	2	12	1	6	1	6		0		0	2	12	1	6		
Iris pseudacorus	Flag-iris	5		0	1	5		0	1	5	1	5	1	5		0		0	1	5		0		0		0	1	5		0		0	1	5		0	2	10	1	5		0
Lemna gibba	Gibbous duckweed	2		0	1	2		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0
Lemna minor	Common Duckweed	4	1	4	3	12	1	4	2	8	1	4	1	4		0	2	8		0	1	4	1	4	1	4	1	4	2	8	3	12	3	12	1	4	1	4	2	8	2	8
Lemna trisulca	Ivy-leaved Duckweed	4		0	1	4		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0
Phragmites australis	Common Reed	4	1	4	5	20	3	12	2	8		0		0		0	1	4		0	1	4	1	4		0	1	4	3	12	1	4		0		0		0	3	12	5	20
Potamogeton berchtoldii	Small pondweed	4										0		0		0				0		0		0		0		0		0		0		0		0		0		0	2	8
Potamogeton crispus	Curled Pondweed	3		0		0	4	12		0		0	2	6	1	3		0	1	3	1	3	1	3	1	3	1	3	1	3	2	6	1	3	2	6	1	3		0		0
Potamogeton natans	Broad-leaved Pondweed	5		0	5	25		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0
Potamogeton pectinatus	Fennel Pondweed	1		0	4	4	6	6	1	1		0	1	1		0	1	1		0	2	2	1	1	2	2	1	1	7	7	8	8	4	4	6	6	5	5	6	6	6	6
Potamogeton perfoliatus	Perfoliate Pondweed	4	5	20		0	6	24	3	12		0	2	8		0		0		0	3	12	3	12	7	28	5	20	4	16	7	28	5	20	6	24	4	16		0		0
Sagittaria sagittifolia	Arrowhead	3	4	12	7	21	4	12	7	21	2	6	3	9	1	3	2	6	2	6		0		0		0	3	9	2	6	4	12	5	15	5	15	1	3	1	3		
Sparganium emersum	Un-branched Bur-reed	3	8	24	2	6	6	18	5	15	5	15	7	21	4	12	4	12	4	12	7	21	5	15	7	21	7	21	6	18	3	9	6	18	6	18	5	15	6	18	6	18
Sparganium erectum	Branched Bur-reed	3		0	1	3	3	9	2	6		0		0								0		0		0		0	2	6	1	3	1	3	1	3	2	6	1	3	1	3
Spirodella polyrhiza	Great Duckweed	2	2	4	3	6	1	2	1	2	1	2	1	2		0	2	4		0		0		0	1	2		0	1	2	2	4	2	4	1	2	1	2	2	4	1	2
Typha latifolia	Bulrush	2		0	1	2		0	2	4		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	1	2
Sub-score for calculating MTR Scores			49	172	63	213	59	188	51	174	28	105	35	124	12	43	23	74	16	54	20	68	25	97	31	116	27	94	58	196	61	216	63	241	70	274	47	160	42	136	50	168
MTR Scores			**35**		**34**		**32**		**34**		**38**		**36**		**36**		**32**		**34**		**34**		**38**		**37**		**35**		**34**		**35**		**38**		**39**		**34**		**32**		**34**	

ANNEX H: JNCC macrophyte survey results.

Site Names		A	1	B	C	2	6	7	8	3	4	5	9	10	11	12	13	14	15	16	17	ploc1	ploc2
	Blue-green algal scum	1100	1100				1100	1100	2100		1100	1100											
Hildenbrandia rivularis	Red alga						1100	2200	3200	1100			2200	2200	1100	2200	2200	2200	2200	3300	2200		
Cladophora glomerata	Blanket Weed				1100	1100	1100	1100	1100				1100	1100	1100	1100	1100	2200	1100	1100	1100		
Vaucheria sp	Mole-pelt alga										1100	1100		1100	1100	1100	1100	1100	1100	1100	1100		
Dermatocarpon fluviatile	Foliose lichen																						
Conocephalum conicum	Liverwort								11														
Marchantia polymorpha	Liverwort														1100								
Pellia endiviifolia	Liverwort							1111	1121	11	1111	11	1122	1111	1111	1122	1111	1111	1122	1122	1111	11	1111
Brachythecium rivulare	Moss												11	11	11								
Brachythecium rutabulum	Moss	1111											1111	11		1111	1122	1122	1122	1111	1111	1122	1122
Bryum pseudotriquetrum	Moss												1122	11	1111	1111	1111	1111	1111	1111	1111	1111	
Cratoneuron filicinum	Moss												1111				1111	1111	1111	1111	1111	11	1111
Fissidens sp.	Moss							11	11														
Fontinalis antipyretica	Willow-moss						1111	2222	3222	2122	2222	1122	2211	2222	1122	2222	2211	2222	2222	3322	2222	1122	1122
Hygroamblystegium tenax	Moss					1100	1111	1111	1111	1111	1111	11	1122	1111	1111	1111	1111	1111	1122	3311	2211	1111	1111
Leptodictyum riparium	moss						1111	1111	2111	1111	1111		1111	1111	1111	1111	1111	1111	2211	1111	1111	1111	1111
Platyhypnidium riparioides	moss												1100	1111	1100	1100	1111	1111	1111	3311	2200		
Equisetum fluviatile	Water horsetail						1111			11												1111	1111
	Ferns					11	11	11	11	21	11	11	11	11	11	11	11	11	11	11	11	11	22
Apium nodiflorum?	Fool's Water-cress								1111				1111	11									
Berula erecta	Lesser water-parsnip			1100	1111	1111	1111			1111			2222	1111	1111	1111	1111	1111	1111	1111	1111	2222	2233
Bidens cernua	Nodding bur-marigold						11	11	11								1111						
Bidens tripartita	Tripartite bur-marigold									11		11		11			1111				11		
Callitriche sp	Starwort indet.							1111	1100	1100	1111			1111	1111	1100							
Callitriche obtusangula	Blunt-fruited w-starwort												1111			1100	1100		1100				
Callitriche hermaphroditica	Pedunculate water-starwort																			1100		1100	
Caltha palustris	Kingcup						11			11													
Cardamine amara	Large bitter-cress													1111	1111		1111	1111	1111				
Ceratophyllum demersum	Common hornwort	2300	2200	1100	3300	2200	1100																1100
Cicuta virosa	Cowbane		1111	1111	1111	1111	1111	1111	1111				1111										
Epilobium hirsutum	Great willow-herb	11	11	11	11	11	22	11															
Eupatorium cannibinum	Hemp-agrimony	12	11	11		11	22	11	11			11	1111	11		11	11	11	11	11	11	1122	1122
Filipendula ulmaria	Meadowsweet						11	11	11	11	11		11	11	11	11	11	11	11	11	11		
Galium palustre	Marsh bedstraw	1111	1111	11		1100																	
Lysimachia vulgaris	Yellow loosestrife						1111	1111	1111	1111	1111	1111		11				11	11	11	11		
Lythrum salicaria	Purple loosestrife	1111	1111	11	11	11	1111	1111	1111	11	1111	1111		11			1111	11	11	11	11	1111	1111
Mentha aquatica	Water-mint					1111	1122	1122	1111	1111	1122	1111		1111	1111	1111	1111	1111	1111	1111	1111	1122	2211
Myosotis scorpioides	Water forget-me-not			11	2222	1111	1111	1111	1111	1111	1111	1111	11	1111	1111	1111	1111	1111	1111	1111	1111	1111	1111
Myosoton aquaticum	Water chickweed							11	11	22	22	1122	11		11				11	11	11		
Myriophyllum spicatum	Spiked water-milfoil	1100	1100	1100	1100		2200															1100	2200
Myriophyllum verticillatum	Whorled water-milfoil	2200	2200	2200	2200	2200	1100	1100	1100														
Nuphar lutea	Yellow water-lily	2200	3300	2200	2200	2200	1100	1100														1100	

Site Names		A	1	B	C	2	6	7	8	3	4	5	9	10	11	12	13	14	15	16	17	ploc1	ploc2
Nymphaea alba	White water-lily	1100	1100	1100	1100																		
Persicaria amphibia	Amphibious bistort		1111	2211	1111	1111							1111	11	11	11							
Persicaria hydropiper	Water-pepper			1111	1111	1111	11	1111	1111	22	11	11			11		11	11	11		11		
Ranunculus circinatus	Fan-leaved water-crowfoot																1100	1100	1100			1100	2200
Ranunculus fluitans?	River Water-crowfoot							2200	2100		1100	1100	1100	1100			1100	1100	1100	1100	2200		
Ranunculus sceleratus	Celery-leaved crowfoot						1111	1111	1111		1111	1111			1111						1111		
Rorippa amphibia	Great yellow-cress	1111	1111	2211	2211	2211	1111	1111	1111					11								1111	2211
Rorippa nasturtium-aquaticum	Water-cress			2200	2211	1111												1111	1100		1111		
Rorippa palustris	Marsh yellow-cress										11												
Rumex hydrolapathum	Great water-dock	1111	2211	1111	1111	1111	1100	11								1111	1111		1111		1111	1111	1111
Scrophularia auriculata	Water figwort	1100	1100	1100	1100	1100	1111	11	11	11	11	11	11	1111	11	11	11	11	11	11	11	11	11
Scutellaria galericulata	Skullcap						1122	1122	1121		1111	1122	11	1122	1111	1111	1111	1111	1111		1111	11	11
Sium latifolia	Greater water-parsnip			1111	1111	1111				11													
Solanum dulcamara	Bittersweet		1111		1111	1122	1111	1111	1111	11	1111	1111	1122	1122	1111	1111	1111	1111	1111	1111	1111	1111	1111
Stachys palustris	Marsh woundwort				1122	1111	1111	1121	1121		1111	1111	11	1122	1111	1111	1111	1111	1111	1111			
Veronica anagallis-aquatica/catenata	Water-speedwell						1100	1111	1111		1111	1111		1111	1111	1111	1111	2211	2211	1111	1111	1122	1122
Veronica beccabunga	Brooklime					1111	1111	1111	1111	11	1111	1111	1122		1122	1111	1111	1111	1111	1111	1111	1122	1122
Alnus	Alder	1111		1111	1111	1122	2233	2233	2233	2233	2233	2233	2233	2233	1133	1133	1133	1133	1133	1133	1133	1133	1133
Salix spp.	Willow	11	11	1111	1111	1111	11	11	11	11													
	Trees						11	11	11	11	11	11	1111	1111	11	11	1111	1111	1122	1122	1122		1111
	other dicotyledon species	1111	1111	1111	1111	1111	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Acorus calamus	Sweet flag			1111	1111	2211	1111										1111						
Alisma plantago-aquatica	Common water-plantain						1100				1111											1111	1111
Butomus umbellatus	Flowering-rush	1100	2211	2200	2200	2200	2200				1100		1100	1100		1100	2200	2200	2200	2200	1100		
Carex acuta	Slender tufted-sedge	1100				1111	1111	11	1111	11	1111	11											
Carex acutiformis	Lesser pond-sedge	2233	2233	1122	1133	2233	1122	1122	1121	1122	1122	1121	1122	1122	1133	1133	2233	2233	2233	1122	1122	2233	2233
Carex hirta	Hairy-sedge	1111	1111	1111																			
Carex paniculata	Great tussock-sedge	1100								11							1111		1111			1111	1111
Carex remota	Remote-sedge						11	11	11	11		11	11	11	11	11	11	11	11	11	11	11	11
Deschampsia cespitosa	Cut-grass	11				11	11	11	11	11	11	11	11	11	11		11	11	11	11	11	11	11
Eleocharis palustris	Common spike-rush																						1111
Elodea canadensis	Canadian waterweed		1100	1100										2200	1100	2200	2200	2200	3300	2200	2200		
Glyceria fluitans	Floating sweet-grass	1111	1111				1111	1111	1111														
Glyceria maxima	Reed sweet-grass	1122	1111	2222	2211	2211	1122	1111			1111			1111		1111	2222	1122	2233	1122	1122	1111	2222
Glyceria sp(p.)	Small sweet-grass indet.																1111	1111	1111				1111
Hydrocharis morsus-ranae	Frogbit	2200	2200	2200	2200	2200	2200		1100								1100	1100	1100			1100	1100
Iris pseudacorus	Yellow iris				1111	1111	1111	1111	1111	11	11	1111	11	11	11	1111	1111	1111	1111	1111	1111	1111	1111
Juncus acutiflorus	Sharp-flowered rush	1111	1111	1111							11												
Juncus effusus	Soft rush		1100				11			11	11	11	11	11	11	11	11	11	11	11	11	11	11
Lemna gibba	Gibbous duckweed				1100	2200																	
Lemna minor	Common duckweed	2200	1100	1100	2200	1100	1100	1100	1100		2100		1100	2200	1100	1100	1100	2200	2200	1100	1100	1100	1100
Lemna trisulca	Ivy-leaved duckweed			1100	2200	1100																	
Phalaris arundinacea	Reed canary-grass	1111	1111	1111	1111	1111	1111	1111	1111	22	1111	1111	1111	1111			1111	1111	1111	1111	1111	1111	1111
Phragmites australis	Common reed	2233	2222	2233	2233	2233	2223			11	1111	1111	1133	1133	1133	1133	2233	1122	1111			2233	2233

ANNEX H: JNCC macrophyte survey results continued.

Site Names		A	1	B	C	2	6	7	8	3	4	5	9	10	11	12	13	14	15	16	17	ploc1	ploc2
Potamogeton berchtoldii	Small pondweed																					1100	2200
Potamogeton compressus	Grass-wrack pondweed		1100	1100																			
Potamogeton crispus	Curled pondweed						2200	1100	1100	1100		1100	1100	1100	1100	2200	1100	2200	1100		1100		
Potamogeton lucens	Shining pondweed				1100	3300																	
Potamogeton natans	Broad-leaved pondweed			2200	2200	2200																	
Potamogeton nodosus	Loddon Pondweed															1100	1100	2200	1100				
Potamogeton pectinatus	Fennel Pondweed		1100	1100	2200	2200	2200		1100		1100		2200	1100	1100	2200	3300	3300	3300	3300	2200	3300	3300
Potamogeton perfoliatus	Perfoliate Pondweed	3300	2200	1100	2200	2200	2200		1100				2200	3300	2200	3300	3300	3300	2200	3333	2200		
Potamogeton praelongus	Long-stalked pondweed		1100																				
Potamogeton x sparganifolius	Hybrid pondweed																3300	3300	2200				
Sagittaria sagittifolia	Arrowhead	2200	3300	3300	3300	3300	3300	2200	2100	1100	2100	2100	2300	3300	3300	3300	2200	2200	3300	2200	3311	1100	1100
Scirpus sylvaticus	Wood club-rush		2222				1122	1122	1121	22	1111	1121	11	11	1122	1111		1111	1111	1111		1122	1122
Sparganium emersum	Unbranched bur-reed	3300	3300	2200	2200	2200	2300	3300	3200	3200	3200	3200	3300	3300	3300	3300	3300	2200	3300	3300	3300	3300	3300
Sparganium erectum	Branched bur-reed					1111	2222										1111	1111	1111	1111	1111	1111	2200
Spirodela polyrhiza	Great duckweed	2200	2200	2200	1100	2200	1100	1100	1100		21		1100	1100	1100	1100	1100	1100	1100		1100	1100	1100
Typha angustifolia	Lesser bulrush			2211		1111																	
Typha latifolia	bulrush	1122			2211	1111	2211												1111			1111	1111
	Monocotyledons not aquatic	1111	1111	1111	1111	1111	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	1111	1111
Non Check-list species	No of checklist spp																						
Ephydatia rivularis	River sponge						1100	2200	3200				1100	1100	1100	2200							
Spongilla lacustris	Lake sponge																						1100
Lyngbya Van-den-Berghenii	Boring blue-green alga						1100	1100	1100						1100	1100							
Calypogia sp.	Liverwort									11													
Bryum sp.	Moss						11																
Oxyrrhynchium hians	Moss						1111	1111	1122	1111	1111		1122	1111	1111	1122	1122	1111	2211	1111	1122	1111	1111
Rhizomnium longirostrum	Moss								11				11	22	11	11							
Equisetum arvense	Creeping horsetail						1111	1111		1111		11											
Bidens frondosa	Beggarticks																						
Cicuta virosa	Cowbane		1111	1111	1111	1111	1111	1111	1111				1111										
Epilobium palustris	Marsh willow-herb						11	11															
Gnapalium uliginosum	Marsh cudweed										11												
Juncus bufonius	Toad rush										11												
Lysimachia nummularia	Creeping jenny						11	1121	1121	22	11	11	11	11	11								
Impatiens noli-tangerine	Touch-me-not balsam							11															
Impatiens parviflorum	Small balsam						22	11	11				11	11	11								
Myriophyllum verticillatum	Whorled water-milfoil	1200	2200	2200	2200	2200	1100	1100	1100														
Oenanthe aquatica	Fine-leaved water-dropwort										1111												
Sium latifolia	Greater water-parsnip			1111	1111	1111	1111	1111		11													
Stratiotes aloides	Water soldier		1100			1100																	
Tussilago farfara	Colt's foot					11		11															
Agrostis stolonifera	Creeping bent	1111	1111	1111	1111	1111	1111	1111	1111		1111											1111	1111

ANNEX K: *Ad hoc* wildlife observations. Numbers represent site location.

	Drawa	Płociczna
Invertebrates		
Fen raft spider (*Dolomedes* sp.)	1	
Banded demoiselle (*Calopteryx splendens*)	Throughout	1, 2
Banded darter (*Sympetrum pedemontanum*)	1	
Common darter (*Sympetrum striolatum*)		1
Small pincertail (*Onychogromphus forcipatus*)	17	
Southern hawker (*Aeshna cyanea*)		1
Camberwell Beauty (*Nymphalis antiopa*)	5	
Map butterfly (*Araschnia levana*)		1
? Pallas's fritillary (*Argyronome laodice*)		2
Silver-washed fritillary (*Argynnis paphia*)	10	
Amphibians		
? Edible frog		
Birds		
Grey wagtail (*Motacilla cinerea*)	11, 15	
Kingfisher (*Alcedo atthis*)	1, 6, 7, 12-13 15, 17	
Marsh harrier (*Circus aeruginosus*)	1	
Mute swan (*Cygnus olor*)	2	2
Rough-legged buzzard (*Buteo lagopus*)	17	
Tawny owl (*Strix aluco*)		1
Mammals		
Beaver (*Castor fiber*) (felled trees)	Throughout 3-17	1, 2
Otter (*Lutra lutra*) (spraints)	5, 6, 13-15	
Red squirrel (*Sciurus vulgaris*)	3	
Wild boar (*Sus scrofa*) (uprooted earth)	7, 8, 9-11, 13-17	

? unverified observation.

Banded darter.

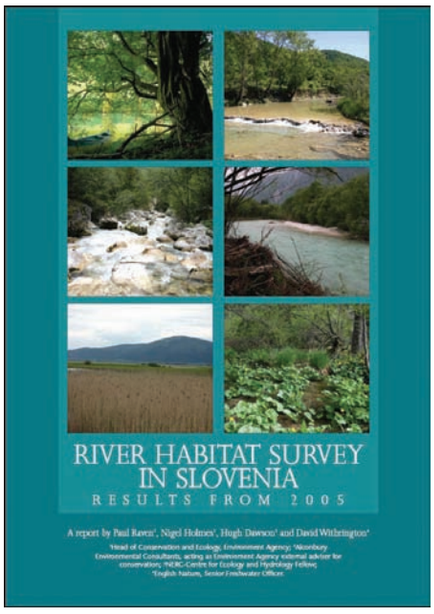
Otter footprint in sand.

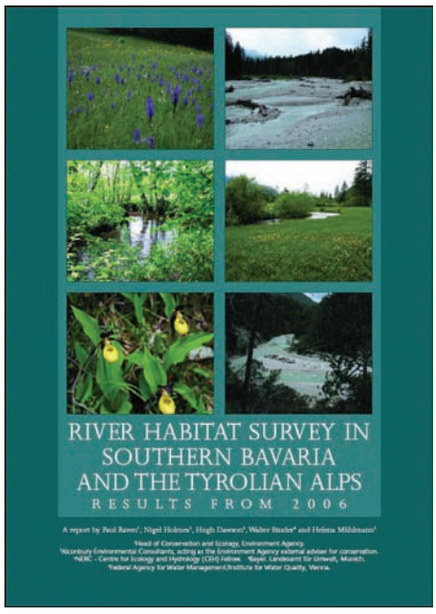
WEB SITES

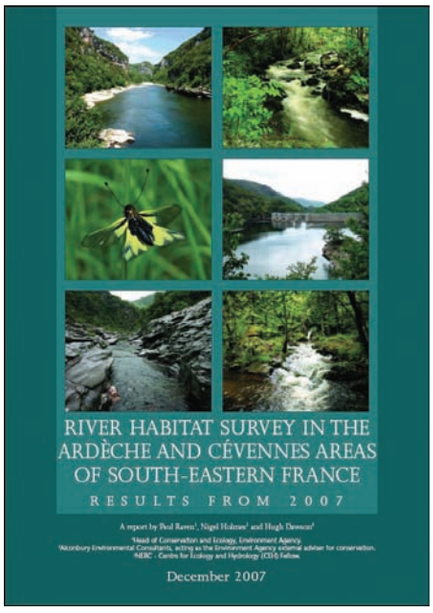
Google Earth: http://earth.google.com/index.html
RHS: www.rhs@environment-agency.gov.uk
STAR: www.eu-star.at
WISE: http://www.eea.europa.eu/themes/water
Drawa National Park: http://www.dpn.pl

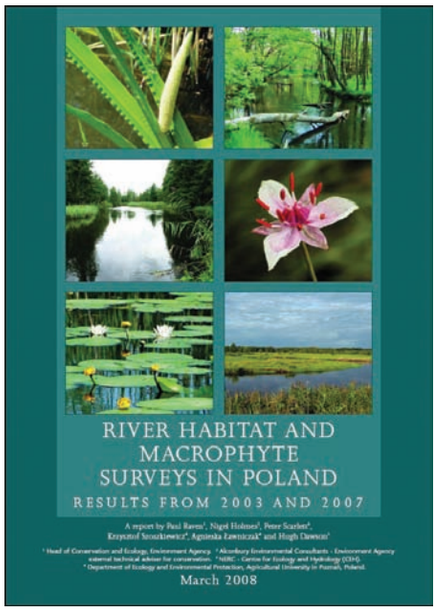
GLOSSARY OF ACRONYMS

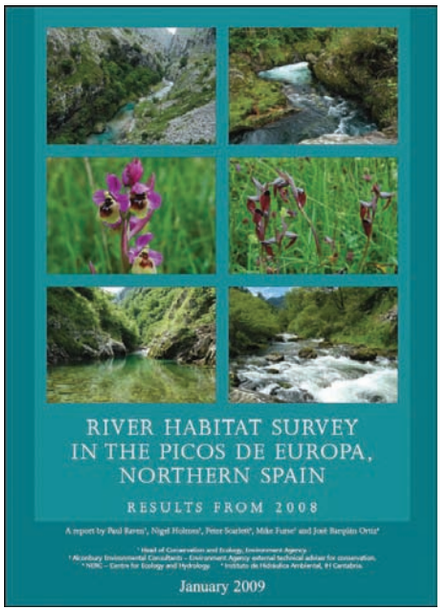
CEH	Centre for Ecology and Hydrology
CEN	Committee for Standardisation
CORINE	Co-ORdination of INformation on the Environment
DNP	Drawa National Park
Drawa-1,etc	Code to identify individual Drawa sites surveyed
GPS	Global Positioning System
HMC	Habitat Modification Class
HMS	Habitat Modification Score
HQA	Habitat Quality Assessment
JNCC	Joint Nature Conservation Committee
MIR	Macrophyte Index for Rivers (Makrofitowy Indeks Rzeczy)
MTR	Mean Trophic Rank
PCA	Principal Components Analysis
Ploc-1, 2	Code to identify Płociczna sites surveyed
RHS	River Habitat Survey
SAC	Special Area for Conservation
STR	Species Trophic Rank
STAR	STAndardisation of River Classifications
WFD	Water Framework Directive
WISE	Water Information System in Europe

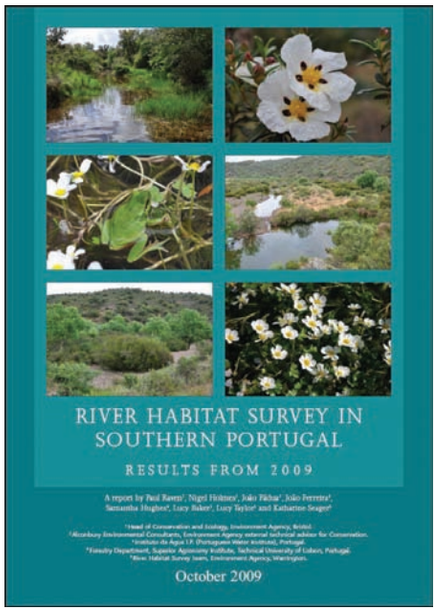




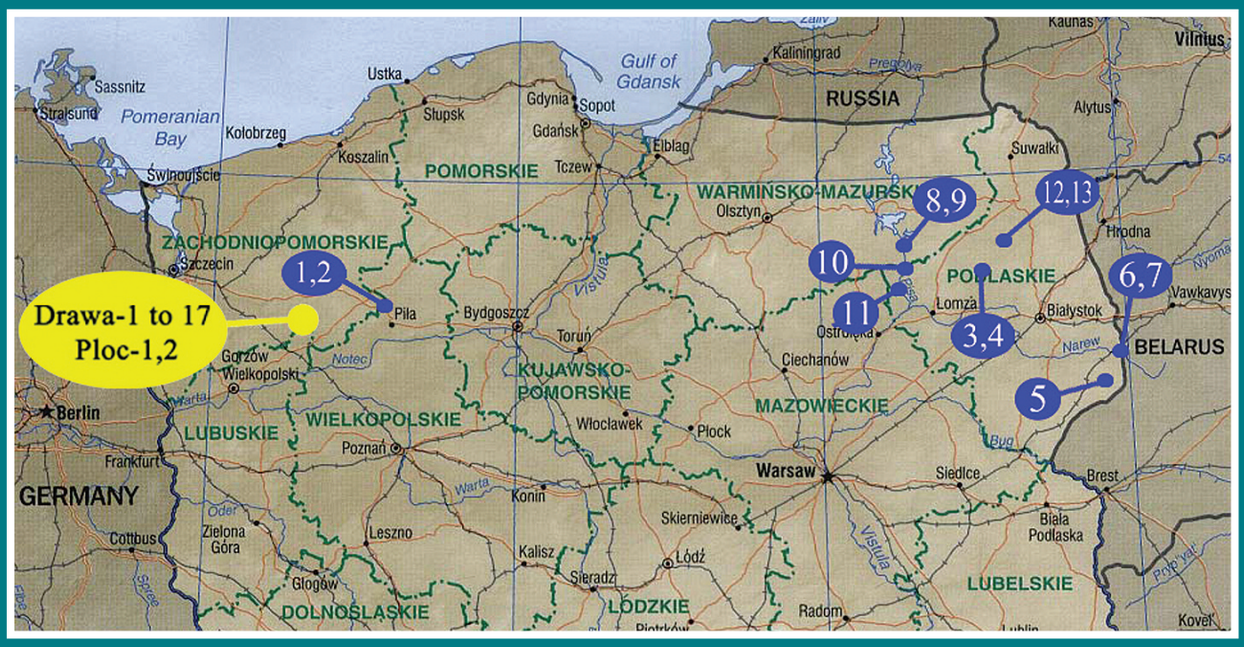






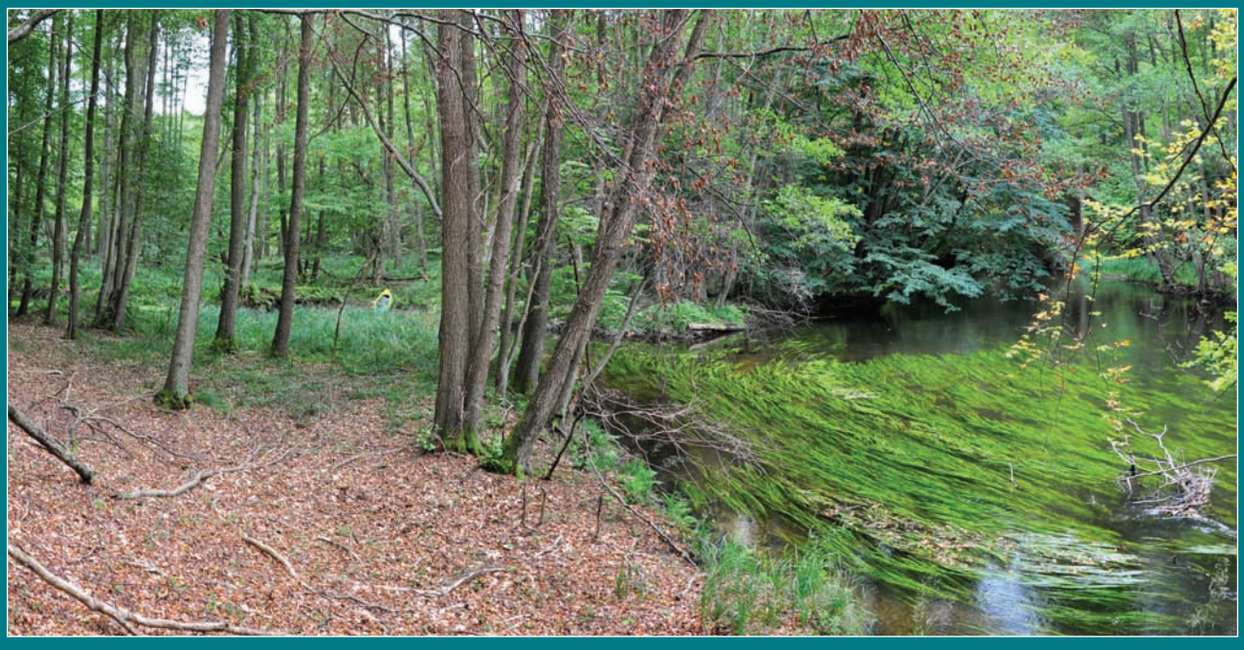


Reports from previous surveys in Europe.



Drawa study area, compared with previous Polish sites[7]
(1 = Pilawa; 2 = Dobrzyca; 3 = Krynica; 4/5 = Biebrza; 6/7 = Narew; 8-11 = Pisa; 12 = Jegrznia; 13 = Elk).

Source: Central Intelligence Agency



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