RIVER HABITAT AND MACROPHYTE SURVEYS IN POLAND

RESULTS FROM 2003 AND 2007

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WEB SITES

Biebrza National Park: www.biebrza.org.pl

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

Life in UK Rivers: www.riverlife.org.uk

REBECCA project: www.environment.fi

RHS: www.rhs@environment-agency.gov.uk

STAR: www.eu-star.at

WISE: http://www.eea.europa.eu/themes/water

GLOSSARY OF ACRONYMS

CEH	Centre for Ecology and Hydrology
CEN	Committee for Standardisation
GPS	Global Positioning System
HMS	Habitat Modification Score
HMC	Habitat Modification Class
HQA	Habitat Quality Assessment
JNCC	Joint Nature Conservation Committee
MIR	Macrophyte Index for Rivers (Makrofitowy Indeks Rzeczny)
MTR	Mean Trophic Rank
PCA	Principal Component Analysis
PL	Unique acronym to identify sites surveyed in Poland
REBECCA	Relationships between ecological and chemical status of surface waters
RHS	River Habitat Survey
STR	Species Trophic Rank
STAR	STAndardisation of River Classifications
WFD	Water Framework Directive
WISE	Water Information System for Europe

PURPOSE

The purpose of our visits in May 2003 and August 2007 was to support development of River Habitat Survey (RHS) and macrophyte surveys in Poland. By carrying out RHS and macrophyte surveys on a selection of rivers, we also tested the techniques for inter-calibration purposes under the EU Water Framework Directive (WFD).

Specific objectives were to:

- Provide expert support for RHS and macrophyte training courses organised by the Agricultural University in Poznań. These were located near Poznań in May 2003 and Białystok in August 2007.

- Locate and survey a selection of lowland rivers in Poland, using RHS[1], plus the Joint Nature Conservation Committee (JNCC)[2] and Mean Trophic Ranking (MTR)[3] macrophyte survey methods.

- Collect RHS and macrophyte data for European inter-calibration purposes and add them to the databases already established for the Standardisation of River Classifications project[4].

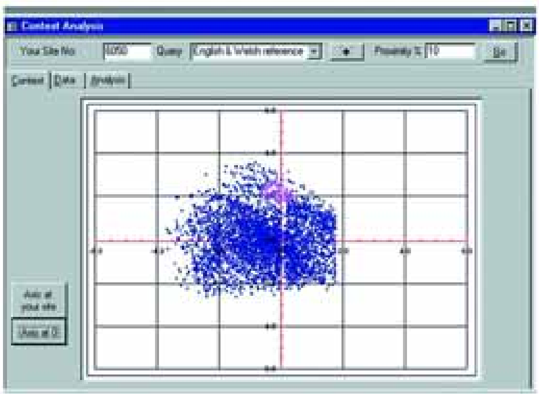
- Generate data for subsequent use in testing and refining the draft CEN guidance standard on the morphological assessment of rivers.

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

BACKGROUND TO METHODS

River Habitat Survey

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



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

The 2007 Polish RHS Manual.

RHS has been carried out in several European countries and the RHS Manual[1] has been adapted and translated into Italian, French and Polish, whilst a Portuguese version is also planned. Publication of the Polish RHS Manual[5], was timed to support the Białystok-based RHS training course in August 2007.

RHS survey data are entered onto a computer database. The UK database now contains field observations, map-derived information and photographs from more than 19,000 surveys undertaken since 1994. During 1994-96 a stratified random network of sites established a geographically representative baseline of streams and rivers across the UK[6]. A second survey, to establish trends in habitat quality since the initial baseline, is being carried out during 2007 and 2008.

The RHS database allows sites of a similar nature to be grouped together for comparative purposes. Slope, distance from source, height of source and site altitude are used to cluster RHS sample sites for so-called “context analysis” based on principal component analysis (PCA) plots[7].

The database allows detailed investigation into the relationship between physical variables (e.g. bedslope,

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

land-use), channel modifications and habitat features. These investigations can make links with water chemistry and hydrological data, plus aquatic macroinvertebrate, macrophyte and fish survey results where additional sampling has been done in or near RHS sites.

Indices of habitat quality and channel modification can be derived from RHS data, and these can be used as a basis for setting physical quality objectives for rivers[8].

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

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

Points are added together to provide the HQA. In contrast to HMS *(see below)*, the higher the score, the more highly rated the site. The diversity and character of features at any site is influenced by natural variation and also the extent of human intervention both in the channel and adjacent land. The RHS database allows HQA scores to be compared using sites with similar physical characteristics (e.g. slope, distance from source) and geology. Features determining habitat suitability for individual species such as European otter *Lutra lutra* or dipper *Cinclus cinclus* can also be selected, thereby providing a more sophisticated and ecologically-specific context for comparing sites[9]. Carrying out RHS and macrophyte surveys at specially selected good quality sites has provided the necessary calibration of HQA for a range of river types in the UK. These special surveys have been extended to mainland Europe, including Finland, Norway, Slovenia, Bavaria, the Tyrolian Alps and the Cévennes area in south-eastern France. The 2003 and 2007 surveys in Poland represent another component in this work. Comparison of various habitat assessment methods has also been part of this European-wide initiative[10].

Habitat Modification Score (HMS) is, by contrast, an indication of artificial modification to river channel morphology. To calculate HMS for sites, points are awarded for the presence and extent of artificial features such as culverts, weirs, current deflectors, and bank revetments. Points are also awarded for modifications to the channel such as re-sectioned banks or heavily trampled margins. The more severe the modification, the higher the score. The cumulative points total provides the Habitat Modification Score (HMS). A Habitat Modification Class (HMC) has been developed which allocates a site into one of five modification classes, based on the total score. In contrast to HQA, higher scores reflect more artificial intervention and modification of the river channel within the site.

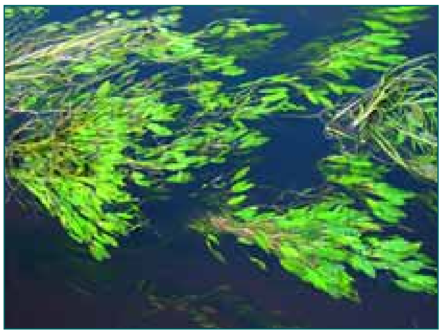
Artificial reprofiling and reinforcement of banks and the channel produce a high HMS score.

RHS made an important contribution to development of the CEN standard "Water quality: guidance standard for assessing the hydromorphological features of rivers (EN 14614)", which was published in 2004[11]. It is a recommended method for the agreed protocol for field survey and feature recording of hydromorphological data, including use for the Water Framework Directive. RHS is also being used to help develop an associated CEN guidance standard on determining the degree of modification or river hydromorphology which will be used to help identify reference conditions and the assessment of hydromorphological pressures as required by the Water Framework Directive.

Since 2003 there has been a programme of RHS surveys carried out in Poland by the Agricultural University of Poznań. Additional sites have been surveyed by the University of Białystok, the University of Warmia and Mazury in Olsztyn, the University of Opole and the University of Silesia. More than 600 sites have now been surveyed and the data are being entered onto a computer database.

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

The project, completed in 2005, aimed to provide standard biological assessment methods compatible with the requirements of the Water Framework Directive. It also aimed to develop a standard for determining the class boundaries of 'ecological status' and another one for inter-calibrating existing methods. In Austria, The Czech Republic, Denmark, Germany and Italy 'core' sites were chosen to reflect a gradient in habitat and morphology degradation. Results from the STAR project were published in a special issue of the journal *Hydrobiologia* in 2006[4].



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

Aquatic macrophyte surveys

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

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

For 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 where hydrology, morphology and floristic character may differ.

Since 2003, a programme of several hundred macrophyte surveys has been carried out, often linked to RHS sites. As a result of this work, the STAR project[4] and research by ecologists in Poznań[12-16], the Polish Macrophyte Index for Rivers method (MIR) has been developed[17].

The Makrofitowy Indeks Rzeczny (MIR) method was developed because: (i) research findings suggested that some taxa in Polish rivers respond slightly differently to nutrient levels compared to those in UK rivers; (ii) local chemistry data were matched more precisely to different plant associations; and (iii) despite many similarities, Polish and UK rivers support some taxa that are not common to both countries.

The method of data collection is identical, but the MIR system uses a different weighting for some species, including those not included in MTR[17]. Additionally, the MIR system differs because: (i) a small number of taxa have different species trophic ranks (STRs); (ii) a small number of taxa (e.g. common reed, *Phragmites*) are excluded; (iii) additional taxa are included because they are either more common in Polish rivers (e.g. greater water-parsnip, *Sium latifolium*) or statistical association with nutrient gradients has been demonstrated (e.g. reed canary-grass, *Phalaris arundinacea*); and (iv) several species common in both the UK and Poland that occupy more marginal habitats than purely aquatic ones (e.g. water mint, *Mentha*) are included.

SURVEY AND ASSESSMENT

The objective of our Poland visits differed somewhat from those for Slovenia[18], Tyrolian Alps[19] and the Cévennes[20], where the primary purpose was to locate near-natural examples of rivers to calibrate RHS and macrophyte surveys. In lowland Poland the landscape is extensively managed, so there are effectively no examples of unmodified rivers in natural wilderness, woodland or wetland landscapes. The same applies to virtually all of lowland Europe west of Belarus. In Poland our surveys therefore focused on a comparative assessment of river types characteristic of the lowland landscape.

In June 2003, several rivers were visited, including one used as a test site for new RHS surveyors. River Habitat Survey was undertaken by Paul Raven, Duncan Hornby and Peter Scarlett, working together for quality assurance and health and safety reasons. Results are available for all the sites surveyed, but for the purposes of this report, only those on the Pilawa, Dobrzyca, Krynica, Biebrza and Narew rivers are included.

In August 2007 we visited the Pisa, Jegrznia and Elk rivers because maps, *Google Earth* images and recommendations from the Polish Environment Ministry suggested they might have near-natural morphological conditions. RHS was carried out by Paul Raven, helped by Marta Szwabinska and Agnieszka Ławniczak. For one site on the Pisa River (PL-10), the survey was carried out by Tomasz Zgoła. Approximate site locations are shown on the back cover map.

Nigel Holmes carried out the macrophyte surveys at all sites in 2003 and 2007, using both the JNCC and MTR methods. In August 2007, MTR was also carried out by Agnieszka Ławniczak.

The RHS survey form entries were checked using digital photos taken in the field. Background information (e.g. altitude, geology, land use), was derived from various map-based and literature sources (Appendix 2). Latitude and longitude readings were obtained using GPS in the field, and *Google Earth* for PL-8, 9, 10 and 11. Topographical maps showing site locations appear in Appendix 8.

The complicated drainage pattern and frequent on-line lakes made it difficult to determine the location of the source of some rivers from maps. Assumptions made about the sources of the Pisa, Elk and Jegrznia have therefore influenced data on altitude of source and the distance from source for the survey sites on those rivers (Appendix 2). Water levels marked on the 1:100,000 and 1:50,000 scale maps in the *Mapa topograficznia Polski* series provide good reference points to help estimate local bed-slope gradient of all the study rivers.

White stork - a familiar sight in Poland.

Green hawker *(Aeshna viridis)*: a dragonfly closely associated with water soldier *(Stratiotes aloides)*.

The spiny leaves of water soldier *(Stratiotes)* provide protection for the eggs of the green hawker.

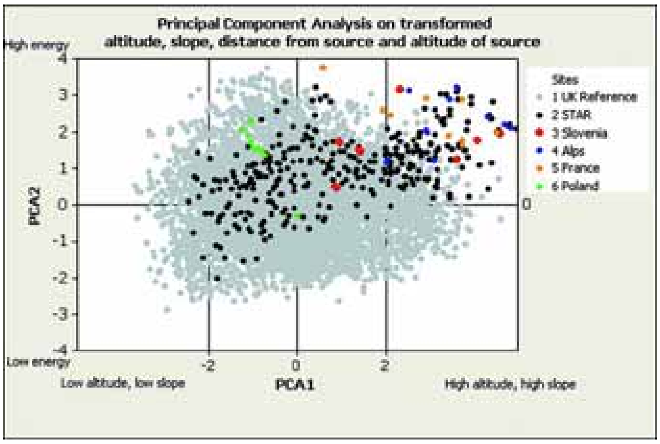


Figure 1. PCA plot, showing Polish sites in relation to UK, STAR and European benchmark sites.

Major drainage channels disrupt the natural hydrology of many rivers such as the Elk.

For some sites surveyed in 2007, basic water chemistry (pH: conductivity, hardness/colour) was determined from samples taken in the field and subsequently analysed in the laboratory. This gives a broad indication of this important influence on river biology (Appendix 6). Water quality information (Appendix 2) was derived from information provided by the Voivodeship Inspectorate for Environmental Protection in Poznań.

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

The weather during survey work in June 2003 and August 2007 was good. Water levels in June 2003 were unusually low following a prolonged dry period; by contrast, strong baseflow in rivers in August 2007 reflected an unusually wet summer.

Peter Scarlett produced the PCA plot in Figure 1. Calculation of the RHS indices (HQA and HMS) was done by Paul Raven, using the 2005 version of these systems - in similar fashion to that done for sites surveyed in Slovenia[18], the Bavarian and the Tyrolian Alps[19] and the Cévennes[20]. This means that assumptions had to be made about the scoring of special features. MTR scores were calculated by Nigel Holmes and the MIR scores by Krzysztof Szoszkiewicz.

A complete set of RHS survey forms, a CD-Rom with digital photographs, maps showing locations, sketches and macrophyte lists for each site visited has been produced and are available from CEH or the Agricultural University in Poznań. The notes in Appendix 1 appear in Section P of the RHS database entry. The abbreviated site names, starting with "PL" are unique acronyms to identify them in the databases.

Results from 13 RHS surveys on six rivers are presented in this report (Appendix 1). Information is based on nine single (500m) sites, plus two "doubled-up" sites (1km) on the Biebrza and Pisa Rivers.

RESULTS

Context in relation to European hydro-ecoregions and UK rivers

All the study sites lie within the "Central Baltic Plain" hydro-ecoregion as defined by the REBECCA project (Table 1).

Figure 1 is a PCA plot, showing the Polish sites compared with those in previous surveys[18-20], STAR project sites[4] and UK baseline sites[6]. It graphically illustrates the extremely low gradient nature of the rivers.

TABLE 1: General characteristics of the "Central Baltic Plain" hydro-ecoregion as defined by REBECCA[21].

Altitude	<125m (lowlands)
Slope	<0.4% (<0.4m per km)
Relief	Plains
Lithology	Sedimentary, non-carbonated
Climate	Continental, cold

Landscape and river character

The dominance of agriculture in the lowland landscape characterised by shallow vee or floodplain valleys contrasted with the steep, wooded mountainous valley surveyed in Slovenia[18], the Tyrolian Alps[19] and the Cévennes in south-eastern France[20] (*see centrefold map*).

There is a complicated pattern of drainage networks and hydrology due in part to the nature of the glacial moraine deposits that dominate northern Poland. Numerous small watercourses run in parallel sub-catchments and often pass through linear on-line lakes. Channel straightening and artificial drainage channels have isolated old floodplain channels in many areas. Nevertheless, extravagant meanders, backwater channels and relic ox-bows remain connected to several rivers (e.g. along parts of the Pisa, Biebrza and Narew). This provides a hint of the near-natural river landscapes that existed before widespread agriculture land drainage and flood control.

Extravagant meanders, back channels and ox-bows along the Biebrza.

Sand is predominant as a substrate in many Polish rivers; PL-1.

Sandy banks are particularly prone to erosion; PL-11.

Google Earth image showing the straightened channel of the Narew (arrow) and historical meanders now isolated from the river.

Morphological character

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

There are noticeable differences in the character of lowland rivers in Poland and the UK. On-line lakes are much more common in Poland, whilst in many rivers sand is the predominant channel substrate compared with gravel-pebble in lowland Britain (Table 4). This reflects differences in post-glacial history, geology and hydrological regimes.

In addition, the hydraulic energy of “smooth” flow in Polish rivers appears greater than that in groundwater-fed rivers of similar gradient and size in Britain. This may partly explain why extravagant meanders, bank erosion and relic cut-off channels are widespread along very low gradient Polish rivers. Erosion is also enhanced by the sandy nature of the river bank material in many places.

A comparison of the main characteristics of lowland rivers with shallow vee or floodplain valley shape in the UK and Poland is illustrated by Table 4. In lowland Britain, most rivers are extensively modified hydrologically and morphologically as a result of intensive land-use. Consequently, natural or near-natural “reference” conditions at the water body scale (10-20 km river lengths) as defined by the Water Framework Directive simply do not exist.

TABLE 2: Basic landscape character of the rivers surveyed.
Sites are arranged in descending order of channel gradient.

Site reference (PL)	River	Channel slope (m/km)	Water width (m)	Predominant valley form	Altitude of source (m)	Distance from source (km)
5	Krynica	1.0	2.0m	Shallow vee	160m	4.0km
1	Pilawa	0.92	7.5m	Concave	160m	64.0km
2	Dobrzyca	0.74	10.0m	Concave	165m	65.0km
6,7	Narew	0.4	12.0m	Floodplain	162m	47.0km
8-11	Pisa	0.23[10,11]; 0.16[8,9]	28.0m[8]; 40.0m[9]; 25.0m[10]; 29.0m[11]	Shallow vee[8,9,10] Floodplain[11]	165m†	60.0km[8], 60.5km[9], 76.0km[10], 100.0km[11]
3,4	Biebrza	0.14	22.0m, 25.0m	Floodplain	155m	135.0km
12	Jegrznia	0.13	16.0m	Floodplain	225m†	130.0km
13	Elk	0.12	22.0m	Floodplain	220m†	130.0km

† assumptions made about the location of source.

TABLE 3: Habitat quality, habitat modification and macrophyte assessment for rivers surveyed.
Sites are arranged in descending order of channel gradient.

Site reference (PL)	River	Habitat quality (HQA)	Habitat modification score (class)	MACROPHYTE ASSESSMENT		
				MTR	MIR	Ecological status
5	Krynica	62	0(1)	33	44	2
1	Pilawa	62	0(1)	40	46	1
2	Dobrzyca	72	0(1)	37[a], 35[b]	42[a], 41[b]	2
6,7	Narew	41; 47	0(1); 0(1)	38[6]	43[6]	2
8-11	Pisa	68[8]; 66[9]; 38[10]; 42[11]	0(1)[8]; 0(1)[9]; 350(3)[10]; 20(1)[11]	34[8], 36[10, 11]	36[8], 38[10], 36[11]	2
3,4	Biebrza	48; 55	0(1); 30(1)	36[3]	40[3]	2
12	Jegrznia	32	0(1)	34	36	2
13	Elk	37	0(1)	38	38	2

Map of extensive wetlands and lattice of inter-connected channels of the Narew River, Narwianski National Park.

The extensive wetlands of the Narew near Waniewo can only be truly appreciated from aerial photographs.

Macrophyte surveys of deep, sluggish reed-fringed river channels can only be done effectively by boat.

Similar landscape, land-use and river morphology characteristics also occur in the northern agricultural plains of Poland. Arable farmland predominates west of Warsaw; more traditional hay meadows are now largely confined to east around Białystok.

Although reed-lined drainage channels are common-place in the East Anglian Fens and Norfolk Broads, there is nowhere in lowland Britain or Ireland remotely on the scale of the network of reed-lined channels and extensive wetlands that occurs in the Biebrza and Narwianski National Parks.

Aquatic macrophytes

Macrophyte data for 12 MTR sites are presented in Appendix 9. Eleven sites prefixed by 'PL' match RHS survey sites, whilst an additional column, labelled 'T1', represents a site on the Świniobródka River that was used as an RHS training site in 2007.

Appendix 10 gives the JNCC macrophyte survey results. Five 500m sites were surveyed in 2003, coinciding with PL-1, 2, 3, 5 and 6. Five JNCC sites were surveyed in 2007, at PL-8, 10, 11, 12 and 13. An additional boat-based survey of a backwater of the Narew River near Waniewo in the Narwianski National Park is also included.

It is unwise to make generalisations about the macrophyte flora of lowland, low gradient Polish rivers because of the small number of sites sampled during our two visits. However, similar river types in the UK are best represented by fenland river systems such as The Old Bedford in East Anglia. These are totally dominated by higher plants, with virtually no lower plants such as bryophytes present. Similarly, the rivers we surveyed in Poland had very few or no bryophytes at all.

All the Polish sites can be classified as broadly equivalent to the UK Rivers Community Type 1, namely 'Lowland, low-gradient rivers'[2]. The mean number of taxa recorded from 102 sites of this type in the UK was 46, with a range of 29 to 67. The number of JNCC check-list taxa recorded at the Polish sites we surveyed varied from 35 to 59 and therefore within the same species-richness range as UK sites of a similar river type. The Jegrznia at PL-13, which was choked by reeds, had by far the least number of taxa, whilst the shade-free Pisa River sites at PL-10 and PL-11 were the most species-rich.

The Old Bedford River in East Anglia is designated a Site of Special Scientific Interest, primarily due to its rich fenland aquatic flora. Species that indicate relatively base-rich water such as flowering rush *(Butomus umbellatus)* and lesser water-parsnip *(Berula erecta)* are found there and also

TABLE 4: Percentage occurrence of selected features in UK and Polish rivers with a source <200m and shallow vee and floodplain valleys. Polish RHS data provided by Agricultural University of Poznań.

Feature	UK BASELINE RHS SURVEY SITES (1996 DATA): All sites with source altitude <200m	Source altitude <200m: Shallow vee	Source altitude <200m: Floodplain	RHS SITES IN POLAND
CHANNEL AND BANKS				
Extensive gravel/pebble substrate*	47.9	49.9	40.9	25.0
Extensive sand substrate*	10.4	7.6	9.9	68.0
Extensive silt substrate*	34.3	19.2	41.8	23.0
Eroding cliffs present or extensive	28.7	38.2	22.0	33.0
Trees isolated or absent	35.2	34.2	43.5	31.0
Extensive resectioned banks †	42.6	30.1	51.2	31.0
Extensive reinforced banks (whole bank) †	7.5	7.1	7.5	2.0
LAND-USE				
Extensive broadleaf woodland†	20.9	21.6	15.8	33.0
Extensive wetland†	4.9	3.8	5.1	21.0
Extensive rough pasture†	15.9	22.4	15.0	22.0
Extensive pasture (improved grass land) †	59.1	55.3	58.2	26.0
Extensive arable/tilled land†	36.3	24.9	43.3	9.0
Number of sites	*1124*	*635*	*545*	*407*

* three or more spot-checks.

† extensive on one or both banks (sweep-up information)

In the East Anglian fens, rivers have been deepened, straightened, widened and embanked.

at many of the Polish sites we surveyed. The Old Bedford also has populations of species such as fine-leaved water-dropwort *(Oenanthe aquatica)*, fan-leaved water crowfoot *(Ranunculus circinatus)*, frogbit *(Hydrocharis morsus-ranae)* and ivy-leaved duckweed *(Lemna trisulca)*, all of which were well represented in the Polish rivers we visited.

The Erne system in Northern Ireland flows through a flat landscape with base-rich fen and reedbeds commonly found along the river and widely elsewhere in the catchment. The Erne macrophyte flora has many similarities to the Polish rivers we surveyed. For instance, unlike the East Anglian fens, but similar to Poland, cowbane *(Cicuta virosa)* and greater water-parsnip *(Sium latifolium)* are common. Further south, in the peatlands of the Irish Republic, whorled milfoil *(Myriophyllum verticillatum)* is common, as it is in several rivers in Poland.

Our brief, boat-based survey of some Narew River back channels in the Narwianski National Park revealed a rich flora dominated by the same species we found elsewhere; the only exceptions were shining pondweed *(Potamogeton lucens)* and hybrid bulrush *(Typha)* which were absent from the other sites we visited. Perhaps more than 400 years ago, before the Old Bedford River was dug as a drainage channel there may have been a similar picture in the East Anglian fens.

From our small sample, it can be concluded that the macrophyte flora typical of lowland rivers in Poland is very similar to the best examples of rivers flowing through calcareous fens in the British Isles. Many of the species that were well represented in the Polish survey sites are uncommon in the UK simply because there are so few fenland rivers. Only one species that is not native to the UK the starwort, *Callitriche cophocarpa*, was recorded during our visits.

Invasive non-native plants

In the UK, non-native invasive plants are a widespread and increasing problem along watercourses. Observations during our visit suggested a much lower incidence of species such as Japanese knotweed *(Fallopia japonica)* and Himalayan balsam *(Impatiens glandulifera)*. This is confirmed by RHS surveys in Poland (Table 5).

TABLE 5: Occurrence of Japanese knotweed and Himalayan balsam at RHS sites in Poland compared with England and Wales.

	England and Wales*	Poland
Japanese knotweed	8.6%	1.7%
Himalayan balsam	14.4%	2.6%
Number of sites	*1532*	*407*

* 1994-1996 baseline sites

DISCUSSION

Reference conditions in lowland catchments

Disruption of natural hydrological conditions as a result of extensive arterial drainage, and the proximity of grazing pasture or tilled land means that habitats such as wet woodland, which would indicate near-natural "reference" conditions are virtually absent from lowland Poland. Of our study sites the most promising near-natural features were found on the Pisa River at PL-8 and PL-9 where the river is active and there is a good combination of active meanders, cut-off channels, wetland and wet woodland. By comparison, the impacts of drainage and cattle grazing on the floodplain some 15 km and 40 km further

The River Erne system in Northern Ireland still has remnant habitat similar to that in Poland.

Himalayan balsam is not nearly so widespread along Polish rivers as it is in the UK.

Classic backwater habitat is not uncommon in Poland: PL-9.

The Kan Rudzki - a major drainage channel that takes most of the flow from the Elk River 15 km upstream from PL-13.

downstream (PL-10 and PL-11 respectively) provide a very contrasting landscape of virtually treeless banks and closely cropped pasture. This difference is well illustrated by the respective HQA scores (Table 3).

The importance of ground-truth surveys to test assumptions made from maps and aerial photographs was illustrated by our surveys of the Jegrznia and Elk rivers (PL-12 and PL-13). Images of extravagant meanders and relic channels suggested good potential for near-natural conditions; in reality, however, two major drainage channels (the Kan Rudzki and Kan Woznawieski) effectively take virtually all the stream energy from both river systems leaving them hydromorphologically moribund. There are also few riparian habitat features because the floodplain is either grazed or regularly cut for hay.

This highlights the differences between the near-natural, undisturbed conditions needed for hydromorphological reference conditions under the Water Framework Directive and habitat of high nature conservation value under the Birds Directive. The Biebrza Wetlands and Narew River in the Narwianski National Park provide habitats of high nature conservation value. However, the Biebrza river in particular cannot be considered hydromorphologically near-natural because of impacts elsewhere in the catchment, whilst land-use in the floodplain prevents wet woodland from developing. Nevertheless, there are some locations on the Pisa, Biebrza and Narew that have the necessary characteristics of near-natural river reaches; these probably represent some of the best examples of remnant lowland riverine habitats west of Belarus.

The impact of beaver dams

Hunted almost to extinction, European beavers *(Castor fiber)* were scarce in Poland until the 1990s. Following a reintroduction programme (1974-92) they are now common and increasing along most lowland rivers (Appendix 5). Evidence for beaver-damaged and felled riverside trees is now widespread and log dams are becoming increasingly common. These dams and associated lodges can be substantial structures, raising water levels more than 0.5m and creating substantial temporary lakes upstream. Trees submerged in these lakes often die.

The impact of beaver dams is of concern to local farmers, notably in the Biebrza National Park. This is because raised water levels caused by the dams mean loss of productive land; they also prevent cattle or hay-cutting equipment from reaching waterlogged areas in mid-summer. A combination of reduced hay-cutting and grazing increase scrub encroachment reduces the economic and nature conservation value of species-rich grazed fen which is such an important feature in the Biebrza area.

A dam on the Świniobródka, a small stream, near Sokole provided a classic illustration of the impact, with the impoundment affecting about 150m of the channel. RHS surveys are also affected because a beaver lake will submerge bankface and banktop features, whilst sweep-up assessments such as banktop tree-line distribution are also affected (Appendix 7).

Bankside trees are felled by beavers to make dams.

A large beaver dam on the Świniobródka river.

Even a small beaver dam can drown trees upstream.

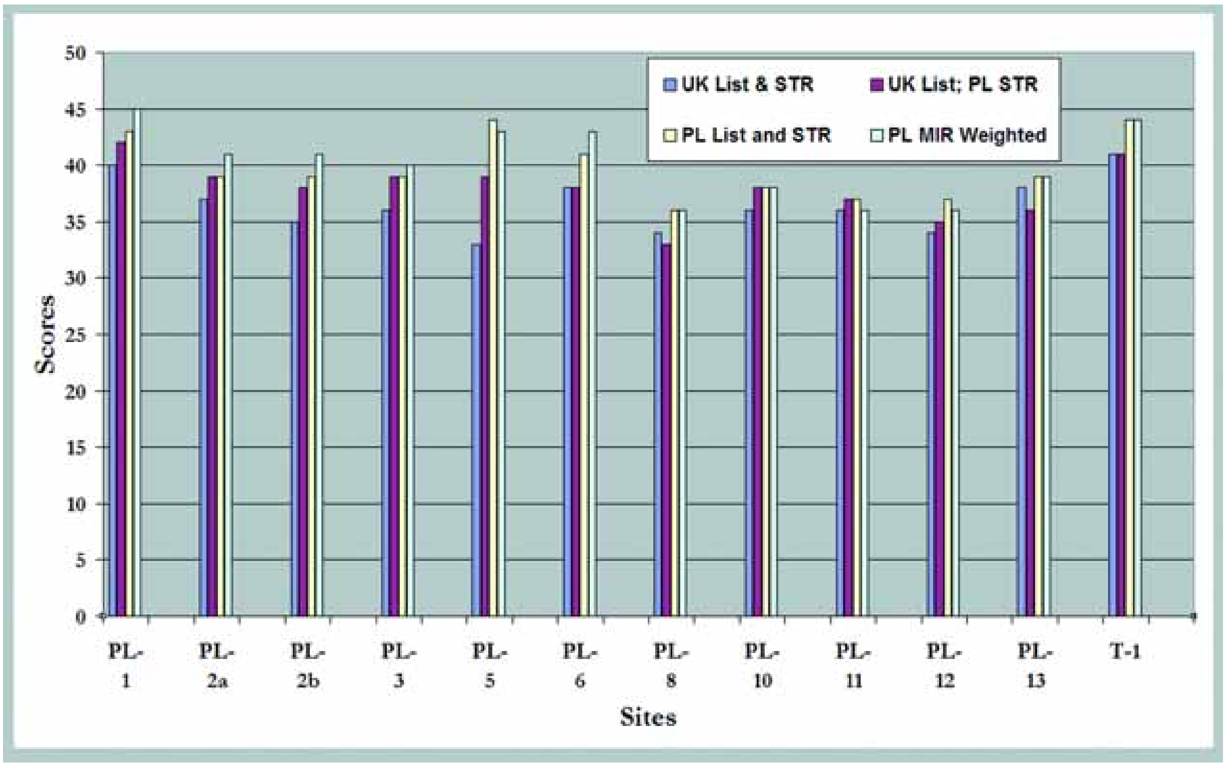


Figure 2. Comparison of MTR and MIR scores (*see Appendices 9a-d for full details*).

Comparing MTR and the Macrophyte Index for Rivers

The MTR system was developed in the mid-1990s to enable macrophytes to be used alongside invertebrates and other methods to assess the biological water quality of rivers in the UK. The check-list of plants used has not changed since the system was first introduced, nor has the rank of macrophyte sensitivity assigned to taxa at the outset. The system was based on the more commonly recorded taxa in macrophyte surveys, and used a combination of expert judgement and water chemistry data to establish the species trophic rank (STRs). Several thousand MTR surveys have been carried out in the UK since then. Some of these were used in research to modify some STRs for application of the method in Poland[12-17].

The Polish MIR system has additional taxa that are common in rivers there, and STRs have been assigned to these taxa too[17]. Based on correlations with nutrient status, some marginal habitat taxa have also been added, but these do not appear in the original UK MTR system. The Polish system can be used in exactly the same manner as the UK system, or by applying a weighting system. The number of taxa used for the MIR method in the sites we surveyed was a third greater than the UK MTR list.

Results from the three different un-weighted scoring systems are presented in Figure 2 and detailed in Appendix 9. Figure 2 also incorporates MTR scores derived by weightings. When the MTR scores are derived using only those taxa on the UK check-list and the original STRs the range is 33 to 41. For scores using the same UK check-list, but using STRs assigned to taxa in the Polish system, the range is 33 to 42. The scores from both systems at each site differed by no more than two or three points, except at PL-5 where the difference was six. The main reason is that the two dominant taxa, unbranched bur-reed *(Sparganium emersum)* and yellow water lily *(Nuphar lutea)*, have an STR of 4 in the Polish system, compared with 3 for the UK method.

The MIR scores (i.e. including weighting, additional taxa and the MIR scoring system) are generally higher.

Frogbit *(Hydrocharis)* and duckweed *(Lemna)* are free-floating macrophytes common in many Polish rivers.

Cowbane *(Cicuta)* is more common in Polish rivers and is part of the MIR system.

The Polish MIR system includes more taxa such as bur-marigold *(Bidens)* that grow along river margins.

The Polish MIR system has different trophic rank scores for some species, such as yellow water-lily *(Nuphar lutea)*.

The MTR manual[3] gives information on the typical scores for the ten JNCC river community types found in the UK. The 49 sites on the original database representing lowland, low gradient rivers had a mean MTR score of 34; the top 10% of sites had an average MTR of 41. Using the UK list and scoring system on the Polish sites, the 2007 Training site (T1) had a score of 41, and the Pilawa River (PL-1) a score of 40. The majority of the other sites scored 34-39. Overall, therefore the Polish sites we surveyed appear to be slightly less nutrient enriched than similar UK rivers. This is also supported by the ecological status (class 1 or 2) for each of the sites as derived by the MIR method (Table 3).

The addition of new taxa to reflect differences in the macrophyte community appears to work well and there is merit in investigating further the wider application of this method in relation to ecological status.

CONCLUSIONS

We achieved our main objectives of supporting the development and testing of the RHS and MTR methods and training surveyors in Poland. The core elements of both methods are suitable for small and medium-sized rivers in Poland.

It was encouraging to find that the MTR and MIR scores gave broadly similar results. This demonstrates that provided the basic principles of the scoring system and inclusion of qualifying species remain, adaptation to reflect local character should mean that results will be directly comparable. This also applies to RHS.

Like other countries that have little baseline information on ecological and hydromorphological features as required by the European Water Framework Directive, a cost-effective sampling strategy is urgently needed in Poland.

A combination of maps and aerial photographic sources can quickly provide basic information on the physical structure of river channels and riparian habitat at the water body scale. Ground-truth samples using RHS and other methods such as MIR are also needed to verify assumptions and calibrate biological water quality and habitat quality. A strategy involving both these elements should be relatively easy to develop, with sampling density determined by variations in factors such as "river type" and land-use. Expanding the database of Polish RHS and macrophyte information will help to increase confidence in the reporting of ecological status and assessing hydromorphological pressures for the Water Framework Directive. This will build on the foundations created by the STAR project results in Poland[4].

Trained and accredited RHS and macrophyte surveyors provide the necessary quality assurance for classifying the biological status of water bodies and the hydromorphological pressures acting upon them; this is important in implementing the ecological objective-setting principles of the Directive.

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

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

APPENDIX 1: NOTES FOR PL-1 TO PL-13.

Pilawa River (PL-1)
3 June 2003. HQA = 62; HMS = 0. MTR = 33; MIR = 46.
One site (500m). 53°21'21.9"N; 16°33'19.9"E.

A small, heavily-shaded, groundwater-fed stream rising three km east of Borne Sulinowo and flowing through three large on-line lakes before reaching PL-1. Here it has a sand channel substrate, peaty earth banks and extensive sedge growth along natural berm and terrace formations. Marsh and wet woodland provide good wildlife habitat features alongside the channel.

The site had a good representation of MTR check-list taxa. Fan-leaved water-crowfoot *(Ranunculus circinatus)* was the commonest aquatic taxon present, firmly rooted to the bed and accreting sand to form mounds up to 1m high. Such accretion has never been recorded in a UK river but the sand substrate and powerful water flow meant the macrophyte assemblage was dominated by firmly rooted taxa. Plants such as Canadian pondweed *(Elodea canadensis)* was firmly rooted, whilst slender-tufted sedge *(Carex acuta)* and lesser pond sedge *(Carex acutiformis)* were dominant over reed sweet-grass *(Glyceria maxima)*.

Growth of *Ranunculus circinatus* can create large mounds of sand on river beds; PL-1.

Dobrzyca River (PL-2)
3 June 2003. HQA = 72; HMS = 0.
MTR = 37, 35; MIR = 42, 41.
One site (500m). 53°16'53.0"N; 16°34'09.5"E.

Low flow conditions reveal silting along the water's edge; PL-2.

Sedge-dominated natural berms; and alder *(Alnus glutinosa)* trees marking the banktop level; PL-1.

The Dobrzyca rises seven km north-east of Czaplinek. At PL-2, some 65km downstream it is a small, heavily-shaded river, with a sand substrate. Low flow conditions during our survey revealed extensive silt along the margins, probably a consequence of forestry management such as logging. Alders *(Alnus glutinosa)*, wet woodland and fen provide the main wildlife interest. The site contained a STAR project[4] macroinvertebrate sampling site.

Two MTR surveys were carried out within PL-2. This was to illustrate the difference between shaded and more open parts of the site. The sand substrate resulted in the majority of the flora being higher plants, with unbranched bur-reed *(Sparganium emersum)* the dominant taxon. The shaded site has 12 taxa, and the more open site 23 taxa present from the Polish check list. The MTR scores suggested enriched nutrient levels, whilst shading did not influence the MTR scoring.

Biebrza River (PL-3 and 4)
6 June 2003. HQA = 48, 55; HMS = 30, 0.
MTR = 36, 37; MIR = 40.
Two back-to-back surveys (1km). 53°25'34.3"N; 22°32'15.8"E and 53°25'32.7"N; 22°32'21.4"E.

The Biebrza wetlands are the largest and most important in central Europe forming a vast expanse of river channels, backwaters and flooded fen in the springtime. They are

Alder-lined channel and fallen tree; PL-2.

Contrasting banks of grazed wetland and ungrazed scrub on the Biebrza; PL-3.

Back channel of the Biebrza, with abundant macrophytes; PL-3.

internationally renowned for their wildfowl and wading birds.

The river channel represents only a fraction of this wetland complex. Both the PL-3 and PL-4 results must be seen in that context, because extensive side and back channels can only be assessed properly by a sampling strategy involving aerial photography and boat-based surveys (Appendix 7). The main channel has extreme meanders and a sand substrate. The strong groundwater flow represents a powerful erosive force producing extensive eroding cliffs despite the very gentle channel gradient.

Major drainage channels enter the river at regular intervals (e.g. the Kan Rudzki, Kan Wozndwieski and Kan Augustowski) and these must affect the hydrology of the Biebrza as well as the sub-catchment areas they drain. There are very few trees, and cattle have trampled the banks extensively in places. Extensive fringing reeds, fen meadows and marshy relic channels are typical features that occur throughout the Biebrza National Park *(see also PL-12 and 13)*.

A single MTR was completed because the deep water, flowing over find mobile sand made it a difficult site to survey. Backwaters and cut-off meanders supported very rich macrophyte communities. The edges were dominated more by fringing reed sweet-grass than sedges, with the co-dominants being *Sparganium emersum* and arrowhead *(Sagittaria sagittifolia)*, both growing in their submerged forms of long-strap-shaped leaves. Loddon pondweed *(Potamogeton nodosus)* was found here; it is very local in the south of Britain, but relatively common in Poland.

Linear-leaved plants, such as *Sparganium emersum*, were the dominant taxa found in the Biebrza; PL-3, 4.

Typical view of the Biebrza river and surrounding wetland landscape; PL-3.

Heavy shading and coarse woody debris; PL-5.

Extensive silting and abundant bankside nettles, PL-5.

Krynica River (PL-5)
7 June 2003. HQA = 62; HMS = 0. MTR = 33; MIR = 44.
One survey (500m). 52°43'28.6"N; 23°44'27.6"E.

The Krynica rises eight km west of Białowieza. It is a tributary of the Latownia and at PL-5 is a heavily-shaded stream flowing through lightly-managed mixed woodland. Extensive silting along the water's edge probably reflects logging operations and construction of an embanked forestry access track further upstream. It was very difficult to assess whether the features were genuine side bars or simply silt deposits along the margins exposed by the very low water level at the time of survey *(see also PL-2)*. Abundant nettles *(Urtica dioica)* on the banks suggested recent disturbance.

Despite heavy shading, there is luxuriant macrophyte growth almost choking the channel in some places. The dominants were a mixture of yellow water-lily *(Nuphar lutea)* and unbranched bur-reed. This was the second site in Poland where the starwort *Callitriche cophocarpa* was found, a species absent in the UK. The MTR site was chosen where the dominant taxa within the whole 500m (see Appendix 10) did not exclude other taxa. As a result taxa typical in Poland, but rare in UK rivers, such as cowbane *(Cicuta virosa)* and bog arum *(Calla palustris)* were recorded. Wood club-rush *(Scirpus sylvaticus)* was the dominant marginal, presumably because it is more shade-tolerant than reeds or sedges. The MTR score was low compared with the Polish MIR score (33; 44); the higher scores derived by the Polish methods is due to the inclusion of marginal taxa that are excluded in the UK system and the two dominant taxa, unbranched bur-reed and yellow water-lily, with increased STRs.

Narew River (PL-6 and 7)
7 June 2003. HQA = 41, 47; HMS = 0, 0.
MTR = 38; MIR = 43.
Two back-to-back surveys (1 km). 52°54'16.2"N; 23°54'13.8"E, and 52°54'14.6"N; 23°53'53.7"E.

The source of the Narew is located in a large wetland about eight km south of Novy Dvor in western Belarus. For its first 12 kms the river has been straightened and forms part of the Skaronau Kanal; in addition, an extensive network of drainage channels discharge into the river via the Kanal Motyljou.

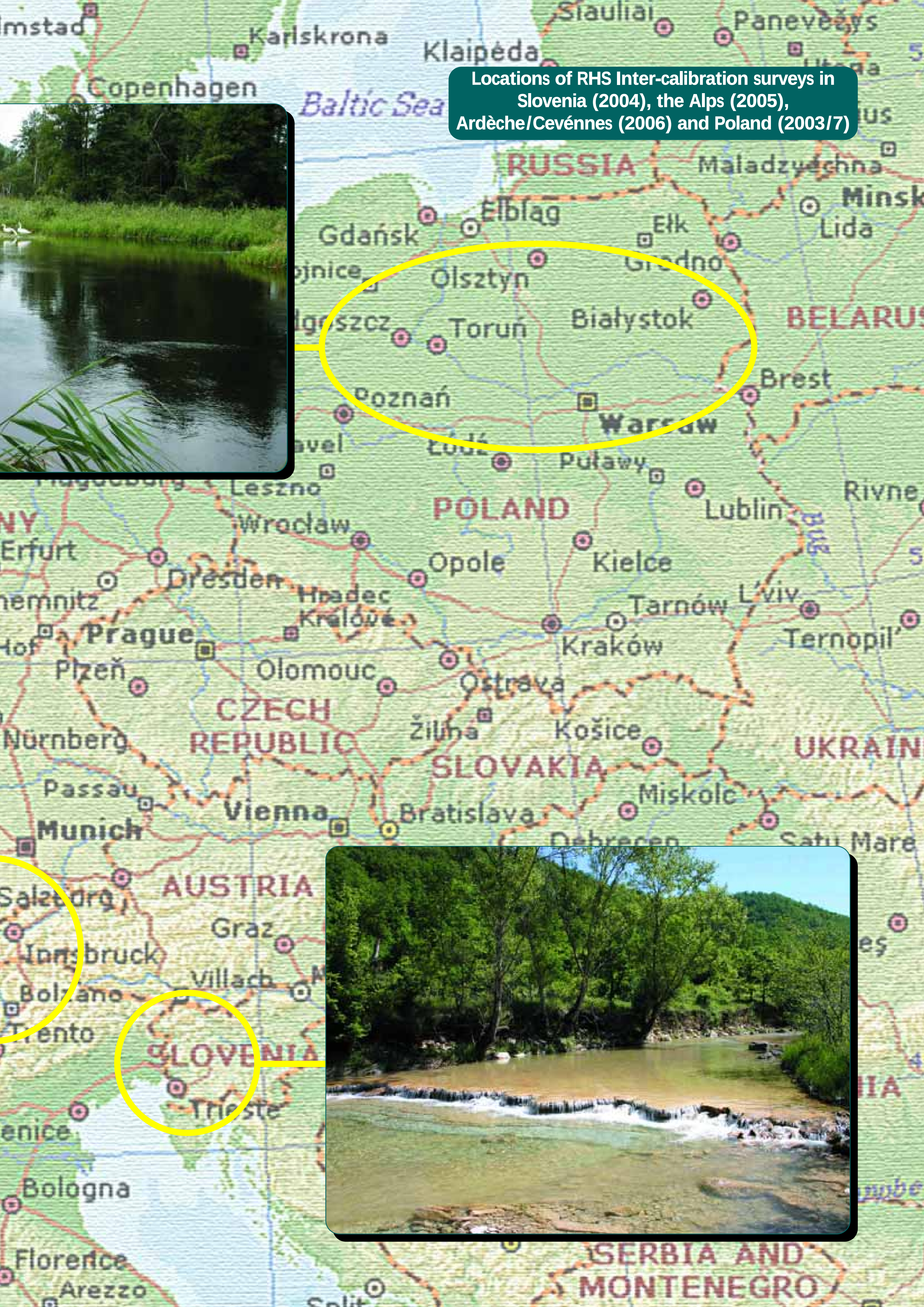
At PL-6 and 7, about 45km from its source, the river is a meandering, low gradient channel flowing through very extensive fen habitat. The survey site is less than 1km upstream from the Siemianowka reservoir (30km^2 surface area), but because of the very gentle gradient the impact on flow is likely to be negligible, particularly since point bars were a feature of the downstream survey site. The treeless banks and extensive fen contribute to a wetland landscape typical in this part of eastern Poland.

A single MTR site was surveyed in PL-6 because of difficulties caused by the deep water and sand substrates. Despite difficulty of survey, 23 Polish check-list taxa were recorded (adding seven to the UK MTR check-list). Some

Dense macrophyte growth typified the Narew at PL-6.

Typical fenland landscape along the upper Narew; PL-7.

Glasgow
Viborg
DENMARK
Southampton
Brussels
English Channel
BELGIUM
Düsseldorf
Fulda
Amiens
Koblenz
Frankfurt
Le Havre
Saarbrücken
Stuttgart
Strasbourg
Bern
SWITZERLAND
MASSIF
Lyon
St.-Étienne
Aosta
Milan
Bordeaux
Turin
CENTRAL
Gap
ITALY
San Sebastián
Toulouse
Genoa
Montpellier
Pamplona
Monaco



Locations of RHS Inter-calibration surveys in Slovenia (2004), the Alps (2005), Ardèche/Cevénnes (2006) and Poland (2003/7)

The dominant macrophyte on the Narew at PL-6 was *Potamogeton natans.*

Backwaters in PL-7 had rich macrophyte communities; *Potentilla palustris* was common.

of the additional taxa were marginals, but those such as tufted loosestrife *(Lysimachia thyrsiflora)*, fine-leaved water-dropwort *(Oenanthe aquatica)* and greater spearwort *(Ranunculus lingua)* are much more common in Polish rivers, especially where they flow through historic fen landscapes. Good macrophytes were found in small ponded habitats in the floodplain.

Pisa River (PL-8,9,10 and 11)
27 August 2007. HQA = 68, 66, 38, 42. HMS = 0(1), 0(1), 350(3), 20(2). MTR = 34^{8}, 36^{10}, 36^{11}; MIR = 36^{8}, 38^{10}, 36^{11}.
One back-to-back survey (PL-8 and PL-9) (1km), plus two individual 500m sites (PL-10 and PL-11).

(PL-8) 53° 33' 20.5" N; 21° 50' 34.6" E.
(PL-9) 53° 33' 11.5" N; 21° 50' 23.6" E.
(PL-10) 53° 27' 33.5" N; 21° 51' 58.4" E.
(PL-11) 53° 20' 44.7" N; 21° 47' 27.0" E.

The Pisa River rises in the Great Mazurian Lakes and flows through Lake Ros near Pisz, joining the Narew River a further 180 kms downstream. The Dybowka, as the main tributary flowing into Lake Ros, was used in assumptions regarding altitude of source and distance to our survey sites. Using distance from source as a surrogate for discharge is rather meaningless for the Pisa because of the complicated series of inter-connected large lakes that discharge into the Ros lake from the Mazurski and Krajobrazowy Landscape Park areas.

For most of its course the Pisa exhibits active meandering, with several ox-bows and back channels evident on large-scale maps (Appendix 8). The river at PL-8 and 9 illustrates these characteristics by way of extravagant meanders and associated wetland and wet woodland habitats. The river here is characterised by strong, groundwater-fed flow with powerful upwellings, producing large pools on the outside and submerged sand bars on the inside of the tightest meander bends. Active erosion and lateral channel movement has led to the development of extensive natural berms and terraces, densely vegetated with *Phragmites* reeds and colonised by alders *(Alnus glutinosa)*. There are few channel features, so habitat diversity is largely confined to the bank and in the floodplain where remnant channels provide a good haven for riparian wildlife. Wet woodland and a good variety of macrophytes add to the habitat diversity of this reach.

About 15km further downstream (PL-10), the river meanders through a landscape of improved pasture; here the channel has been modified by construction of a bridge. A further 25km downstream, (PL-11) the Pisa floodplain is grazed by cattle, with marshy hollows marking relic channel meanders. Active erosion means that the sandy banks easily collapse. The river here is like a smaller version of the Biebrza (*see PL-3 and PL-4*) and interestingly has several physical characteristics of the Hampshire Avon in Southern England and the Unshin River in Ireland.

Sandy margins can become vegetated to form natural berms; PL-8.

Dense reed growth on natural berm/terrace; PL-8.

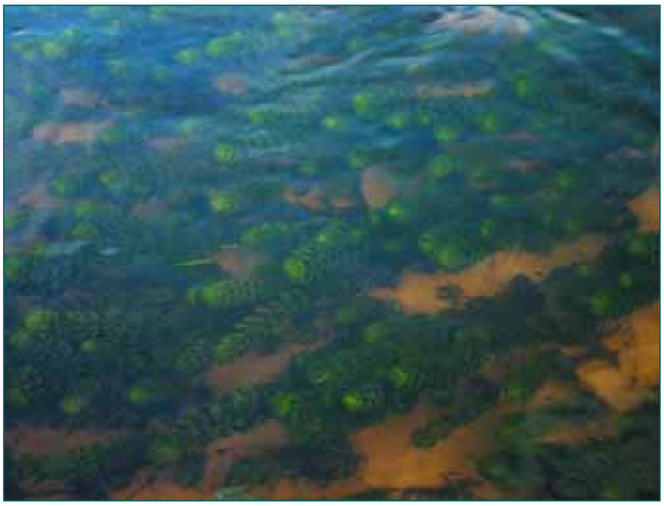
Natural berm/terrace features, plus a small wetland marking an old cut-off channel on the left; PL-10.

Actively meandering channels produce sandy point bars, with natural berms forming behind; PL-10.

Three MTR sites (in PL-8, 10 and 11) were surveyed as well as three JNCC sites that covered the identical areas as the RHS sites in PL-8, 10 and 11. All three sites had areas where the channel was easily accessible, but nowhere was it possible to wade across the entire channel. For all three sites, using three combinations of scoring, the range of MTR scores was 33-38. This suggests enriched nutrient levels in the water. This may not be a true reflection since the scoring taxa are all lowland plant species, associated with low velocity and fine sediments that have co-variance with higher nutrient levels.

All sites had species-rich communities recorded (Appendix 9, 10). PL-11 was structurally the most diverse and supported the richest macrophyte community. There were many similarities between the sites; reed sweet-grass *(Glyceria maxima)* always present as a dominant species at the margins, and the strap-leaved form of arrow-head *(Sagittaria sagittaria)* and unbranched bur-reed *(Sparganium emersum)* were well represented in the channel. All sites supported river water-crowfoot *(Ranunculus fluitans)*; this species was not recorded at any other survey sites visited in Poland in 2003 and 2007. Areas of sluggish flow in PL-8 resulted in water soldier *(Stratiotes)* being present. In PL-10 grass-wrack pondweed *(Potamogeton compressus)* was found; this is generally rare in the UK but has been increasing in recent years in rivers as a result of improved water quality (e.g. in the River Trent).

Major bridge structure on the Pisa River at PL-10.



Ceratophyllum firmly rooted on accreting sand substrate; PL-11.

Vegetated point bar and eroding banks on the meandering Pisa; PL-11.

Google Earth image of the Jegrznia, showing "necklace" pattern of narrow channels and wide pools; PL-12.

PL-11 was noteworthy for supporting taxa not found at the other sites. The sparse presence of yellow water-lily here, but not elsewhere, suggests that it does not thrive on sand substrate. Interestingly, flat-stalked pondweed *(Potamogeton friesii)* was confined to this site (although seen in other locations in Poland), whilst common hornwort *(Ceratophyllum demersum)* was found growing in swiftly-flowing water firmly rooted to the substrate, actively accreting sand. This feature was similar to the growth of fan-leaved crowfoot in PL-1, a phenomenon not observed for either species in the UK.

Jegrznia and Elk Rivers (PL-12 and 13)
28 August 2007.
Two individual 500m sites. HQA = 32; 37.
HMS = 0(1); 0(1). MTR = 34[12], 38[13];
MIR = 36[12], 38[13].

(PL-12) 53° 37' 27.5" N; 22° 42' 11.5" E.
(PL-13) 53° 35' 24.1" N; 22° 42' 09.2" E.

The Jegrznia (as the Lega) and Elk rivers rise within 15km of each other, about 20km south of Gołdap. They flow in parallel catchments through several linear lakes and join up about 15km south east of Grajewo; the confluence is 130 km from each of their respective sources.

Large-scale maps and *Google Earth* show extravagant meanders and cut-off channels that suggest a similar hydrological and morphological character to the Pisa and Biebrza Rivers. However, major drainage channels six km upstream from PL-12 (the Kan Woznawieski) and 15km upstream from PL-13 (the Kan Rudzki) have effectively taken the natural stream energy out of both systems.

Both PL-12 (the Jegrznia) and PL-13 (Elk) are deep, peaty channels fringed with dense *Phragmites* reeds that encroach across the channel in places. The meandering and relic channels are therefore a historical reminder of how active these rivers would have been prior to construction of the two major drainage channels. The character is similar to the backwater channels of the Narew River near Waniewo that we explored by boat. Since morphologically, the channel and banks are virtually featureless, aquatic vegetation provides most of the diversity although otter *(Lutra lutra)* slides were of special interest.

The Jegrznia has enlarged circular open water patches, with narrower reed-infested 'necks' in between; this produces a necklace pattern. Apart from a solitary mature alder in PL-13 there are no bankside trees at either site, emphasising the man-made nature of the landscape. This is typical of the Biebrza National Park rich-fen meadow (grazed or cut in the summer), with reed-filled relic cut-off channels, and occasional woodland and scrub.

Dense fringing reeds narrow the channel and restrict bankside views of the river; PL-13.

"Necklace" pool seen at ground level; PL-12.

Water soldier *(Stratiotes aloides)* on the Elk River; PL-13.

Google Earth image showing extensive historic meandering and low intensity agricultural use along the Elk River; PL-13.

Both sites had MTR and JNCC surveys carried out, but neither can be considered entirely satisfactory because the channel was deep, with a soft bed. Observations were made from the bank, and grabbing vegetation from the channel using a grapnel. At both sites the flora was totally dominated by aquatic higher plants that were emergent, submerged or free-floating. The extremely sluggish flow resulted in a disproportionately large number of free-floating taxa being present, with water soldier, greater duckweed *(Spirodella polyrhiza)* and frogbit *(Hydrocharis morsus-ranae)* common; this association is typical of many fenland drainage systems in East Anglia. The presence of whorled water-milfoil *(Myriophyllum verticillatum)* was unique to this river system. Common reed was also so dominant at the margins it reduced the diversity of edge communities (to the point, in PL-13 of excluding reed sweet-grass and sedges). Other emergents, such as branched bur-reed *(Sparganium erectum)* and lesser bulrush *(Typha angustifolia)* are forced to grow within the channel due to this competition. Exceptionally vigorous stands of common reed in PL-13 also resulted in only 20 Polish check-list taxa being recorded compared with 33 in PL-12 where reeds were less pervasive.

Deep pools have fringing vegetation that floats over the surface; Jegrznia River.

Reed-fringed channel and recently-cut fen; Jegrznia river near PL-12.

APPENDIX 2: Characteristics of the rivers surveyed.

	Pilawa PL-1	Dobrzyca PL-2	Krynica PL-3	Biebrza PL-4, 5	Narew PL-6, 7	Pisa PL-8, 9, 10, 11	Jegrznia PL-12	Elk PL-13
Drift geology	Moraine	Moraine	Moraine	Moraine/alluvium	Moraine/alluvium	Moraine	Moraine/alluvium	Moraine/alluvium
Predominant land use	Forest	Forest	Forest	Meadow/ fen/marsh	Fen/marsh	Forest [8, 9]; Rough pasture [10, 11]	Meadow/fen	Meadow/fen
Valley shape	Concave / bowl	Concave / bowl	Shallow vee	Floodplain	Floodplain	Shallow vee[8, 9,10] Floodplain[11]	Floodplain	Floodplain
Valley relief	10m	20m	10m	10m	15m	15m[8, 9, 10]; 10m[11]	5m	5m
Altitude (mid-site)	98m	88m	153m	104m	145m	112m[8,9], 109m[10], 103m[11]	112m	111m
Channel slope (m/km)	0.98m/km	0.74m/km	1.0m/km	0.14m/km	0.4m/km	0.16m/km[8, 9], 0.23m/km[10, 11]	0.13m/km	0.12m/km
Distance from source (midpoint)	64.0km	65.0km	4.0km	135.0km; 135.5km	47.0km; 47.5km	60.0km[8]; 60.5km[9]; 76.0km[10]; 100.0km[11]	130.0km	130.0km
Height of source	160m	165m	160m	155m	162m	165m	225m	220m
Water width	7.5m	10.0m	2.0m	25.0m; 22.0m	12.0m; 12.0m	28.0m[8]; 40.0m[9]; 25.0m[10]; 29.0m[11]	16.0m	22.0m
Bankfull width	9.0m	11.0m	4.0m	26.0m; 23.0m	13.0m; 13.0m	38.0m[8]; 45.0m[9]; 26.0m[10]; 30.0m[11]	18.0m	30.0m
On-line lakes upstream? (number)	Yes (3)	Yes (1)	No	Yes (1)	No	Yes (2)	Yes (7)	Yes (8)
Predominant channel substrate	Sand	Sand	Sand	Sand	Sand	Sand	Peat	Peat
Predominant flow type	Rippled	Rippled	Rippled	Smooth*	Smooth	Smooth*	None perceptible	Smooth
Water quality class†	1	No data	No data	3	3	2	3	2
HQA	62	72	62	48; 55	41; 47	68[8]; 66[9]; 38[10]; 42[11]	32	37
HMS (and class)	0(1)	0(1)	0(1)	0(1); 30(1)	0(1); 0(1)	0(1); 0(1); 350(3); 20(1)	0(1)	0(1)
MTR (UK) score	33	37; 35	33	36; 37	386	34[8]; 36[10]; 36[11]	34	38
MIR score	46	42, 41	40	44	436	36[8], 38[10], 36[11]	36	38
Impacts on site	Negligible	Forestry	Forestry	Grazing; cut-off channels	Major reservoir downstream	Grazing [10, 11] Major bridge[10]	Bypass channel	Bypass channel
Protected Nature Area	No	No	Yes	Yes	No	No	Yes	Yes

* powerful smooth flow

† broad category 1 (excellent) - 5 (bad)

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

Site number (PL)	1	2	3	4	5	6	7	8	9	10	11	12	13
HQA sub-score category													
Flow-types	5	7	8	5	5	5	5	5	5	5	5	5	6
Channel substrates †	5	6	5	3	3	3	3	3	3	5	3	4	4
Channel features	2	0	0	0	0	1	1	1	1	1	1	0	0
Bank features	5	7	3	7	7	0	7	8	9	4	8	0	0
Bank vegetation structure	6	10	8	6	10	0	0	10	9	11	5	0	0
In-stream vegetation	9	10	5	9	7	11	10	7	7	9	7	11	11
Land-use ‡	13	11	14	4	7	14	14	14	11	1	4	3	3
Trees and associated features	11	13	14	3	4	0	0	11	10	0	1	0	1
Special features ‡	6	8	5	9	12	7	7	9	11	2	8	9	12
Total HQA score	**62**	**72**	**62**	**48**	**55**	**41**	**47**	**68**	**66**	**38**	**42**	**32**	**37**

† assumptions made regarding “not visible” entries

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

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

Site number (PL)	1	2	3	4	5	6	7	8	9	10	11	12	13
HMS score	0	0	0	30	0	10	10	0	0	350	20	0	0
Habitat modification class	1	1	1	2	1	1	1	1	1	3	2	1	1

APPENDIX 5: Selected habitat features and *ad hoc* observations of wildlife.

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

	Pilawa PL-1	Dobrzyca PL-2	Krynica PL-3	Biebrza PL-4, 5	Narew PL-6, 7	Pisa PL-8, 9, 10, 11	Jegrznia and Elk PL-12, 13
Habitat features							
Natural berms/terraces	E	P				E	
Fringing reedbeds	E	P		E	E	E	E
Relic channels				E		E	E
Fen		P		E	E		E
Wet woodland	P	E		P			
Wildlife observations							
Beaver *(Castor fiber)* (tree damage)	•		•	•			
Otter *(Lutra lutra)* slides		•				•	• [13]
Banded demoiselle *(Calopteryx splendens)*	•	•		•	•	•	
Black stork *(Ciconia nigra)*					•		
Black tern *(Chilidonius niger)*				•			
Corncrake *(Crex crex)*					•		
Crane *(Grus grus)*				•			
Green sandpiper *(Tringa ochropus)*			•				
Hoopoe *(Upupa epops)*	•						
Kingfisher *(Alcedo atthis)*	•						
Lesser spotted eagle *(Aquila pomarina)*					•		•
Marsh harrier *(Circus aeruginosus)*							•
Sand martin *(Riparia riparia)*						• [11]	
Snipe *(Gallinago gallinago)*						• [11]	
White stork *(Ciconia ciconia)*				•			
White-tailed eagle *(Haliaeetus albicilla)*							•
Yellow wagtail *(Motacilla flava)*						• [11]	

APPENDIX 6: Water chemistry at selected sites.

Values of acidity as pH (±0.2 units), calcium and magnesium hardness and nitrate were made on site using test papers. Single spot (unfiltered) water samples were collected in full sealed containers subsequently tested within 14 days for calcium and carbonate hardness by titration and with calibrated conductivity and pH meters at 16° C. Conductivity and acidity were again tested after 28 days.

Key: Nitrate: trace = <5mg/l; Total hardness scale as calcium carbonate: 'medium' = 125 - 250 mg/l.

Site reference	Acidity as pH (value after 1-3, 14 and (28) days, if changed)	Conductivity ($\mu S\ cm^{-1}$)	Total hardness (Ca & Mg as $CaCO_3$)	Calcium mg/l	Carbonate mg/l $CaCO_3$	Nitrate mg/l	Water colour
PL-9	7.5 - 7.35 (7.4)	375 (390)	Medium	58	135	0	Clear
PL-12	6.7 - 7.3 (7.7)	445 (460)	Medium	68	170	0	Clear- very slightly yellow brown
PL-13	7.2 - 7.5 (7.3)	460 (470)	Medium	74	180	0	Clear, but particles present
Narew (Waniewo)	7.5 - 7.2 (7.4)	500 (510)	Medium	82	200	Trace	Slightly yellow brown with particles
Świniobródka (T1)	7 - 7.25 (7.3)	310 (310)	Medium	55	120	0	Clear

In multi-thread channel and reedbed areas, it is essential to use aerial photographs.

APPENDIX 7: Recommendations for improving the RHS manual.

These recommendations are in addition to those made in the reports for Slovenia[19], Bavaria and Tyrolian Alps[18] and the Cévennes[20].

Recommendations

It is recommended that densely reed-lined channels and backwaters are surveyed using aerial photographs and a boat or canoe (‡). Spot-checks every 50m could be estimated using calibrated range-finders or GPS, with substrate in the channel and bank at spot-checks determined using a ranging pole, plumb-line or, in very deep channels, an echo-sounder.

It is recommended that multi-channel lowland rivers such as the Biebrza and the Narew in the Narwianski Park are surveyed using aerial photographs. A stratified random or systematic sampling strategy using boat-based 500m samples could be used to calibrate/ground-truth the results(‡).

It is recommended that in the spot-check section (Page 2 of the survey form) "TR" (artificial substrate) is moved from channel features to channel modifications.

It is recommended that natural impoundment (e.g. beaver dams, temporary dams caused by flood debris) is recorded in the sweep-up. We suggest "naturally impounded water" is inserted after 'marginal deadwater' and before 'eroding cliffs' on the list of channel and bank features in Section K. Surveyors would then be able to include present or extensive impoundment caused by beaver dams or temporary flood debris.

The text in the Guidance Manual needs to explain that beaver dams (and flood debris that completely blocks the channel) can cause significant changes in the habitat. The increase in beavers will be an important feature along Polish rivers, hence the need to record the effect and clear differentiation from artificial impoundment (Section D on page 1; DA in channel modifications spot-check in Section E, page 2).

Where natural impoundment occurs, the spot-checks under water will need to reflect the ponding of the water and submergence of the banks - so flow would be 'NV' (under water). Depending on visibility/clarity of the water, the banktop vegetation structure and land-use within 1m would also have to be 'NV'. A spot-check coinciding with a beaver dam itself would have to be recorded with a new acronym in the channel features - possibly 'BD' or Polish equivalent. Pictures illustrating these factors would need to be included in the Manual.

In countries where beavers occur, *it is recommended* that beaver dams are included in the special features section.

It is recommended that the Polish recording of present (✓) and extensive (L) is changed because both characters look like 'L' on completed forms.

It is recommended that the diagram of natural berm and terrace formation in actively-eroding channels (Figure B9 in the manual) is repeated alongside the sequence in Figure E4 to offer direct comparison with the process of natural recovery in over-widened, modified channels.

‡ Health and safety guidance for boat-handling must be followed.

Naturally impounded water caused by a beaver dam.

Active meandering produces extensive natural berm and terrace features in many Polish rivers.

APPENDIX 8: Maps showing PL-1 to PL-13 and the Świniobródka training site. Source: Mapa Topograficzna Polski Series.

PL-1

PL-5

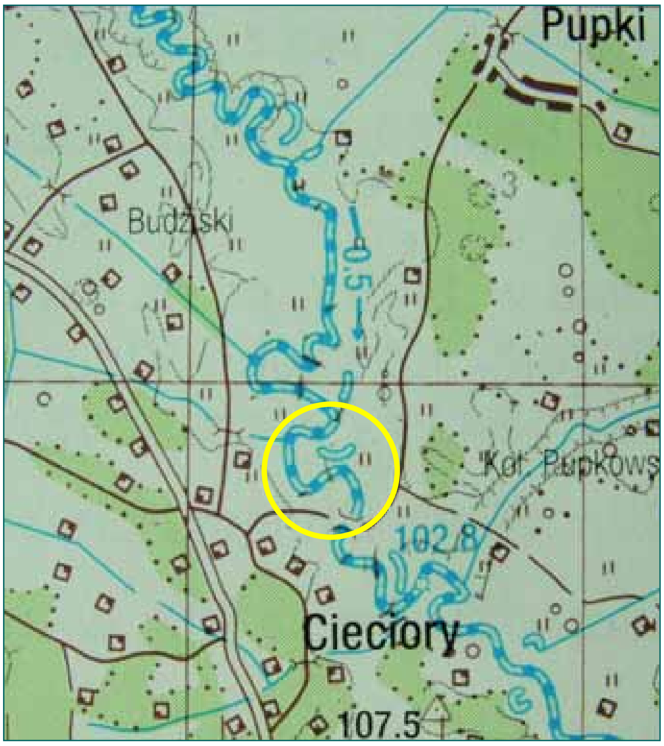
PL-6/7

PL-2

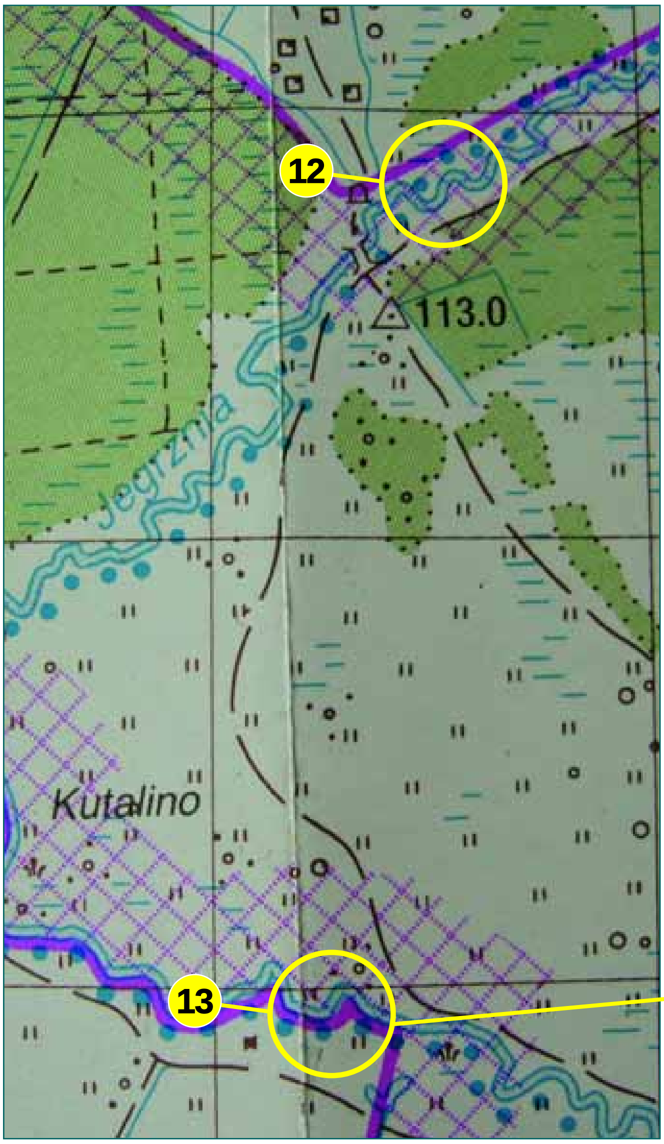
PL-3/4

PL-8/9

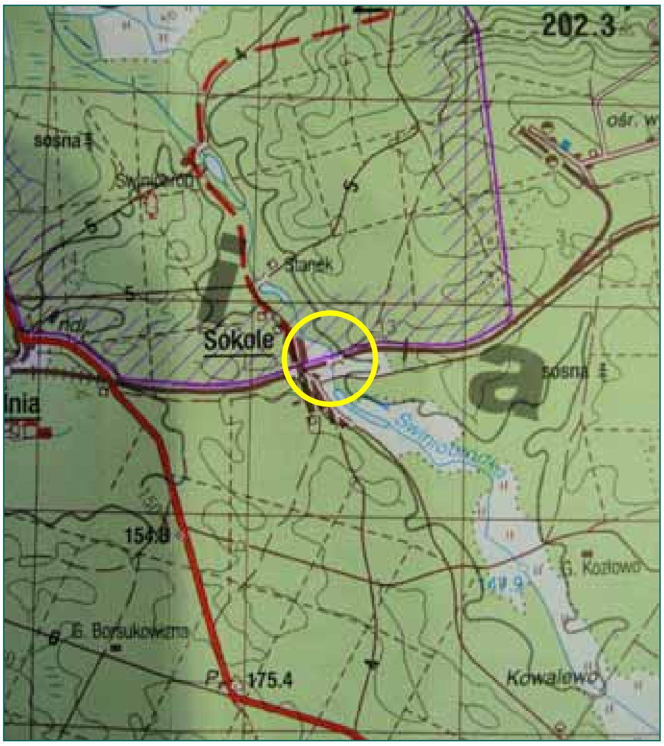
PL-10



PL-11



PL-12/13



T1 Training site

Google Earth

APPENDIX 9a. MTR scoring using the UK check-list and UK scoring protocol.

STR = Species Trophic Rank; SCV = Species Cover Value - scale 1-9; CVS = Cover Value Scores (STRxSCV)
(*) = Species given different STR in Polish system (see Appendices 9b/c); $ = Species deleted in Polish scoring system

Polish MTR Sites			PL-1		PL-2a		PL-2b		PL-3		PL-5		PL-6		PL-8		PL-10		PL-11		PL-12		PL-13		T-1	
UK Check-list of taxa and UK 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**
Acorus calamus	Sweet-flag	2	1	2		0		0		0		0		0		0		0	6	12		0		0		0
Alisma plantago-aquatica(*)	Common Water-plantain	3		0		0	1	3	1	3	1	3	1	3	1	3	1	3	1	4		0		0		0
Berula erecta(*)	Lesser Water-parsnip	5	1	5	2	10	3	15		0		0	1	5	1	5	1	5	2	10	2	10	6	30	6	30
Bryum pseudotriquetrum$	moss	9		0		0		0		0	1	9		0												
Butomus umbellatus	Flowering Rush	5		0		0		0	4	20		0		0		0	1	5	6	30		0		0		0
Calliergon cuspidatum	Moss	8		0		0		0		0		0		0		0		0		0		0		0	2	16
Carex acuta	Slender-tufted Sedge	5	3	15		0		0	1	5		0	4	20	1	5	1	5	1	5	1	5		0		0
Carex acutiformis(*)	Lesser Pond-sedge	3	4	12	1	3	1	3		0		0		0	1	3		0	2	6	2	6		0	6	18
Carex rostrata(*)	Bottle-sedge	7		0		0		0		0		0		0		0		0		0		0		0	1	7
Ceratophyllum demersum	Common Hornwort	2		0		0		0		0		0		0	3	6	1	2	4	8	3	6	3	6	2	4
Cladophora glomerata agg.	Blanketweed	1		0		0	1	1		0		0		0	3	3	1	1	2	2	1	1		0		0
Elodea canadensis	Canadian pondweed	5	4	20	2	10	3	15		0	1	5		0	3	15	1	5	5	25	1	5		0	3	15
Eleocharis palustris	Common Spike-rush	6		0		0		0		0		0		0		0		0	3	18		0		0		0
Equisetum fluviatile	Water horsetail	5	1	5	1	5		0	1	5		0	1	5												
Equisetum palustre	Marsh horsetail	5	1	5		0		0		0		0		0												
Fontinalis antipyretica(*)	Willow-moss	5	3	15		0	1	5		0		0		0												
Glyceria maxima	Reed Sweet-grass	3	2	6		0	2	6	5	15		0	4	12	7	21	5	15	5	15	3	9		0		0
Hildenbrandia rivularis	encrusting red alga	6	4	24		0	1	6		0		0		0												
Hydrocharis morsus-ranae	Frog-bit	6		0		0		0		0		0	1	6	1	6	1	6	1	6	1	6	5	30		0
Iris pseudacorus(*)	Flag-iris	5	2	10	1	5	1	5		0		0		0	1	5		0		0		0		0	1	5
Lemna minor(*)	Common Duckweed	4		0	1	4	1	4	1	4		0	1	4	1	4	1	4	1	4	2	8	2	8	3	12
Lemna trisulca	Ivy-leaved Duckweed	4	1	4		0		0		0		0	1	4	1	4		0	1	4	3	12	1	4	3	12
Leptodictyum riparium	moss	1	2	2	1	1	1	1		0	1	1		0												
Myriophyllum spicatum	Spiked Water-milfoil	3	2	6		0		0		0		0		0		0	1	3	2	6		0		0		0
Nuphar lutea(*)	Yellow Water-lily	3		0		0	2	6	1	3	5	15	4	12		0		0	1	3	6	18	3	9		0
Phragmites australis($)	Common- Reed	4											3	12	7	28			3	12	7	28	7	2	4	16
Potamogeton berchtoldii(*)	Small Pondweed	4	3	12		0		0		0		0		0												
Potamogeton crispus(*)	Curled Pondweed	3	2	6		0		0		0		0		0												
Potamogeton friesii	Flat-stalked Pondweed	3		0		0		0		0		0		0		0		0	1	3		0		0		0
Potamogeton obtusifolius	Blunt-leaved Pondweed	5		0		0		0		0		0		0		0		0		0	2	10		0		0
Potamogeton natans(*)	Broad-leaved Pondweed	5		0		0		0	1	5		0	6	30		0	1	5		0	2	10	3	15		0
Potamogeton pectinatus	Fennel Pondweed	1	1	1		0		0		0		0		0	3	3	1	1	2	2		0		0		0
Potamogeton perfoliatus	Perfoliate Pondweed	4	3	12		0		0		0		0		0		0	3	12	5	20		0		0		0
Ranunculus circinatus(*)	Fan-leaved Water-crowfoot	4	5	20		0		0		0		0	1	4		0		0		0	1	4		0	3	12
Ranunculus flammula	Lesser Spearwort	7		0		0		0		0		0		0		0		0		0		0		0	1	7
Ranunculus fluitans	River Water-crowfoot	7		0		0		0		0		0		0	1	7	3	21	2	14		0		0		0
Ranunculus trichophyllus(*)	Thread-leaved W-crowfoot	5	1	5		0		0		0		0		0												
Ranunculus sceleratus(*)	Celery-leaved Buttercup	3		0		0	1	3		0		0		0												
Rorippa amphibia(*)	Great Yellow-cress	4		0		0		0		0		0		0		0	1	4	1	4	3	12	3	12		0
Rumex hydrolopathum(*)	Great Water-dock	3	1	2		0		0		0		0	4	12		0	1	3	1	3	1	3		0		0
Sagittaria sagittifolia(*)	Arrowhead	3		0		0		0	6	18		0	4	12	2	6	2	6	2	6	4	12	3	12		0
Schoenoplectus lacustris(*)	Common Club-rush	3		0		0		0		0		0	2	6		0		0		0	2	6		0		0
Sparganium emersum(*)	Un-branched Bur-reed	3	1	3	7	21	6	18	4	12	5	15		0		0		0		0	1	6		0	4	12
Sparganium erectum	Branched Bur-reed	3	2	6	1	3	1	3	2	6	2	6	3	9	2	6	2	6	2	6	3	9	2	6	4	12
Spirodella polyrhiza	Great Duckweed	2		0		0		0		0		0	1	2		0	1	2	1	2	6	12	5	10	2	4
Typha angustifolia	Lesser Bulrush	3		0		0		0		0		0		0		0		0		0	2	6	2	6		0
Vaucheria sp(p.)(*)	Mole-pelt alga	1		0		0	1	1		0		0		0												
Veronica anagallis-aquatica	Blue Water-speedwell	4	1	4	1	4	1	4		0		0		0	1	4		0	1	4		0		0		0
Veronica catenata	Pink Water-speedwell	5		0		0		0		0		0		0		0		0		0	1	5		0		0
Sub-scores for calculating MTR Scores			**51**	**203**	**18**	**66**	**29**	**102**	**27**	**96**	**16**	**54**	**42**	**138**	**40**	**135**	**30**	**108**	**64**	**232**	**60**	**206**	**45**	**171**	**45**	**183**
MTR Scores from UK List and Scores			**40**		**37**		**35**		**36**		**33**		**38**		**34**		**36**		**36**		**34**		**38**		**41**	

APPENDIX 9b. Changed Species Cover Scores in Polish system, and differences resulting in scores from listings in Appendix 9a.

UK Check-list of taxa and UK Species Trophic Rank			PL-1		PL-2a		PL-2b		PL-3		PL-5		PL-6		PL-8		PL-10		PL-11		PL-12		PL-13		T-1	
UK Check-list of taxa and UK 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**
Alisma plantago-aquatica(*)	Common Water-plantain	4		0		0	1	4	1	4	1	4	1	4	1	4	1	4	1	4		0		0		0
Berula erecta(*)	Lesser Water-parsnip	4	1	4	2	8	3	12		0		0	1	4	1	4	1	4	2	8	2	8	6	24	6	24
Carex acutiformis(*)	Lesser Pond-sedge	4	4	16	1	4	1	4		0		0		0	1	4		0	2	8	2	8		0	6	24
Carex rostrata(*)	Bottle-sedge	6		0		0		0		0		0		0		0		0		0		0		0	1	6
Fontinalis antipyretica(*)	Willow-moss	6	3	18		0	1	6		0		0		0												
Iris pseudacorus(*)	Flag-iris	6	2	12	1	6	1	6		0		0		0	1	6		0		0		0		0	1	6
Lemna minor(*)	Common Duckweed	2		0	1	2	1	2	1	2		0	1	2	1	2	1	2	1	2	2	4	2	4	3	6
Nuphar lutea(*)	Yellow Water-lily	4		0		0	2	8	1	4	5	20	4	16		0		0	1	4	6	24	3	12		0
Potamogeton berchtoldii(*)	Small Pondweed	5	3	15		0		0		0		0		0												
Potamogeton natans(*)	Broad-leaved Pondweed	4		0		0		0	1	4		0	6	24		0	1	4		0	2	8	3	12		0
Ranunculus circinatus(*)	Fan-leaved Water-crowfoot	5	5	25		0		0		0		0	1	5		0		0		0	1	5		0	3	15
Ranunculus trichophyllus(*)	Thread-leaved W-crowfoot	5	1	5		0		0		0		0		0												
Ranunculus sceleratus(*)	Celery-leaved Buttercup	2		0		0	1	2		0		0		0												
Rorippa amphibia(*)	Great Yellow-cress	3		0		0		0		0		0		0		0	1	3	1	3	3	9	3	9		0
Rumex hydrolopathum(*)	Great Water-dock	4	1	4		0		0		0		0	4	16		0	1	4	1	4	1	4		0		0
Sagittaria sagittifolia(*)	Arrowhead	4		0		0		0	6	24		0	4	16	2	8	2	8	2	8	4	16	3	12		0
Schoenoplectus lacustris(*)	Common Club-rush	4		0		0		0		0		0	2	8		0		0		0	2	8		0		0
Sparganium emersum(*)	Un-branched Bur-reed	4	1	4	7	28	6	24	4	16	5	20		0		0		0		0	1	4		0	4	16
MTR Scores from UK List and Poland Scores			**42**		**39**		**38**		**39**		**39**		**38**		**33**		**38**		**37**		**35**		**36**		**41**	

APPENDIX 9c. MTR Scores using the Polish check-list of taxa and changes to UK Species Trophic Ranks. (+) = added taxa; (*) = changed STR.

Polish Check-list of taxa and Polish Species Trophic Rank			PL-1		PL-2a		PL-2b		PL-3		PL-5		PL-6		PL-8		PL-10		PL-11		PL-12		PL-13		T-1	
Acorus calamus	Sweet-flag	2	1	2		0		0		0		0		0		0		0	6	12		0		0		0
Alopecurus geniculatus(+)	Marsh Foxtail	4		0		0		0		0		0		0		0		0		0	1	4		0		0
Alisma plantago-aquatica(*)	Common Water-plantain	4		0		0	1	4	1	4	1	4	1	4	1	4	1	4	1	4		0		0		0
Berula erecta(*)	Lesser Water-parsnip	4	1	4	2	8	3	12		0		0	1	4	1	4	1	4	2	8	2	8	6	24	6	24
Butomus umbellatus	Flowering Rush	5		0		0		0	4	20		0		0		0	1	5	6	30		0		0		0
Calliergon cuspidatum	Moss	8		0		0		0		0		0		0		0		0		0		0		0	2	16
Callitriche cophocarpa(+)	Starwort	5		0		0	2	10		0	2	10		0		0		0		0		0		0	1	5
Caltha palustris(+)	Marsh Marigold	6		0		0		0		0		0		0		0		0		0		0		0	1	6
Carex acuta	Slender-tufted Sedge	5	3	15		0		0	1	5		0	4	20	1	5	1	5	1	5	1	5		0		0
Carex acutiformis(*)	Lesser Pond-sedge	4	4	16	1	4	1	4		0		0		0	1	4		0	2	8	2	8		0	6	24
Carex paniculata(+)	Great Tussock-sedge	5	1	5		0		0		0	1	5		0		0		0		0		0		0	2	10
Carex rostrata(*)	Bottle-sedge	6		0		0		0		0		0		0		0		0		0		0		0	1	6
Ceratophyllum demersum	Common Hornwort	2		0		0		0		0		0		0	3	6	1	2	4	8	3	6	3	6	2	4
Cicuta virosa(+)	Cowbane	6	1	6		0		0		0	1	6		0		0		0		0	1	6	1	6	2	12
Cladophora glomerata agg.	Blanketweed	1		0		0	1	1		0		0		0	3	3	1	1	2	2	1	1		0		0
Elodea canadensis	Canadian pondweed	5	4	20	2	10	3	15		0	1	5		0	3	15	1	5	5	25	1	5		0	3	15
Eleocharis palustris	Common Spike-rush	6		0		0		0		0		0		0		0		0	3	18		0		0		0
Equisetum fluviatile	Water horsetail	5	1	5	1	5		0	1	5		0	1	5												
Equisetum palustre	Marsh horsetail	5	1	5		0		0		0		0		0												
Fontinalis antipyretica	Willow-moss	6	3	18		0	1	6		0		0		0												

APPENDIX 9c. (continued)

Polish Check-list of taxa and Polish Species Trophic Rank			PL-1		PL-2a		PL-2b		PL-3		PL-5		PL-6		PL-8		PL-10		PL-11		PL-12		PL-13		T-1	
Glyceria fluitans(+)	Floating Sweet-grass	5		0		0		0	1	5	1	5	1	5		0	1	5	2	10	1	5		0	3	15
Glyceria maxima	Reed Sweet-grass	3	2	6		0	2	6	5	15		0	4	12	7	21	5	15	5	15	3	9		0		0
Glyceria notata(+)	Plicate Sweet-grass	5	1	5		0		0		0	1	5		0		0		0		0		0		0	2	10
Hildenbrandia rivularis	encrusting red alga	6	4	24		0	1	6		0		0		0												
Hydrocharis morsus-ranae	Frog-bit	6		0		0		0		0		0	1	6	1	6	1	6	1	6	1	6	5	30		0
Iris pseudacorus(*)	Flag-iris	6	2	12	1	6	1	6		0		0		0	1	6		0		0		0		0	1	6
Lemna minor(*)	Common Duckweed	2		0	1	2	1	2	1	2	2	4	1	2	1	2	1	2	1	2	2	4	2	4	3	6
Lemna trisulca	Ivy-leaved Duckweed	4	1	4		0		0		0		0	1	4	1	4		0	1	4	3	12	1	4	3	12
Leptodictyum riparium	moss	1	2	2	1	1	1	1		0	1	1		0												
Lysimachia thyrsiflora(+)	Tufted Loosestrife	7		0		0		0		0	1	7	1	7												
Mentha aquatica(+)	Water-mint	5	1	5		0	1	5	1	5	1	5	1	5	2	10		0	2	10	3	15	1	5		0
Myriophyllum spicatum	Spiked Water-milfoil	3	2	6		0		0		0		0		0		0	1	3	2	6		0		0		0
Myriophyllum verticillatum(+)	Whorled Water-milfoil	5		0		0		0		0		0		0		0		0		0	1	5	1	5		0
Nuphar lutea(*)	Yellow Water-lily	4		0		0	2	8	1	4	5	20	4	16		0		0	1	4	6	24	3	12		0
Oenanthe aquatica(+)	Fine-leaved Water-dropwort	5	1	5	1	5		0	1	5		0	1	5	1	5		0		0		0	1	5		0
Persicaria hydropiper(+)	Water-pepper	3		0		0		0		0		0		0	2	6	1	3	1	3	2	6	1	3	1	3
Phalaris arundinacea(+)	Reed canary-grass	2	1	2	1	2	1	2	3	6	1	2	3	6	1	2	2	4	2	4	2	4	2	4	1	2
Potamogeton berchtoldii(*)	Small Pondweed	5	3	15		0		0		0		0		0												
Potamogeton compressus(+)	Grass-wrack Pondweed	4		0		0		0		0		0		0		0	1	4		0		0		0		0
Potamogeton crispus(*)	Curled Pondweed	4	2	8		0		0		0		0		0												
Potamogeton friesii	Flat-stalked Pondweed	3		0		0		0		0		0		0		0		0	1	3		0		0		0
Potamogeton obtusifolius	Blunt-leaved Pondweed	5		0		0		0		0		0		0		0		0		0	2	10		0		0
Potamogeton natans(*)	Broad-leaved Pondweed	4		0		0		0	1	4		0	6	24		0	1	4		0	2	8	3	12		0
Potamogeton nodosus(+)	Loddon Pondweed	3		0		0		0	1	3		0		0												
Potamogeton pectinatus	Fennel Pondweed	1	1	1		0		0		0		0		0	3	3	1	1	2	2		0		0		0
Potamogeton perfoliatus	Perfoliate Pondweed	4	3	12		0		0		0		0		0		0	3	12	5	20		0		0		0
Ranunculus circinatus(*)	Fan-leaved Water-crowfoot	5	5	25		0		0		0		0	1	5		0		0		0	1	5		0	3	15
Ranunculus flammula	Lesser Spearwort	7		0		0		0		0		0		0		0		0		0		0		0	1	7
Ranunculus fluitans	River Water-crowfoot	7		0		0		0		0		0		0	1	7	3	21	2	14		0		0		0
Ranunculus lingua(+)	Great Spearwort	8		0		0		0		0		0	1	8		0		0		0		0		0	1	8
Ranunculus trichophyllus(*)	Thread-leaved W-crowfoot	6	1	6		0		0		0		0		0												
Ranunculus sceleratus(*)	Celery-leaved Buttercup	2		0		0	1	2		0		0		0												
Rorippa amphibia(*)	Great Yellow-cress	3		0		0		0		0		0		0		0	1	3	1	3	3	9	3	9		0
Rumex hydrolopathum(*)	Great Water-dock	4	1	4		0		0		0		0	4	16		0	1	4	1	4	1	4		0		0
Sagittaria sagittifolia(*)	Arrowhead	4		0		0		0	6	24		0	4	16	2	8	2	8	2	8	4	16	3	12		0
Schoenoplectus lacustris(*)	Common Club-rush	4		0		0		0		0		0	2	8		0		0		0	2	8		0		0
Scirpus sylvaticus(+)	Wood Club-rush	5	1	5		0	1	5		0	4	20		0	1	5		0	1	5	1	5		0	4	20
Sium latifolia(+)	Greater Water-parsnip	7		0		0	1	7	1	7		0	2	14												
Sparganium emersum(*)	Un-branched Bur-reed	4	1	4	7	28	6	24	4	16	5	20		0		0		0		0	1	4		0	4	16
Sparganium erectum	Branched Bur-reed	3	2	6	1	3	1	3	2	6	2	6	3	9	2	6	2	6	2	6	3	9	2	6	4	12
Spirodella polyrhiza	Great Duckweed	2		0		0		0		0		0	1	2		0	1	2	1	2	6	12	5	10	2	4
Stachys palustris(+)	Marsh Woundwort	2		0		0		0		0		0		0		0		0		0	2	4	1	2		0
Stratiotes aloides(+)	Water Soldier	6		0		0		0		0		0		0	2	12		0		0	2	12	5	30		0
Typha angustifolia	Lesser Bulrush	3		0		0		0		0		0		0		0		0		0	2	6	2	6		0
Utricularia vulgaris+	Bladderwort	5		0		0		0		0		0		0		0		0		0		0		0	1	5
Vaucheria sp(.)(*)	Mole-pelt alga	2		0		0	1	2		0		0		0												
Veronica anagallis-aquatica	Blue Water-speedwell	4	1	4	1	4	1	4		0		0		0	1	4		0	1	4		0		0		0
Veronica catenata	Pink Water-speedwell	5		0		0		0		0		0		0		0		0		0	1	5		0		0
Sub-scores for calculating MTR Scores			**58**	**245**	**20**	**79**	**34**	**1345**	**35**	**137**	**30**	**125**	**49**	**204**	**42**	**148**	**35**	**129**	**69**	**255**	**69**	**250**	**51**	**195**	**60**	**263**
MTR Scores from Poland List and Scores			**43**		**39**		**39**		**39**		**44**		**41**		**36**		**38**		**37**		**37**		**39**		**44**	

Appendix 9d. Summary of comparative MTR scores derived through application of variations in methods.

Polish MTR Sites	PL-1	PL-2a	PL-2b	PL-3	PL-5	PL-6	PL-8	PL-10	PL-11	PL-12	PL-13	T-1
MTR Scores from UK List and scores	40	37	35	36	33	38	34	36	36	34	38	41
MTR Scores from UK List and Poland scores	42	39	38	39	39	38	33	38	37	35	36	41
MTR Scores from Poland List and scores	43	39	39	39	44	41	36	38	37	37	39	44
Scores derived using the MIR Polish weighting system	45	41	41	40	43	43	36	38	36	36	39	44

Appendix 10: JNCC macrophyte survey results.

Figures (scale 1-3) are relative, and absolute, estimates of cover within the river channel (first two figures) and the second two figures are estimates for the margin. For details see[2]. For the Narew, the column lists taxa seen from the boat - R = Rare; O = Occasional; F = Frequent; A = Abundant; D = Dominant.

		PL-1	PL-2	PL-3	PL-5	PL-6	PL-8	PL-10	PL -11	PL-12	PL-13	Narew
Hildenbrandia rivularis	Red alga	3300	1100									
Vaucheria sp(p.)	Mole-pelt alga	1100										R
Cladophora glomerata	Blanket Weed		1100				2200	2200	1100	1100		
	Other filamentous algae			1100								
Chara sp(p.)	charophyte	3300										
Verrucaria	Encrusting lichen	2200										
Conocephalum conicum	liverwort				11							
Marchantia polymorpha	liverwort				11							
Amblystegium fluviatile	moss				1111							
Fontinalis antipyretica	Willow-moss	3311	1111									
Leptodictyum riparium	moss	2200	1100		1111							
Equisetum fluviatile	Water Horsetail	1111	1111	1111		2211		1100	1111			R
Equisetum palustre	Marsh Horsetail	1111	1111	1111		11			1111			
	ferns	11	11		2133	11	11	11	1122	1122	11	
Achillea ptarmica	Sneezewort						11	11	1122	1122	11	
Angelica sylvestris	Angelica		11				11					
Berula erecta	Lesser Water-parsnip	2211	4422	1111	1111	1111	1111	1112	1111	3323	2311	A
Bidens cernua	Nodding Bur-marigold						11	11	11			O
Bidens tripartita	Tripartite Bur-marigold				1144	11	11	11	1111	1111		
Caltha palustris	Kingcup	11		11	1122	1111			1111	11		
Cardamine amara	Large Bitter-cress		22									O
Ceratophyllum demersum	Common Horwort			1100			2200	2200	3300	2200	2200	O
Epilobium hirsutum	Great Willow-herb				1111	1111	11	11				O
Eupatorium cannibinum	Hemp Agrimony	1111	22		1133	1122	11	11	11	11	11	
Filipendula ulmaria	Meadowsweet	11	11		1122	1122	11		11	11		
Galium palustre	Marsh Bedstraw	11	1122	11	1133	1122		1111	11	1111		O
Lycopus europaeus	Gipsywort		1122	1111	1111	1111	1122	1122	1122	1122	1111	O
Lysimachia vulgaris	Yellow Loosestrife		1122	1111	1122	1122	1111	11	1111	11		R
Lythrum salicaria	Purple Loosestrife	1111	11	1111	1122	1111	11	11	1122	11	1111	O
Mentha aquatica	Water Mint	1122	2222	1121	1122	1122	1111	1112	1111	1122	1111	O
Myosotis scorpioides	Water Forget-me-not	1111	1122	1121	1111	1111	1111	2211	1111	1111	1111	F
Myosoton aquaticum	Water Chickweed		11		11		1111	1111	1111	11	1111	
Myriophyllum spicatum	Spiked Water-milfoil	3300						2100	2200			
Nuphar lutea	Yellow Water-lily		2200	1100	3300	3300	1100		1100	2300	2200	O
Nymphaea alba	White Water-lily										1100	O
Persicaria amphibium	Amphibious Bistort			2111		1111	1111	1111	2211	2211	1111	R
Persicaria hydropiper	Water-pepper						1111	1111	11	2211	1111	R
Potentilla palustris	Marsh Cinquefoil	1111		1111		1111						R
Ranunculus circinatus	Fan-leaved Water-crowfoot	3300		1100		1100				1100		R
Ranunculus flammula	Lesser Spearwort								1100			
Ranunculus fluitans	River Water-crowfoot	1100					1100	1100	2200			
Ranunculus sceleratus	Fine-leaved W-crowfoot	1111	1111	11								
Ranunculus trichophyllus	Celery-leaved Crowfoot	1100										
Rorippa amphibia	Great Yellow-cress			3221		3322	1111	1111	1122	2322	2211	R
Rorippa palustris	Marsh Yellow-cress							11	11			
Rumex hydrolopathum	Great Water-dock	1111	1111	2121		1111	1111	11	1111	1111	1111	O
Scrophularia auriculata	Water Figwort	22	11	11	22	11				11	11	R
Scutellaria galericulata	Skullcap	11	11		11	11				11		
Senecio aquaticus	Marsh Ragwort				11							
Solanum dulcamara	Bittersweet	11	1111	1111	1111	1111	1122	1111	1111	1122	1111	R
Stachys palustris	Marsh Woundwort	11	1111	1111		2122	1111	1121	1122	2222	2211	F
Symphytum officinalis	Comfrey	11	11		11		11	11		1111	1122	
Veronica anagallis-aquatica	Blue Water-speedwell	1100		1111			1111	11	1111			
Veronica beccabunga	Brooklime		111	1111	1122							
Veronica catenata	Pink Water-speedwell									11		
Alnus glutinosa	Alder	1133	1133	11	1122		11	11	11			
Salix spp.	Willow	1111		1122	1111	1111	1111	11	11			R
	Trees	1122	1122	1111	1133		11	11				
	Other Dicotyledon species	1122	1122	1121	1133	1111	1122	1122		11	11	

Appendix 10: JNCC macrophyte survey results (continued).

Figures (scale 1-3) are relative, and absolute, estimates of cover within the river channel (first two figures) and the second two figures are estimates for the margin. For details see[2]. For the Narew, the column lists taxa seen from the boat - R = Rare; O = Occasional; F = Frequent; A = Abundant; D = Dominant.

		PL-1	PL-2	PL-3	PL-5	PL-6	PL-8	PL-10	PL- 11	PL-12	PL-13	Narew
Acorus calamus	Sweet-flag	1111	11	1111				1111	2222	1111		R
Alisma plantago-aquatica	Common Water-plantain	1111	1111	1111	1111	1111	1100	1111	1111			R
Alopecurus geniculatus	Marsh Foxtail			11	11			1111	1111	1111		R
Butomus umbellatus	Flowering Rush			2311				2211	22			R
Carex acuta	Slender Tufted-sedge	2233	1122	1111	1111	2233	1111	11	1111	1111	1111	R
Carex acutiformis	Lesser Pond-sedge	2233	1133				1122	2223	2223	1122	1111	F
Carex hirta	Hairy-sedge							1111	1111	11		
Carex paniculata	Great Tussock-sedge	1111			1111							R
Carex remota	Remote Sedge				11							
Carex rostrata	Bottle Sedge					1122	1111					
Carex riparia	Greater Pond-sedge									1111	1111	F
Carex vesicaria	Tufted Hair-grass					1111	1111					
Deschampsia cespitosa	Bottle Sedge		11				1111					
Eleocharis palustris	Common Spike-rush			1111		1111		1111	1122			
Elodea canadensis	Canadian Pondweed	3300	3300	1100	1100		1100	2200	2200	1100		R
Glyceria fluitans	Floating Sweet-grass			1111	2222	2222	1111	1111	1111	1111		R
Glyceria maxima	Reed Sweet-grass	1122	1122	3232		3322	3223	3233	3333	2323		F
Hydrocharis morsus-ranae	Frog-bit					1100		1100	1100	2200	2300	F
Iris pseudacorus	Yellow Flag	1122	1122	1111	1111	11	1111	1111	1111	1111	1111	R
Juncus acutiflorus	Sharp-flowered Rush				1111		1111	1122	1122	1111		
Juncus effusus	Soft Rush				1122			11	11			R
Juncus inflexus	Hard Rush			11				11				
Lemna minor	Common Duckweed		2211	1100	2211	2200	1100	2200	2200	2200	2200	F
Lemna trisulca	Ivy-leaved Duckweed	1100				1100	1100	1100	1100	2200	1100	A
Phalaris arundinacea	Reed Canary-grass	11	1133	2233	1122	2233	1122	2233	2222	1122	1122	F
Phragmites australis	Common Reed			2233		2233	3233	1112	2222	3333	3333	D
Potamogeton berchtoldii	Small Pondweed	2200										R
Potamogeton crispus	Curled Pondweed	2200		1100								R
Potamogeton friesii	Flat-stalked Pondweed									1100		
Potamogeton lucens	Shining Pondweed			1100								R
Potamogeton natans	Broad-leaved Pondweed			1100		2200		1100		2300	2200	O
Potamogeton nodosus	Loddon Pondweed			2100								R
Potamogeton obtusifolius	Blunt-leaved Pondweed									2200		O
Potamogeton pectinatus	Fennel Pondweed	2200					2200	3200	2200			
Potamogeton perfoliatus	Perfoliate Pondweed	2200						3200	3300			
Potamogeton praelongus	Long-stalked Pondweed									1100		
Potamogeton pusillus	Lesser Pondweed											R
Potamogeton trichoides	Hair-like Pondweed			1100								R
Sagittaria sagittifolia	Arrowhead			3311		2200	1100	2211	2200	2200	2200	A
Scirpus/Schoenoplectus lacustris	Club-rush/Bulrush			1100		2100		1111		1100		R
Scirpus sylvaticus	Wood Club-rush	1122		3233			1122	1122	1122			R
Sparganium emersum	Unbranched Bur-reed	1100	3300	3311	3322	1100			1100	2200	1100	O
Sparganium erectum	Branched Bur-reed	2222	1100	2211	2222	1111	2200	2200	2200	2211	2211	F
Spirodella polyrhiza	Great Duckweed			1100		1100	1100	2200	1100	2300	2300	A
Typha angustifolia	Lesser Bulrush						1100			2222	1111	A
Typha latifolia	Bulrush	11		1111	1111	1111						F
Typha hybrid												F
	Monocotyledons not aquatic	1122	1122	1122	1122	2222	1122	1133	1133	1122		
Non Check-list species present (if not recorded in Appendix 9)												
Agrostis stolonifera	Creeping Bent	1111		1111	1122	1122	1111	2233	1122	2211	2222	O
Equisetum arvense	Creeping Horsetail				11		11	11	11			
Bidens frondosa	Beggarticks (alien)						11	11	11			R
Calla palustris	Bog Arum				1111							
Carex pseudocyperus	Cyperus-sedge	1111										
Cicuta virosa	Cowbane											O
Cyperus fuscus	Brown Galingale							11	11			
Juncus bufonius	Toad Rush							11	11			
Lychnis flos-cuculi	Ragged-robin				1111				11			
Impatiens noli-tamgere	Touch-me-not Balsam		1122		1133							
Impatiens parviflora	Small Balsam (alien)		22				11					
Myosotis palustris	Marsh For-get-me-not						1111					
Spongilla lacustris	Lake sponge									1100	1100	
Thalictrum flavum	Meadow Rue						11	11	11	11		
Valeriana dioica	Marsh Valerian		11									

Source: Central Intelligence Agency

APPROXIMATE LOCATIONS OF SITES SURVEYED

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