The Waterways Bird Survey

An Evaluation and Appraisal of its Future Role

British Trust for Ornithology

R&D Technical Report W22

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SUMMARY

The requirements for biological surveys of rivers, particularly for birds, are established and then examined in relation to schemes that currently collect such data. Bird surveys are required by statutory and voluntary conservation bodies, and also by the Environment Agency for fulfilling its conservation objectives. Bird monitoring at national, regional and catchment scales provides a necessary background to survey results at particular sites and enables local causes, for example waterway management, to be distinguished from those that are widespread.

Recommendations are made for improving the match between requirements and methodology for bird surveys along rivers, particularly by redesigning the methodology of the British Trust for Ornithology's Waterways Bird Survey in line with current needs of the statutory conservation bodies and the Environment Agency at national, regional, catchment and individual river section levels. WBS as currently formulated provides monitoring data but the representativeness of waterways could be improved. Using a random sample, and in particular linking WBS to the River Habitat Survey, would improve the monitoring of population trends and allow more comprehensive modelling of bird distributions along waterways. Monitoring programmes should be supplemented by bird surveys designed to assess the relative conservation value of waterway stretches and the effects of river management.

KEY WORDS

waterways, rivers, bird survey, bird population, habitat.

1. INTRODUCTION

This report examines the value of the British Trust for Ornithology's Waterways Bird Survey (WBS) as it is currently formulated and possible changes to its role, in particular in relation to the current and future requirements of the Environment Agency (incorporating NRA, the former National Rivers Authority). It follows from an earlier BTO report to NRA which examined the ability of WBS to measure bird population trends, with special reference to the Severn-Trent Region (Marchant & Gregory 1994).

The main stimuli which gave rise to the present study were:

- the BTO's need to review its current WBS scheme to improve its scope and organisation, make it a better supplement to the new Breeding Bird Survey (BBS) programme and to increase its value to outside interests; and

- the Environment Agency's need to appraise the appropriateness and value of its bird survey work in the light of its statutory commitment to furthering conservation and its need to report regularly on progress in this area.

1.1 Objectives of this study

The overall objective of this report is:

- to evaluate the use of the WBS to provide regional and national monitoring of waterbirds and to augment site-specific appraisal of river works.

More specific objectives are:

- to interrogate the WBS and BBS databases to determine their effectiveness for measuring changes in waterbird populations, in relation to the Environment Agency's catchment management; and

- to review the methodologies of WBS, BBS, RCS and RHS to identify potential links for development, in collaboration with the Environment Agency.

A glossary of the various acronyms and abbreviations used in this report is given in Appendix 1. Scientific names of bird species are listed in Appendix 2.

2. RATIONALE FOR CENSUSING WATERBIRDS

Birds are relatively easy to census for skilled fieldworkers, and there is a substantial amount of information concerning their habitat requirements. Consequently, changes in bird distribution and population size can be considered either in isolation or in relation to habitat features. There are several bird monitoring schemes operating in the UK which provide measures of annual population change. Different habitats and bird species present their own special problems in terms of developing suitable methodology for censuses - hence the evolution of several schemes that cover different ranges of habitats and species.

Freshwater habitats are of special importance in terms of their biodiversity. To assess the conservation importance of freshwater sites requires information on species diversity, frequency of occurrence and habitat use by different taxa. Waterbirds are an important component of freshwater systems. Many bird species are dependent on water bodies and their fringes for nesting, feeding or roosting and others, though widespread, are attracted to the habitat types and special feeding opportunities that exist in the waterside environment. The establishment by the BTO of WBS in 1974 was in recognition of the special nature of waterways.

2.1 Birds as indicators of waterway habitat quality

The value of bird censusing would be severely limited if the distribution of many bird species along rivers and canals were independent of habitat quality. However, evidence from various sources is available to demonstrate that strong links exist between breeding bird numbers and the nature of the available habitat; this evidence is summarised below. That there are such links greatly enhances the value of bird surveys for monitoring the overall quality of river systems. It also demonstrates that birds are sensitive to management operations and that bird censuses can therefore be of value for post-project appraisal. Some of this evidence comes from the WBS itself, although relatively little study has been made of this aspect of WBS data as opposed to the measurements of population trends.

Using an example from the BTO's Common Birds Census (CBC), Williamson (1971) showed the effects on seven waterside species of dredging and bank clearance operations along the River Stour at Hammoon in Dorset. Three years after the work had been carried out, the numbers of Kingfishers, Reed Warblers and Sedge Warblers were still depleted compared with the three seasons immediately preceding the clearance. Sedge Warbler in particular showed a marked movement away from the main river into adjacent hedgerow ditches. The management operations totally removed the nesting site for a pair of Kingfishers and all potential Sand Martin nesting sites along the stretch.

A single-season study along the River Wye in 1977 enabled a comparison to be made of a managed stretch with an adjacent stretch of unmanaged river (Williams 1980). On 10.5 km of managed river there were 11 breeding species and (excluding Sand Martin) an overall density of 43 territories per 10 km, compared with 25 species and 146 territories per 10 km along the unmanaged stretch. Using such examples, RSPB and RSNC have published a

Rivers & Wildlife Handbook giving advice on management practices which further wildlife conservation on rivers (Lewis & Williams 1984, RSPB *et al.* 1994).

Marchant & Hyde (1980) recorded the relationships between waterbird density and both altitude and river gradient, using data from the initial years of the survey. They also included an example where intervention in the form of dredging and re-grading of 3.9 km of the River Ravernet in Co. Antrim was the apparent cause of a drop in numbers of Moorhen territories from five to one between the breeding seasons of 1975 and 1976. Also using WBS data, Taylor (1984) linked a decrease in Moorhen breeding success to the effects of river management.

A particularly focused example comes from the studies of Dippers and Grey Wagtails on rivers in upland Wales in relation to the acidity of the water (Ormerod & Tyler 1987, 1991; Tyler & Ormerod 1991). They present evidence that the distribution of Dipper, but not Grey Wagtail, is strongly linked to stream acidity, with lowest densities on the most acid streams. Low invertebrate densities and low calcium availability have both been implicated in reduced Dipper breeding performance at acidic sites (Tyler & Ormerod 1992).

In a general review, Ormerod & Tyler (1993) give examples of the value and limitations of using birds as indicators of water quality change. They point out that the effects of changing water quality on biological systems are often the reason for there being quality standards, and that birds themselves are an important conservation resource. More general assessments are needed of the relationships between birds and water pollution.

Rushton *et al.* (1994) took habitat and bird data, both collected in 1982, for 837 500-metre WBS stretches, and compared them using detrended correspondence analysis (DCA) and generalised linear modelling. They found that water quality, and DCA habitat scores were important factors affecting the abundance of waterbird territories. Redshank, Grey Wagtail and Pied Wagtail were the species most sensitive to water quality; these and at least seven other species were less abundant on rivers of poorer water quality, taking altitude and geographical position into account. For several species the link with water quality is likely to operate through food availability within the water body or in river sediments, but for Redshank, which feeds mainly in surrounding pasture and flood meadows, no mechanism is obviously apparent.

Further interactions between riparian birds and their habitats have recently been demonstrated with reference to North American rivers (Brown & Trosset 1989, Strong & Bock 1990, Finch 1991). Current studies in Nepal indicate that, apart from altitude, habitat trends may be independently associated with bird species richness (Dr S J Ormerod, pers. comm.). Although relatively few of the bird species involved in these studies are the same as those found in the UK, the results add to the evidence for bird-habitat interactions.

The general conclusion from all these pieces of work is that the nature of the habitat both within and beside the bank-tops is a strong determinant of the abundance of bird species, and waterbirds in particular. It follows that the results of bird censuses along waterways can be

used as part of a general appraisal of habitat quality, and also to assess changes as a result of management intervention.

Despite their apparent suitability for the purpose, WBS data have not so far proved to be of value for the Environment Agency's management planning. The main reason for this is likely to be that the plots are located according to the convenience of the BTO's volunteer observers, and do not necessarily cover the waterway stretches where data would be of most value to the Environment Agency. Van Dijk (1991) concluded that WBS in its present form could not provide the data required for determining the impact of flood defence work. He pointed out that no flood defence work had been reported on any of the stretches in his study, and also drew attention to lack of rigour in the recording of habitat change on WBS plots and the possible importance of differences in recording efficiency between observers.

2.2 Main users of waterbird census data

The main users and potential users of waterbird census data are:

- statutory conservation bodies: the Joint Nature Conservation Committee (JNCC) and the country agencies

- voluntary conservation bodies: *e.g.* the Royal Society for the Protection of Birds (RSPB) and the county Wildlife Trusts.

The UK government has a commitment to conserve and, where practicable, enhance wild species and wildlife habitats (UK Biodiversity Action Plan). Knowledge of the status of different taxa is an essential prerequisite for effective conservation policy and practice, enabling targeting of effort where it is most needed. Monitoring populations of selected species assemblages permits the detection of temporal and spatial changes and so underpins effective conservation. Conservation practice is primarily the statutory function of JNCC and the country agencies - English Nature, the Countryside Council for Wales, Scottish Natural Heritage (Environmental Protection Act 1990) and the Department of the Environment for Northern Ireland. It is also the role of various non-governmental organisations, including RSPB and the Wildlife Trusts.

- environmental consultancies

Environmental consultancies could use waterbird census results as baseline data for individual sites and contextual data at larger spatial scales. A nationally recognised scheme such as WBS provides a methodological standard for widespread application in site assessments. WBS is recommended as a suitable tool by the Institute of Environmental Assessment (1995).

- NRA and its successor the Environment Agency, and clients they represent

The Environment Agency has a duty to further conservation, when consistent with its other functional activities, and to take into account any effects that proposals relating to any of its

functions may have on the environment (Water Resources Act 1991). Conservation extends beyond sustaining existing site quality, to rehabilitation or restoration of degraded sites. The NRA's strategic objectives for conservation were:

1) to assess and monitor the conservation status of inland and coastal waters and associated lands;

2) to ensure that regulatory, operational and advisory activities take full account of the need to sustain and further conservation; and

3) to promote conservation to enhance the quality of the aquatic and related environment for the benefit of wildlife and people.

The development of suitable methods for describing, classifying and monitoring the conservation resource, and for assessing changes arising from various activities, is essential for the fulfilment of these objectives. The conservation remit of the NRA continues in the new Environment Agency established in April 1996.

The Environment Agency is developing the River Habitat Survey (RHS) to classify rivers on the basis of their habitat characteristics, notably physical and some vegetation features. RHS will generate a Habitat Quality Index (HQI) for sample sites along the rivers. This site evaluation procedure provides a basic module to which other data collection can be added. Information on the biological quality of rivers, based on an assessment of different taxa using the river corridor, will thus complement the RHS. Data from bird censuses provide relevant data for one biological group.

Additionally, the Environment Agency's operational works require post-project appraisal (PPA). This would be much more powerful if the assessment of the physical environment were augmented by biological evaluation. Here, again, censuses of waterbirds would make a useful contribution.

In summary, waterbird censusing can be used to inform conservation policy and practice and to investigate habitat change at different spatial scales, for example as a result of river engineering works. The collection of information is a clear prerequisite for the furthering and promotion of conservation. Census work is necessary to provide properly quantified data by which bird populations can be assessed and monitored, and is thus essential for bodies such as JNCC and the Environment Agency to discharge their responsibilities.

2.3 Requirements for national and regional population monitoring

National population statistics are of particular relevance to the needs of central government and provide the national context for investigations of regional and site-based trends. For example, overall national monitoring of waterbirds can provide useful baseline information for the Environment Agency, against which to compare data for different Environment Agency regions, different river catchments or different river lengths in the same catchment

with contrasting water quality, physical characteristics or management approaches. This might enable local, regional or national causative factors of the observed changes to be distinguished.

Population trends may vary at the regional level, for reasons which are specific to one or more regions. This regional variation may be hidden in the national trend because increases for one or more regions might be counteracted by decreases elsewhere within the UK. Such features of trend analysis are important because they may require different action to be taken in different regions. However, at the European or other international scale such regional variation may be of less importance than national data.

The value of census work at a single site is greatly enhanced where there are data from other sites that can act as controls. Routine monitoring of a large number of sites improves the national or regional baseline information against which the results from any site of particular interest can be assessed. The maximum value of these baseline data will be achieved where sample sites are selected on a random basis and represent a wide geographical spread.

2.4 Requirements for appraisal of specific sites

The Environment Agency is required to take the conservation of flora and fauna into account in its river engineering works, which may potentially be damaging to the environment. Channel excavation and dredging, lining of channels, clearing and snagging, and weed cutting all have major effects on aquatic plants and animals. Birds may be affected through their food supply or through loss of fringing vegetation for nesting cover. Birds are also affected by the removal of bankside trees, bushes and plants that may occur during management operations. Where the engineering works improve drainage, or reduce the incidence of flooding, the consequent lowering of the water-table in the flood plain might have far-reaching effects in removing habitat for wetland birds and in encouraging riverside development. Guidelines are available to help minimise the environmental effects of river management (*e.g.* Brookes 1988, RSPB *et al.* 1994). Coles *et al.* (1989) emphasise that low-level maintenance affects far greater lengths of rivers than major capital or engineering works and potentially has much larger effects on wildlife.

Prior knowledge of the relative conservation value of different sites may aid the planning of engineering or maintenance activities, by keeping damaging operations away from important sites; alternatively such activities might be minimised or modified to reduce any detrimental effects. Such a system requires widespread, ideally complete and site-based, biological surveys of river corridors.

RHS is not a detailed method for PPA. However, it can monitor change in the physical character of rivers, particularly in respect of river engineering works, whilst RCS maps the features of conservation importance. Targeted surveys of the waterbird populations along river sections (comprising the river corridor and its floodplain) that are destined for operational works, and along control sections of river, will provide assessments of the effects of the operations on birds, and a measure of the recovery time for those aspects of the works

which cause only temporary disruption. A comparison of site-specific information with that at the regional and national scale will enable site-based changes to be distinguished from changes taking place at a larger geographical scale.

Biological assessment is also relevant to monitoring water quality with respect to pollution incidents and to statutory water quality objectives (SWQOs) or river quality objectives (RQOs). It can also be usefully employed for monitoring the effectiveness of Water Level Management Plans in maintaining at least minimum surface or groundwater level requirements. However, it may be difficult to assess the impact on birds for individual river sections.

Evaluation of rivers for waterbirds, as part of catchment management planning, could be incorporated in the biological component of General Quality Assessment (GQA) and contribute to assessing the ecological status of rivers.

Post-project appraisal (PPA), ideally accompanied by pre-project appraisal, will provide advisory information for future schemes or developments and so enhance the Environment Agency's ability to ensure that such works take conservation into account. The selected methods for surveying individual river sections, as part of post-project appraisal, are likely to differ from those used for the national and regional population monitoring of waterbirds. This is because the site-based assessment requires more detailed information, in order to identify changes in relatively small units compared with the home range of territorial birds.

2.5 Why the Environment Agency needs censuses of waterbirds

The Environment Agency's specific requirements for waterbird censusing in respect of population monitoring and site appraisal are set out above. In summary, the main reasons for waterbird monitoring are as follows.

- To assess the conservation importance of freshwater habitats requires information on species diversity, frequency of occurrence and habitat use by different biological taxa.
- Birds are highly visible and are of proven value as indicators of environmental quality.
- National population statistics provide the context for site-based and regional trends, while also contributing to the overview of the status of bird populations in the United Kingdom.
- The impact of operational works can be assessed more fully by monitoring biological as well as physical parameters.

Waterbird monitoring can be complementary to the Environment Agency's other work in the following ways.

- Provision of a method of quantifying and reporting on the Environment Agency's effectiveness in furthering conservation, using taxa that have particularly wide appeal.

- Vulnerable bird species, and sites and catchments of special conservation importance, can be identified.

- The Environment Agency's RHS classifies rivers on the basis of physical features. Waterways bird monitoring provides a biological measure of river habitat quality at a variety of spatial scales. At catchment level, it enables the performance of catchment management plans to be monitored.

- Waterways bird monitoring before and after the Environment Agency's operational works or consented works can provide temporal and spatial biological data relating to impacts and recovery time. Where there is a national or regional background of annual population monitoring, distinctions can be made between those changes that are due to Environment Agency management and those beyond Environment Agency control.

3. RIVER SURVEY METHODS IN CURRENT OR RECENT USE IN THE UNITED KINGDOM

3.1 River Corridor Survey (RCS)

RCS is a map-based system for surveying 500-metre stretches of river, developed during the 1980s. It is similar to RHS in that it records physical features - but these are mapped which does not readily allow for objective and comparative site evaluation. There are many differences between Environment Agency regions in the details of the methods used to collect, store and evaluate RCS data (ap Rheinallt 1990). High-level information such as landscape scale and major channel features can be extracted, but the resulting classifications are not nationally consistent.

No Environment Agency region holds a computerised database of RCS habitat information, and only Anglian has a database of species information; computer capability is thus very low compared to the other surveys discussed in this report.

Thames, Anglian and Severn-Trent regions have rolling RCS programmes which are nearing the end of their first cycle. The Environment Agency plans that RHS methodology should be built into remaining RCS programmes, and that all new surveys for catchment management planning should be based on RHS methods. The RCS data that have been collected will continue to be a major tool for identifying conservation features to be safeguarded or enhanced at sites where changes to the physical structure of the river are proposed.

3.1.1 RCS methodology

The methods used for the RCS stem from draft guidelines published by NCC (1985). The original ambition of the method was to record species, physical features and wildlife habitats within 50 metres of rivers, and also the human uses made of these river corridors for all purposes. However, to maximise the number of rivers that could be covered within the first few years of the scheme, the recommended survey methodology is based essentially on recording habitats.

The survey method consists of recording a variety of habitat features along the river corridor. Environment Agency regions differ as to whether adjacent areas of land that might be affected by the proposed management of the river are also included in the survey (ap Rheinallt 1990). Recent guidelines (NRA 1992) define the river corridor as a stretch of river, its banks and the land close by. The width of the corridor depends on how much the nearby land is affected by the river and vice versa. Usually the river corridor includes land and vegetation within 50 metres of each river bank, but where there are extensive water meadows, marshes or other wetland areas, the corridor may be wider to include these associated features.

The corridor is divided into 500-metre stretches, and a sketch is made of each with the upstream end at the bottom of the page. On the sketches are recorded the substrate and depth

characteristics of the river channel, the profiles, vegetation types and extent of trees on the banks, and the adjacent land-use. On the survey card that accompanies the sketch-map, a variety of vegetation types, bank features, river characteristics and habitats are recorded. Some of these features are expressed qualitatively and others as numbers or percentages.

RCS visits are made preferably between late April or early May and early October, during which period the relevant plant species should be readily identifiable.

Some Environment Agency regions also collect systematic photographic records as part of RCS procedure. This is now part of standard RCS methodology (NRA 1992). All regions build into the RCS information from other sources, such as SSSI data and surveys of fish stocks, macroinvertebrates and water quality.

An NRA Fellowship Study has recently been completed on methodologies for optimising the value of RCS data (R&D Note 271). Principal conclusions from this work include the following:

- RCS maps provide a wealth of information;
- in hard copy form, RCS does not permit overviews of rivers to be obtained easily;
- a six-point abundance scale can be used to extract semi-quantitative information; and
- potential exists to integrate RCS information with other survey data.

3.1.2 Use of RCS data

It was recommended that RCS should concentrate initially on collecting data from rivers due for management by heavy dredging (Holmes 1986). By the late 1980s, RCS prior to engineering works being instigated was considered essential and it has developed as standard practice. In all Environment Agency regions, RCS results are taken into account when deciding among various options, and recommendations arising from the RCS are included in the design of the operation. The RCS has proved most valuable in this way as a management tool, and one which is readily understood by engineers.

In Anglian Region, the programme of low-level maintenance is also formulated with reference to RCS data.

3.2 River Habitat Survey (RHS)

RHS is being developed to provide a system to classify rivers on their physical features, including those of value to wildlife. It appears to be the only such system in existence;

similar surveys in Belgium and Germany differ in being more qualitative and subjective. Assessing the physical character of the river contributes to monitoring the performance of catchment management planning, and helps to provide the data needed for environmental impact assessment. RHS is complementary to systems for the biological monitoring of rivers, such as RIVPACS for invertebrates which has been developed by the Institute of Freshwater Ecology (IFE).

The RHS is designed to fulfil, for the physical aspects of rivers, the requirements of the European Commission Directive on the Ecological Quality of Waters, and to comply with monitoring aspects of the United Kingdom Biodiversity Action Plan. The Institute of Terrestrial Ecology (ITE) is considering using RHS in its Environmental Change monitoring Network (ECN). RHS will provide an extra component to the Environment Agency's General Quality Assessment scheme (GQA) which is under development. It is not in itself a conservation classification but contributes information on physical features that can be used in the System for Evaluating Rivers for Conservation (SERCON), a computer system that combines RHS and other data on physical structure and naturalness with biological information. SERCON works at a larger scale than either the RHS or RCS 500-metre-length basis, and provides a complete overview of conservation interest of larger segments within the river catchment.

RHS uses a database of information collected from randomly selected sites to predict river features based on slope, geology and river size. Typing of rivers, using similarities in overall features, enables comparisons to be made between sites of the same river type. Sites are evaluated by comparing the features observed with those predicted. Good sites have most or all of the predicted features within the standard sample length of 500 metres, and poor sites very few.

During 1994-96, more than 4500 separate 500-metre sample sites are being surveyed throughout England and Wales. Map-based information is being extracted for these sites as a separate Environment Agency project. Benchmark sites of known high conservation value are used for calibration. This will form the reference site network of 3 sites per 10-km square in England and Wales. In addition, one site per 10-km square will be surveyed in Scotland, in a parallel programme developed by SNH, and in Northern Ireland.

3.2.1 RHS site selection criteria

The sampling regime involves the random selection of one tetrad in each 10-km square of which land area above mean high water forms at least 50%. Tetrads are retained in the sample if they contain a suitable river, aiming for one reference site per sampled tetrad, according to the following priorities:

1) RQO river (River Quality Objective classified on the basis of chemical water quality);

2) unclassified river, sampled for water quality;

3) watercourse not sampled previously for water quality but which is evident on the 1:50000 Landranger Ordnance Survey map.

The point on the selected watercourse closest to the mid-point of the tetrad is taken as the mid-point of the RHS site. The sample site extends 250 metres to each side of this point.

The sample length of 500 metres was established after analysis of transect data from the River Derwent in Cumbria indicated that this was the length most likely to include the important features for characterising the river without incurring excessive data redundancy.

3.2.2 RHS methodology

Field methodology for RHS is described in a guidance manual (NRA 1995). Recording forms from this manual are copied here as Appendix 3.

On the outgoing route, ten spot checks are made at 50-metre intervals to record flow type, physical features, vegetation structure, land use and vegetation types along narrow transects across the river. "Sweep-up" recording on the return walk produces an inventory of features along the full 500-metre section. Additionally, channel dimensions are recorded at one standard location. A brief site description completes the survey form. Recommendations are given for suitable timing and conditions for survey work, suggesting that spate conditions and other weather conditions which could significantly affect the assessment are avoided.

RHS is not map-based and thus avoids the problems associated with retrieving large amounts of data from maps. Also, the spot checks function as sampling replicates within each river section, thereby strengthening the analytical capability of the method.

RHS data are entered onto a database which has been developed by IFE as part of an NRA research and development project. All data from all the reference sites will be available for users to interrogate and provide the basis for site evaluation and for reporting on the state of river habitats.

3.3 Anglian Region Rivers Environmental Database (REDs)

The Anglian Region of the Environment Agency has supplemented its habitat-based RCS data with species-based biological surveys. These were carried out between 1990 and 1993 by EcoSurveys Ltd, an independent environmental consultancy. The survey covered 6000 km of rivers and 850 km of sea defences within the Anglian Region.

Counting units were 500-metre stretches, with each stretch visited on five occasions. Botanical surveys were made on two visits between May and August, and three bird counting visits were made - once each in April, May and June (see below). The output from botanical surveys consisted of a habitat map, a plant list, and estimates of relative plant species abundance and of aquatic vegetation density.

The REDs Linear Bird Survey data are maintained on a database which gives ready access to information concerning the value for birds of any particular waterway stretch. These data, matching bird surveys and habitat data for about 12,000 500-metre stretches, provide a valuable opportunity for multivariate analysis of bird-habitat associations. To date, however, the data have not been used in this way.

3.3.1 Methodology for REDs Linear Bird Survey

The area covered was that between the banks of the river, including any raised banks and any soak drains beside them. Visits were made during the morning and, if possible, during fine weather. On each visit, observers mapped every bird seen or heard on a copy from the 1:2500 Ordnance Survey map, using notation borrowed from the CBC and WBS. Only birds using the defined area were noted, including aerial feeders such as Swallow, and hunting raptors, but excluding wildfowl seen only in flight and birds such as gulls or Starlings passing overhead. Even so, species coverage was wider than for the WBS, which covers only riparian species.

Each visit was summarised by totalling the numbers of birds represented by registrations of each species for each 500-metre stretch. For each stretch, the resulting database contains the results of each of the three visits, tabulated separately, and a fourth column showing the highest of the three counts for each species.

Observers also recorded habitat details on each visit, concentrating on structural features on the April visit and on fringing vegetation, crop types and land use in May and June.

3.4 Waterways Bird Survey (WBS)

3.4.1 WBS methodology

The WBS is a national bird census scheme, operated by the BTO since 1974, that covers breeding birds of linear waterways (Taylor 1982, Marchant *et al.* 1990). It is a monitor both of population change and of habitat usage by waterside birds. It was designed partly as:

- an addition to the BTO's CBC, which covers primarily farmland and woodland, that would allow population monitoring for waterbirds too scarce or too restricted in habitat choice to be surveyed adequately by that scheme; and partly as

- a monitor of birds in a habitat widely perceived in the early 1970s to be under considerable threat, in particular from pollution and unsympathetic management.

From the late 1970s until recently, WBS was funded under contract to the Nature Conservancy Council and its successor, JNCC, on behalf of English Nature, Scottish Natural

Heritage, the Countryside Council for Wales and the Department of the Environment Northern Ireland. Currently, however, the scheme receives no outside funding.

Like the CBC, the WBS uses a mapping bird census method, which produces not only numbers of breeding territories but also detailed maps showing the distribution of those territories. WBS differs from CBC chiefly in that it is a linear survey, rather akin to a belt transect. It also differs in that species coverage is limited; WBS covers waterbirds and others that are largely riparian, with the additions of Whitethroat and Grasshopper Warbler for which extra information was required to add to that available from CBC. Instructions for the survey (Taylor 1982) are included here as Appendix 4.

Survey volunteers, mostly BTO members, choose stretches of river or canal to which they have access. There is thus no formal sampling strategy for this survey. The minimum plot length is 3 km, and most survey plots are between 3 and 5 km in length. Each year, the observers make a number of visits, typically nine, to their plot between late March and early July, to record the positions and activities of all the birds encountered. Observers generally spend about 1-2 hours mapping birds on each visit. The BTO recommends that visits should be spaced fairly evenly through the survey season.

The visit maps are processed, first, by transferring all information referring to each species onto separate species maps and, second, by dividing the registrations on those species maps into clusters that appear to represent the territorial activities of particular pairs of birds during the survey season (Marchant 1994).

These territory maps can then be analysed to define the locations of registrations or of territories in relation to the habitat information that observers also collect. WBS habitat information consists of ticklists of habitat features recorded in each 500-metre stretch of the plot, and also maps showing the distribution of habitat types or any major changes from maps submitted earlier.

An alternative, non-standard method of processing maps was tested during 1991-93, in which the results of each mapping visit were treated as if a transect method were being used to collect the data. In each of these years, observers compiled totals of registrations of certain types, for the whole survey stretch, for each species and visit. Processing the data in this way is more efficient in terms of measuring population changes, but loses the detailed information on territory location in relation to habitat that is produced by the standard mapping method.

3.4.2 WBS plot distribution

While the WBS is a national scheme, survey plots are distributed unevenly within the United Kingdom (Figure 1). The areas around Sheffield and Lancaster are covered well, but there are few plots in the Fens, in Northumberland and the far southwest of England. Coverage of Wales, Scotland and Northern Ireland is also poor. In the absence of a formal sampling strategy, the major influence on plot distribution, aside from the distribution of waterways, is the distribution of BTO members. Environment Agency regional boundaries are also

mapped in Figure 1. Coverage in most Environment Agency regions is rather patchy, but a reasonable scatter of plots is achieved in Severn-Trent and in North West.

The numbers of plots surveyed in each of the Environment Agency regions, and in the remaining geographical regions of Britain and Ireland, during the period 1989-94 are shown in Table 1. In 1994, the largest regional samples were in Severn-Trent and North West. A large number of plots have been surveyed in Thames Region, but relatively few of these surveys were active in recent years. Annual WBS sample sizes during the early 1990s were higher than in any earlier years.

A further classification of WBS plots, based on Environment Agency criteria, is shown in Table 2. This uses the Chemistry Window of the new General Quality Assessment (GQA) for rivers and canals in England and Wales. GQA replaces the previous NWC river quality classification. The six grades reflect differing degrees of pollution and are derived from measurements of dissolved oxygen, biochemical oxygen demand (BOD) and total ammonia, and the frequency with which these fall below certain set limits. GQA Windows for Biology, Nutrients and Aesthetics are still under development.

It is clear from WBS plot distribution that the scheme is not fully representative of either the UK or of England and Wales. It is not known, however, to what extent WBS might be a representative sample of rivers and canals in those Environment Agency regions in which there are most plots. The data in Table 2 suggest that, in most regions, there are likely to be water quality types that are currently unrepresented in the WBS sample.

3.4.3 WBS outputs

The main outputs from the WBS are indices of population change for 19 species of waterside birds. Index graphs for all these species covering the period 1974-93 have been published recently (Marchant & Balmer 1994). Population changes are standardly assessed on a national basis, but the WBS sample is sufficient to allow estimation of long-term trends for some species at a regional scale, such as the Severn-Trent, Northumbria & Yorkshire, North West and Thames Regions (Marchant & Gregory 1994).

Studies have also been published that demonstrate links between territory location or territory density and features of the habitat (Marchant & Hyde 1980, Taylor 1984, van Dijk 1991, Rushton *et al.* 1994). In general, however, WBS information on territory location (as opposed to territory numbers per site-year) has been little used.

3.5 Breeding Bird Survey (BBS)

The BTO began a new national bird population monitoring scheme in 1994 that it anticipates will take over from CBC (and possibly WBS) the long-term task of keeping track of population changes of widespread birds within the UK. The BBS is jointly funded by BTO, JNCC (on behalf of the country agencies) and RSPB. During the current initial phase of BBS development, the national programme of CBC and WBS will be maintained alongside BBS

for as long as proves possible, so that the monitoring results of the different schemes can be compared.

The BBS is the first ongoing national bird survey to use a fully randomised selection of survey sites. Its sampling unit is the 1-km square of the national grid. In its first season in 1994, 1549 random squares were surveyed. These same squares, together with additions to increase the sample, will be covered in 1995 and future seasons. The final sample size will be in the range 2000-3000 squares. The BBS thus differs from CBC and WBS in that its survey sample is demonstrably a representative one, both regionally and nationally. This enables the results to be referred directly to UK or UK regional bird populations as a whole. BBS has a wider geographical coverage and habitat range than CBC or WBS and this will allow a larger suite of bird species to be monitored. Monitoring results will begin to be available from BBS after the second season of the survey in 1995.

In using random 1-km squares, BBS site selection methodology is similar to that of the DoE Countryside Survey. This raises the potential for links between the two schemes, although there is little overlap between them in the sample squares actually selected for coverage. The great strengths of the BBS are the random survey design (akin to RHS) and the relatively quick and efficient fieldwork which enables a large number of volunteers to get involved. The transect data are readily computerised and so incur relatively low staffing costs at the BTO.

3.5.1 BBS methodology

BTO observers are asked to visit each square twice to count birds, once early and once later in the breeding season which is defined as between April and June. A transect method is used, in which all birds seen or heard are counted. Transect routes should follow as closely as possible a standard 2-km route through the square. Most squares demand some deviation from the standard to cope with problems of access or unsuitable terrain, but such deviation is kept to the minimum. Simpler methods than those of CBC and WBS have enabled many more observers to take part in monitoring surveys than could do so previously.

Habitat is also recorded, using the standard system devised for BTO surveys generally (Crick 1992). The BBS counting routes cover all habitat types where birds nest and are not restricted to waterways; only open water and coastal fringes below mean high water are excluded.

The recording unit for both birds and habitat is the 200-metre stretch of transect, of which there are ten per square. Birds are recorded in three distance categories - 0-25 metres, 25-100 metres and over 100 metres. Birds seen only in flight are recorded in a separate category. Up to two main habitat types present within 25 metres of the transect line can be coded for each transect stretch.

4. COMPARISON OF METHODS

This section of the report provides an overview of methods in use for surveys of rivers and of waterbirds, with the aim of identifying gaps and areas of overlap between schemes. Areas of overlap are investigated in detail, where appropriate by comparing results between survey schemes.

Some general features of survey methodology are shown in Table 3, for purposes of ready comparison between schemes. Note that RCS, alone among the surveys considered, is not routinely maintained as a computerised database.

4.1 Population monitoring via WBS and BBS

Both WBS and BBS set out to measure population changes among waterbirds, although the remit of BBS extends to all common and widespread birds in the UK. The ability of these schemes to monitor population changes of waterside birds depends to a large extent on the sample sizes that are achieved. In this section of the report, the WBS and BBS datasets are interrogated to determine:

- the comparative sample sizes for waterbirds achieved by WBS and BBS in 1994, the first BBS season;
- the likely precision of BBS monitoring of waterbirds compared to that of WBS;
- the kinds of wetland habitat sampled by BBS; and
- the potential for monitoring population changes using transect methods along waterways.

4.1.1 WBS results for 1994

Sample sizes from the WBS in 1994 are shown in Table 4, for direct comparison with those from BBS in Table 5. For WBS mapping, recording units for birds are territories, not birds counted as is the case for BBS. The number of plots is the number on which the species was recorded as present, even if no territories were assessed. Observations of non-territorial birds are of no value for studies of territory number, but do provide data for studies that treat WBS visits as transects (see below).

4.1.2 BBS results for 1994

In all, 1549 BBS squares were surveyed in 1994, the first season of the survey. Results for waterbirds are shown in Table 5. The figures tabulated are: the number of BBS squares, from

the total of 1549, in which each species was recorded; the mean number of birds of each species counted per square; the standard deviation of that mean; and the total number of birds counted, across all squares. For this analysis, the number of birds taken as the count for a square was the higher of the two visit totals. Each visit total was calculated as the sum of flying birds and those in the three distance bands, summed across all transect stretches surveyed in the square.

Most waterbirds occurred in less than 10% of squares, but sample sizes for many are substantial and will allow considerable precision in monitoring population changes between years. Precision of population change estimates will also depend on the numbers of birds recorded per square, which are also tabulated.

In addition to the transect counts, BBS collects counts of occupied nests within the sample squares for certain bird species that nest in colonies. These include Cormorant, Grey Heron, gulls, Sand Martin and Rook. These counts supplement the transect results for the species concerned, providing greater standardisation of data for birds whose distribution is typically highly aggregated. Although several of these colonial species are waterbirds, Sand Martin is the species most associated with linear waterways. In 1994, a total of 311 Sand Martin nests were counted in 12 occupied squares. The total is small compared with the 1753 Sand Martin nests found on WBS plots in 1994 (Table 4).

4.1.3 Comparison of 1994 results from WBS and BBS

Comparisons of estimates of population change and the precision of those estimates must wait until the first year-to-year comparisons of BBS data are available. For 1994, the first BBS season, it is nonetheless possible to compare results with those from WBS in that year.

The data for the two schemes separately are shown in Tables 4 and 5. Figure 2 shows a comparison of the numbers of plots for each species, using the data in these tables. Only those species occurring in at least 25 WBS plots are included. The identity of the species plotted is represented by the standard BTO two-letter code, to which the figure caption provides a key.

Generally, the number of plots holding waterside birds in 1994 was much higher for BBS than WBS. This is to be expected given that 1549 BBS squares were surveyed and only 125 WBS plots. The pre-eminence of BBS in this regard will increase as the BBS sample expands in future seasons. However, the precision of estimates of year-to-year change depends not only on sample sizes but on the variability within the data. The much larger time input by WBS observers is likely to provide greater consistency, as has already been shown for CBC. Comparisons of BBS-type methods and CBC territory mapping suggest that the greater variability of BBS data, based on just two visits per season, would require that sample sizes be about four times larger than mapping samples to achieve equivalent precision in population monitoring (Gregory *et al.* 1994). Figure 2 shows the line:

$$x = 4y$$

Species occurring on more than four times as many BBS as WBS plots lie between this line and the BBS axis, and would be monitored more precisely by the BBS, while those occurring on fewer than this proportion of BBS plots lie closer to the WBS axis and would be monitored more precisely by that scheme. On this basis, and ignoring any bias in the selection of plots, most waterbirds would, in 1994, have been monitored more precisely by WBS than BBS; allowing for an eventual doubling in the numbers of BBS squares surveyed, however, this position may be reversed.

Even with the projected increase in the BBS sample, some species are likely to be monitored better by the targeted approach of WBS than by BBS. Figure 2 shows that the outlying species towards the WBS axis are river specialists, such as Kingfisher, Common Sandpiper and Dipper, while those closest to the BBS axis are species such as Whitethroat, Pied Wagtail, Mallard and Lapwing, which are all found widely in habitats other than linear waterways, for example on farmland. In 1994, Kingfishers were found on 3.2 times as many WBS stretches as BBS squares.

These results demonstrate that

- BBS on its own would not be an adequate replacement for the current population monitoring by WBS, in that it would give poorer coverage for specialist birds of linear waterways
- for the purposes of determining broad-scale population changes in these species, therefore, BBS monitoring should be supplemented with some form of targeted monitoring of riparian birds.

4.1.4 Coverage of waterside habitats by BBS

Squares for BBS coverage are selected randomly and are located throughout the UK. Not all selected 1-km squares were covered in 1994, but the 1549 that were surveyed were drawn from all UK regions. Site distribution is not even geographically, because random selections were stratified by region and the number of plots selected was proportional to the numbers of potential participants.

The waterbirds recorded by the BBS in 1994 (Table 5) were not necessarily located in river corridors, since standing waters are also represented in the BBS sample. In addition, many of the species listed use other habitats, such as marshes, moorland or farmland, and were found by the BBS in squares for which no aquatic habitats were recorded within 25 metres of each side of the transect.

The representation of all bodies of fresh water on BBS squares is set out in Table 6. The recording unit for habitat recording is the 200-metre transect stretch. The number of stretches for which fresh-water habitat codes were given, either as a first or a second habitat, are tabulated, together with the percentages these represent of the total number of stretches for which that habitat was recorded. Data are presented both for the transects that were counted

(actual) and the transect stretches that should have been surveyed (ideal) had it been possible to follow the standard pattern.

The BBS is a scheme designed to cover all types of habitat. The incidence of rivers in BBS squares is low, given that the proportion of rivers in 1-km squares nationally is low. The comparison between actual and ideal transects shows no evidence of systematic bias towards or away from aquatic habitats as a result of deviations from the standard layout of transect stretches. Linear waterways, particularly streams, rivers and ditches, were represented more strongly than standing waters, particularly when comparing the actual and ideal transects.

The types of linear waterways surveyed by BBS observers in 1994 are further explored in Table 7. Up to two further codes could be added by observers to describe the kind of linear waterway in the stretch. The incidence of these sub-categories is tabulated, to indicate the level of information that will be available from BBS. This is not an objective classification of waterway types, however, because only one or two of the sub-categories could be recorded by the observers for any one transect stretch, and the codes entered are those they considered to be most relevant to the bird community. It would not be valid, for example, to compare the incidence of codes 7 (dredged) and 8 (undredged): the latter is not likely to rank high in an observer's priorities for recording the habitat available to birds, alongside for example recording the trophic state of the water or whether it was fast- or slow-running.

It is clear from these data that BBS population changes derived from the whole BBS sample would not refer directly to rivers but to a representative mix of the habitats occupied by each species. Restriction of the sample to those transect stretches containing rivers would reduce the sample sizes enormously and, even given the planned increase in BBS sample sizes generally, probably would not allow any species to be monitored purely in riverside habitats.

4.1.5 Treating WBS visits as transects for the purposes of monitoring population change

WBS mapping is a relatively expensive method of monitoring population change, because it requires nine site visits and because of the time needed to process the resulting maps to obtain estimates of territory numbers. These cost factors, which apply both to the volunteer observers and to the central organisation of WBS at BTO headquarters, have limited the sample size that has been achievable during the 21 years of the survey to date. This section of the report considers the scope for using transect methods to reduce the time required for individual contributions, and so increase sample sizes.

The staffing costs associated with the central organisation of WBS mapping have already been reduced from 1994 onwards by asking observers to make their own assessments of territory numbers before returning their maps to BTO headquarters. However, this transfer of responsibility increases the workload of survey volunteers and so is likely to reduce rather than increase WBS sample sizes. Time savings for both BTO staff and volunteers could be achieved by changing to a survey method that, compared with mapping, was less demanding in both fieldwork and subsequent paperwork.

During 1991-93, BTO organised simulations of the use of transect methods on WBS plots. No extra fieldwork was required of survey volunteers, but each was asked to provide totals of birds seen on each mapping visit as well as the usual territory maps. The results can be taken as approximating to those that would have been obtained had formal transect methodology been employed. An important difference from any transect method that would actually be employed is that, in this study, the sampling unit in each case was the whole length of the WBS stretch. A shorter, standardised transect length would have greatly increased the effective number of replications and allowed bird counts to be related to habitat features at a more appropriate scale. Dedicated transect methodology would take account of this.

These three years gave two year-to-year comparisons of transect-style data. These data were used to assess the numbers of transect visits that might be required to obtain adequate levels of precision in estimating population change. Considerable time-savings could be introduced were it possible to reduce the number of visits needed for population monitoring. The time saved on each survey could be re-employed to increase sample sizes.

The precision of monitoring achieved by the WBS standard mapping method for each species is indicated by the standard error of population change, derived from the estimates of change on individual survey plots. Where the plots tend to give the same results, the standard error will be small, and relatively small percentage changes in numbers can be recorded as statistically significant. The standard errors of population change from WBS mapping for the 1991-92 and 1992-93 comparisons are presented in Table 8. These figures are summarised, as mean and standard error across species, in Figure 3, for comparison with the transect results.

For each species, the standard errors of year-to-year population change that were derived from different numbers of transect visits were compared. To ensure that sample sizes were the same, and thus that standard errors were comparable, only those plots with at least nine visits were included. For each survey, the transect totals used for comparison between years were the means of the counts recorded on the separate visits. Where there were more than nine visits in total, nine were selected on the basis of the visit date to give an even spread through the survey season. Simulated changes in the numbers of visits were achieved by selecting visits according to a standard pattern: 1 visit (visit 5 only); 2 visits (visits 3 and 7); 3 (visits 2, 5 and 8); 4 (visits 1, 4, 6 and 9); 5 (visits 1, 3, 5, 7 and 9); 6 (visits 1, 3, 4, 6, 7 and 9); 7 (all visits except 3 and 7); 8 (all except visit 5); and 9 (all nine). In each case, therefore, the selected visits were spread more-or-less evenly through the season, each number of visits representing a transect methodology that might be considered for adoption as a replacement for WBS mapping.

In both year-to-year comparisons, the standard errors that were obtained decreased with the numbers of visits (Figure 3). Even for nine visits, however, the standard errors were generally noticeably larger than for the mapping census results. This was expected because WBS mapping is interpreted according to the locations and behaviour of the birds, as recorded on the maps, as well as the total numbers of birds seen. Differences between mapping and nine-visit transects were not significant, however.

While Figure 3 shows the overall pattern, obtained by taking means and standard errors across species, the results were different at species level. Table 9 indicates which species, according to the results of this test, could be monitored effectively using different numbers of transect visits, assuming that the sample size of survey plots remained unchanged. For Mallard, Moorhen and Coot, relatively small standard errors were achieved in both comparisons even from a single mid-season visit (Table 9a). With a two-visit survey, Mute Swan and Dipper would also be monitored adequately. For other waterside species, more visits were required in at least one of the year-to-year comparisons. The majority of the species of interest would be monitored if more than 5 transect visits were made per season.

The different ordering of the species, and the differing numbers of visits required for most of the species, in the two year-to-year comparisons shows the variability inherent in the data. For effective monitoring, the standard error of year-to-year ratio estimators must be predictably small, as in this analysis for Mallard, Moorhen and Coot, but not for Pied Wagtail or Sedge Warbler for which the standard errors from the results of a single visit were not consistently small. As comparison between Tables 9a and 9b reveals, conclusions from these analyses depend heavily on the criterion taken to represent acceptable monitoring. Nevertheless, the shapes of the graphs (Figure 3) and the data in Table 9 indicate the benefits in monitoring terms of making a certain number of visits, in relation to the costs which increase with the number of visits made.

4.1.6 Conclusions for population monitoring

The results of interrogating the WBS and BBS data-sets indicate the following:

- there should continue to be a national programme of monitoring waterside birds, supplementing BBS, to supply data on population changes of these species both nationally and regionally, as WBS has done up to now;
- the WBS sample is not a good representation of waterway types and locations at regional or at national level;
- there is scope for reducing the time input of volunteers into WBS without substantial loss in precision of monitoring - this would enable sample sizes to be increased;
- WBS should be redesigned to use more efficient methods and to incorporate random selection of survey sites, thus enabling representative monitoring to be achieved in the most cost-effective manner.

4.2 Site appraisal via RHS, WBS and REDs

The overall purposes of site appraisal are:

- to gather information on the relative value of different sites, for example as habitats for breeding birds;

- to measure the effects of management, using surveys before and after.

4.2.1 Site appraisal by RHS

The RHS is well suited to site appraisal for both operational and catchment description purposes since, within each 500-metre sampling unit, features are recorded quantitatively at 50-metre intervals and for the site as a whole. The quantitative ability of RHS enables change to be measured, and so makes post-project appraisal more rigorous than was possible with RCS. Repeat RHS surveys at a site allow comparison at the level of the whole site and for each of the ten spot checks. This ability can be enhanced by marking the location of each spot check, so that the sites of spot checks do not differ between visits, at sites which are to be surveyed several times as part of post-project appraisal. The standardised methodology of RHS makes it particularly useful for the evaluation of physical features associated with the river corridor.

Ultimately, RHS could be used to predict the outcome of proposed engineering operations and to influence those works, where appropriate, for the enhancement of the river for wildlife. This would be of particular value in the case of river restoration schemes. The RHS database can be used to further knowledge of features of the river habitat which are of importance to different taxonomic groups, through multivariate analyses. The use of bird data in such analyses would require the data to be collected in a way compatible with the rest of RHS. Additionally, it may be possible to investigate any effects of land-use change along the river corridor or on the river system itself, in conjunction with assessments of water quality.

4.2.2 The use of WBS for site appraisal

The territory mapping approach of WBS has the advantage of recording the positions and approximate extent of bird territories. These data can be used in temporal and spatial comparisons of changes in physical features, for example from RHS. This improves the chance of pinpointing those aspects of local changes that are responsible for changes in the number, size or distribution of territories within a site. The essential aspect of determining change is to collect data before and after, which is particularly applicable for post-project appraisal. Various habitat parameters are also recorded as part of WBS, but the scale of recording is not fine enough to determine habitat change resulting from operational works (van Dijk 1991).

WBS data have hardly ever been used by the Environment Agency or its predecessors for the purposes of site appraisal. There has been little overlap between the sites of interest; for example, no flood defence work was reported at any of the WBS sites investigated by van Dijk (1991). However, there are published examples from the WBS of localised changes in bird populations following waterway management (Marchant & Hyde 1980, Taylor 1982).

Such observations are limited by the lack of detail in WBS habitat recording and by lack of contact between WBS volunteers and the Environment Agency before and during management operations. These problems would be reduced where:

- the selection of study sites was determined with reference to planned management operations, and
- habitat data were collected by a more rigorous methodology, such as RHS.

At 500 metres, the sampling unit used for the randomly selected network of RHS reference sites is relatively small in terms of bird habitat use. Community studies could be made at this scale but, because of the small sample of bird territories within a 500-metre section, it would be difficult to obtain results for individual species that were statistically significant. However, RHS surveys for PPA purposes could be of any appropriate configuration and could for example consist of a number of contiguous 500-metre units.

The complementary use of RHS with a suitable waterbird survey technique is likely to be the preferred option for the Environment Agency. One possible solution would be for RHS to be carried out on more than one river section within the ideal 3-5 km WBS sample length. The WBS sample length corresponds well with SERCON's Evaluated Catchment Section (ECS) standard minimum of 5 km.

Site evaluation for conservation inventory purposes has potentially different requirements from detailed project appraisal. It may be that variables such as species richness and abundance measures are adequate to characterize a given stretch of river, and that locational information within the river section is not needed. SERCON uses species richness, *i.e.* the number of species, without reference to the relative abundance of each.

WBS is a labour-intensive method for censusing waterbirds, particularly if the standard requirement of 9 or 10 visits is fulfilled, although, as demonstrated, this can be reduced without losing the ability to measure species richness and abundance. The substantial time input of WBS is only merited for site appraisal if detailed spatial information is needed.

4.2.3 Comparison of WBS and REDs methodologies for ornithological appraisal

Both WBS and the REDs Linear Bird Survey produce maps showing the precise locations of birds recorded along the waterway. In this section of the report, the comparative performance of the two schemes is investigated with reference to waterway stretches surveyed by both methods in the same season.

Field methodology for REDs drew heavily on that already employed for WBS, although the standard analytical methods of the two schemes are entirely different. The main differences between REDs and WBS are as follows (see also Table 3):

- REDs records all species of birds, but WBS only the riparian species;

- REDs records birds only if they are using the area within the banks of the river, while WBS records within a broader corridor and includes territories adjacent to the watercourse;

- REDs uses maps at 1:2500, allowing more precise plotting than on WBS maps which are 1:10000;

- REDs uses 3 visits, and WBS typically 9 visits;

- the REDs recording unit is the sighting, thus including non-territorial visitors, while WBS counts breeding territories;

- REDs maps are analysed as 500-metre transects, thus losing the fine definition of locality as recorded on the maps, while on WBS the localities of sightings are used to define the locations of territories - on REDs, birds holding territory across transect boundaries may be recorded twice, whereas on WBS the plots have no internal boundaries and double-recording is likely only in those cases where plots abut.

Nine river stretches were identified where WBS and REDs were both carried out, but in only four of these were the surveys made in the same season. Details of these four sites are given in Table 10.

Data for these sites were investigated to determine the relative performance of the two schemes. A detailed comparison of results as obtained on the Stour in 1990 is shown in Table 11 & Figure 4. REDs data are tabulated separately for each of the nine 500-metre stretches that make up this WBS plot. Each was visited on three occasions. In Table 11, the results of each of the three visits are shown, summed across the nine stretches. Also tabulated is the sum, again across the nine stretches, of the highest of the three counts in each stretch.

The highest counts compared very well with the numbers of territories detected by the WBS (Figure 4). The expected ratio of REDs counts to WBS territories is 2:1, since normally two birds would be present per territory. A dotted line on the graph represents this ratio. Some extra birds might be expected on REDs counts, representing non-territorial individuals. Most species lay very close to the line, the most important exceptions being the species that were unrecorded by one of the schemes.

The position of Canada Goose, Sand Martin, Golden Plover, Grey Heron, Little Grebe, Cormorant and Snipe along the vertical axis in Figure 4 indicates that these species were recorded by REDs but had a WBS territory count of zero. All except Golden Plover were seen during WBS visits, but registrations were insufficient to indicate the presence of a territory. It is likely that all of these were non-breeding visitors to the plot.

Two Pied Wagtail territories were found by the WBS, but no birds were seen on the REDs visits. This may have been a function of the smaller number of REDs visits compared to the

WBS, with the species absent from the waterway or inconspicuous on each of the three visits, or of the narrower recording corridor that is defined by the REDs methodology.

High counts for Yellow Wagtail were recorded only on the first REDs visit (Table 11) and may have been passage birds present only for a short period. Transect methodology may overstate the importance of such species that can sometimes be present in abnormal numbers during the counting period. WBS territory counts allow for such temporary high numbers by excluding passage flocks from the territorial pattern.

Some species gave their highest counts on the first REDs visit, in April. These included Mallard and Moorhen, for which the growth of vegetation may have made counting more difficult later in the season. Others, notably Sedge and Reed Warblers which are late-arriving migrants, were counted best on the June visit. This shows the importance of a seasonal spread of transect visits if the aim is that all riparian species are to be counted.

4.2.4 Conclusions for site appraisal

The main conclusions from these investigations are as follows:

- annual bird surveys on a national and regional scale are required because they provide controls indicating bird population changes at sites not affected by management;
- WBS mapping provides high-quality distributional data for birds, but habitat data are poor compared with RHS;
- collecting bird data in a way compatible with RHS would allow more powerful analyses of bird-habitat relationships;
- relating bird surveys to RHS would enable an integrated approach to PPA;
- the REDs approach, using transect-style data and fewer visits than WBS mapping, results in relatively little loss of information at the 500-metre scale.

5. FUTURE REQUIREMENTS FOR WATERBIRD SURVEYING

5.1 Population monitoring

Future requirements for population monitoring will be:

- a continuation of annual national statistics on population change among waterside birds, as provided to date by WBS. This will enable large-scale population changes to be detected as they occur, and provide a background against which local changes can be viewed.

Additionally, from the viewpoint of the Environment Agency:

- the capacity to detect population changes that are specific to certain reaches or catchments; and

- the capacity to determine whether population changes that are detected are influenced by factors within the Environment Agency's control or influence.

5.2 Site appraisal

Post-project appraisal of operational works will require detailed surveys before and after the works are carried out. In order to ascertain which of the changes arising from the works affect waterbirds, detailed territory mapping would be the best approach. Ideally, a control section of the same river should also be monitored, upstream from the works, to compensate for any local changes which are not attributable to the operations. Alternatively, the control could be on another local river of similar type.

For the territory mapping approach to post-project appraisal to function adequately, it will be advisable to concentrate on those river sections for which operations are planned well ahead, so that the "before" data can be collected in at least one breeding season prior to the works being carried out. It will be important to consider the scale of potential changes at the outset of planning post-project appraisal, so that appropriate recording detail can be implemented.

6. OPTIONS FOR THE FUTURE

6.1 Discontinue WBS

Given the absence of funding currently for the WBS, the continuation of the scheme is in considerable doubt. A failure to ensure new funding is likely to mean that the scheme will finish in 1996.

The consequences of no special monitoring of birds along waterways would be potentially serious since substantial and widespread population declines could go undetected for some time. This would be a particular concern because birds feeding and breeding along waterways can act as highly valuable barometers of environmental change (Ormerod & Tyler 1993). Bird monitoring provides an early warning system. That being said, the number of species monitored uniquely by WBS is less than ten, although these are among the species of greatest relevance to the work of the Environment Agency and are of conservation importance.

If WBS was stopped, BBS would be the only means of large-scale monitoring for waterway birds. However, preliminary analysis of the BBS data set indicates that:

- the precision of monitoring would be generally lower for BBS than for WBS and fewer waterbird species would therefore be monitored;
- there would not be an adequate way of distinguishing population changes of waterbirds along waterways from those occurring in other wetland habitats;
- the scale of monitoring would be too crude to provide adequate monitoring results at regional or catchment levels.

In addition, in the absence of a suitable overlap period of several years of WBS and BBS monitoring in parallel, it would not be possible adequately to calibrate the results such that the continuity of monitoring results could be maintained.

BBS totals for waterbirds could be improved by encouraging volunteers to follow watercourses within their survey squares, but this would not be very productive because the incidence of waterways in random survey squares is relatively low.

Currently, the Environment Agency does not monitor any taxonomic groups in relation to its conservation remit. Future development of waterways bird monitoring might provide an opportunity to enhance the Environment Agency's potential to fulfil its conservation objectives. Priorities would be before and after surveys for PPA. However, the lack of an adequate national or regional context for the data collected at such sites would make survey results difficult to interpret.

6.2 Continue current practice

The WBS continues to provide good national monitoring of specialist waterbirds. The particular strength of its method is the high level of detail of the bird data. The drawbacks are the non-random selection of sites and the large commitment of time in fieldwork and in the analysis of territory maps at the end of the season. To remedy the latter problem BTO has, since 1994, asked volunteers to carry out their own territory mapping. This provides a large saving of staff time but the maps still need to be copied, checked and processed.

The continuation of the WBS in its present form would allow a valuable time-series to be continued. However, the scheme as it stands is not ideal for Environment Agency purposes, in particular because the sites are not the ones the Environment Agency would like to see covered and because the methods are incompletely compatible with RHS. Also, the scheme is costly in terms of the number of survey visits required from volunteers and the data processing requirements.

Ideally, the BTO would want to make changes to the sample size and sampling strategy of WBS that would improve the quality of monitoring and bring WBS more into line with BBS.

6.3 Modify current practice

The most sensible option would seem to be a redesigned WBS, to be developed through a pilot phase. This could ensure that river typology becomes complementary between RHS and WBS, thus enhancing the predictive capability of the results. The most important features of a new WBS would be the sampling framework and the counting methods. The primary objective of the scheme would be:

- to track population levels of waterway birds at a national level (England and Wales, as well as UK), allowing for analysis at the level of Environment Agency regions and catchments.

A randomised design, perhaps stratified by observer density, would be necessary to guarantee the representativeness of survey sites and monitoring. Regional boundaries used in any stratification would have to take account of the need to allocate plots to Environment Agency regions and potentially EU regions for the purposes of reporting. A randomised design should provide coverage of river types and qualities although this may need to be built into the selection of sites to ensure adequate coverage.

Pilot survey planning should take account of the following.

- Location of survey plots: the pilot survey could target a sample of the random RHS sites, perhaps stratified by waterway type.

- The balance of costs and benefits and the implications for optimising the number of site visits.

- Accreditation: for the Environment Agency's accreditation purposes, bird surveyors may need to undergo some training.

- Frequency of surveys at each site: the Environment Agency's requirements might be achievable by surveys that are less than annual.

Starting points for river stretches could be chosen from within randomly selected squares (1-km, 2-km or 10-km). The incorporation of pre-existing WBS plots into any new scheme should be considered as a priority as this would make use of experienced and motivated volunteers and enable comparison of results with earlier data.

Survey methods could be developed using territory mapping (with the observers doing their own analyses) or by some form of line/belt transects. The latter has been piloted on WBS plots and would seem to be preferable because the methods are broadly comparable with those of BBS, REDs Linear Bird Survey, RHS and RCS, would require a smaller time input from volunteers, and be more cost-effective to process and analyse. Territory mapping would be needed only if there was a requirement for detailed information at a particular site.

The number of site visits has repercussions for the number of volunteers who may be able to participate in the scheme and the cost of processing the data. The number of visits in the present WBS (generally 9 or 10) restricts the number of people willing and able to take part. The analyses above suggest that two survey visits, as used in the BBS, may be adequate to monitor some waterbirds, depending on the sample size of plots, and that the great majority of species would be monitored at a high level of precision with between 4 and 6 site visits.

The length of survey stretches is a related issue because longer stretches will require a larger time input. Transect lengths in the range 3-5 km would seem to be optimal with recording intervals for the bird and habitat information set at either 200 metres (as in BBS) or 500 metres (as in WBS and RHS).

The costs and benefits of varying the number of survey visits, transect lengths and recording intervals could be explored usefully in a pilot study. The response of volunteers to such methods would be an important component of the pilot work.

A further issue is the balance between amateur and professional fieldworkers within any redesigned WBS. The BTO is fortunate in being able to call upon a highly skilled and motivated force of volunteers. It is likely that volunteers would be able to cover a large number of sites, particularly using simplified and efficient methods. The BTO's regional network has a long history of amateur involvement in extensive census and atlas work in Britain, and it is likely that Regional Organisers would coordinate local volunteer effort within a new WBS. The BBS illustrates the potential for expanding the geographical spread of bird monitoring, but it should be noted that, because of the remoteness of the sites, around 5% of BBS squares in Scotland were surveyed by professionals. Limited use of professionals might, depending on the survey design and requirements of the Environment Agency, be desirable or even necessary within a redesigned WBS. This would be a particular problem for river types associated with the uplands where observer densities are low, or perhaps on

rivers of poor quality with little interest for volunteers, although BTO has been successful in recruiting observers for specific waterways, even of poor water quality, for WBS in Severn-Trent Region (Marchant & Gregory 1994).

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions from this study

In summary, the main conclusions of this report are the following.

1. There should continue to be a national programme of monitoring waterside birds, supplementing BBS, to supply conservation bodies with information on population changes of these species both nationally and regionally, as WBS has done up to now.

2. Annual bird surveys on a national and regional scale are required for the Environment Agency's PPA because they provide controls indicating bird population changes at sites not affected by management.

3. Collecting bird data in a way compatible with RHS would allow more powerful analyses of bird-habitat relationships.

4. Monitoring programmes should be supplemented by site-based bird surveys aimed at assessing the relative conservation value of river stretches and at post-project appraisal. Territory mapping, as used by the WBS, is recommended for PPA whenever possible because it gives maximum detail on the distribution of breeding waterbirds.

7.2 Recommendations for future work

We recommend that:

- WBS should be redesigned to use more efficient methods and to incorporate random selection of survey sites - this would enable representative monitoring to be achieved in the most cost-effective manner;

- a pilot survey should be designed and tested for new methods of monitoring waterbirds along watercourses.

The following future priorities have emerged from the study for action by the BTO:

- consult with potential users of bird survey data;

- design a new waterways bird monitoring scheme, taking into account the strengths and shortcomings of WBS and the requirements of such a scheme;

- carry out cost-benefit analyses and plan a pilot survey;

- identify potential sources of funding.

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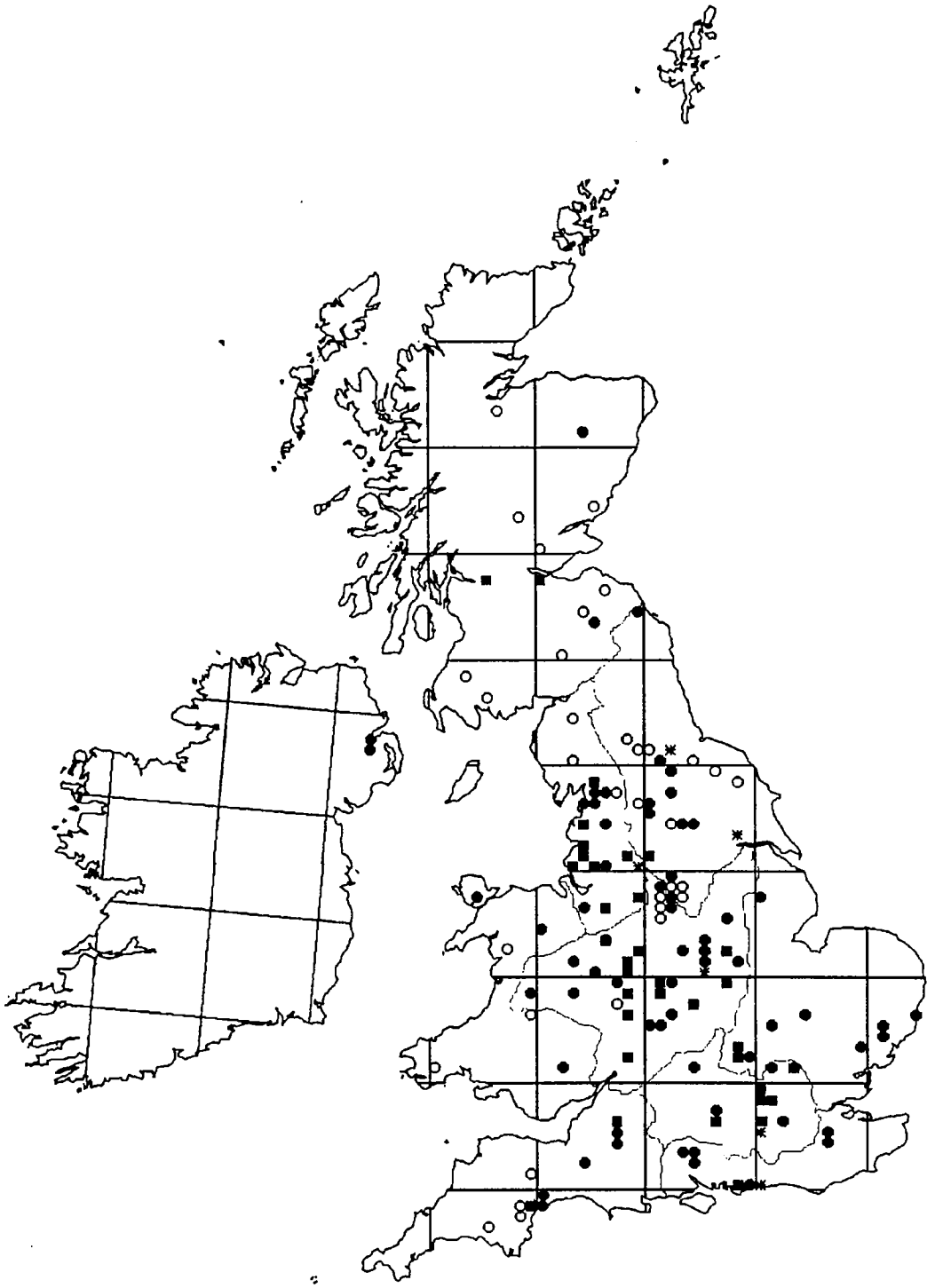


Figure 1. **Distribution of plots used to calculate Waterways Bird Survey population indices between 1989 and 1994, and regional divisions of the Environment Agency. Symbols used are: open circles - fast rivers; filled circles - slow rivers; squares - canals; and stars - mixed river/canal plots.**

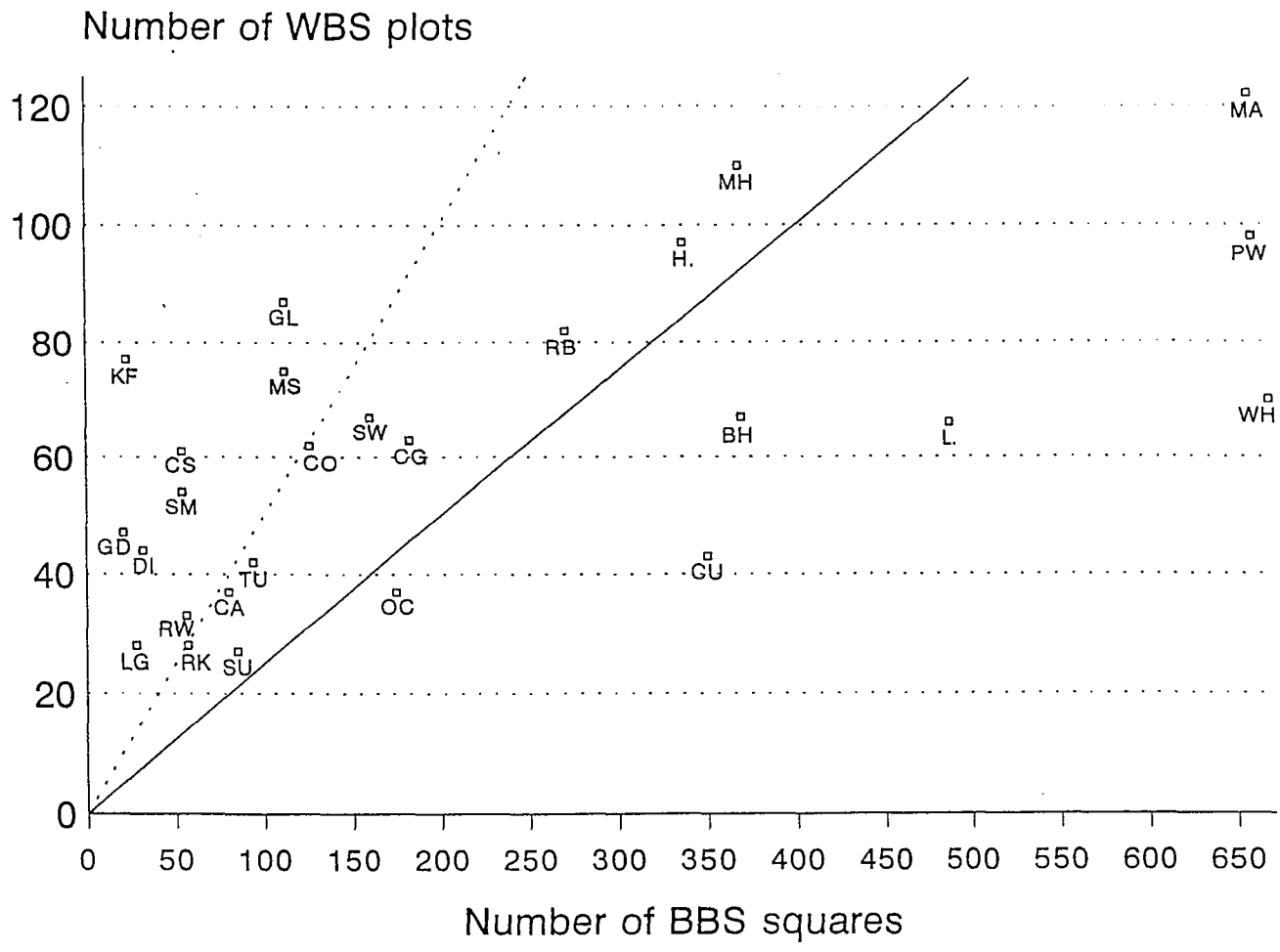


Figure 2. **Incidence of waterside bird species on Waterways Bird Survey plots and Breeding Bird Survey plots in 1994. Species appearing on fewer than 25 WBS plots are omitted.**

Key Standard BTO two-letter codes have been used for species: **BH** Black-headed Gull; **CA** Cormorant; **CG** Canada Goose; **CO** Coot; **CS** Common Sandpiper; **CU** Curlew; **DI** Dipper; **GD** Goosander; **GL** Grey Wagtail; **H.** Grey Heron; **KF** Kingfisher; **L.** Lapwing; **LG** Little Grebe; **MA** Mallard; **MH** Moorhen; **MS** Mute Swan; **OC** Oystercatcher; **PW** Pied Wagtail; **RB** Reed Bunting; **RK** Redshank; **RW** Reed Warbler; **SM** Sand Martin; **SU** Shelduck; **SW** Sedge Warbler; **TU** Tufted Duck; **WH** Whitethroat.

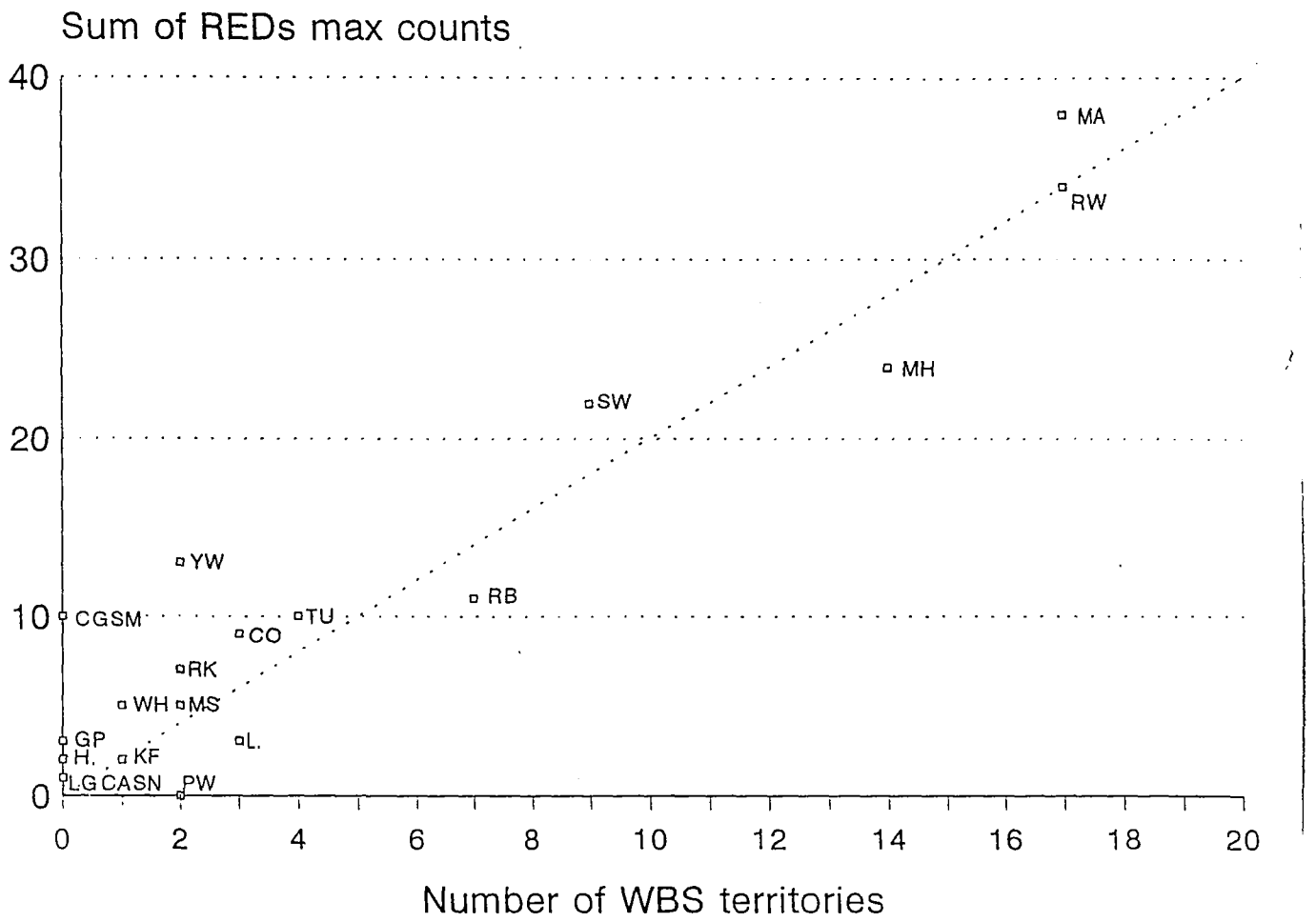


Figure 3. **Standard errors of estimation of population changes between years using WBS transects (see text), in relation to the number of visits made and in relation to standard WBS mapping (M): (a) 1991-92 comparison; (b) 1992-93 comparison.**

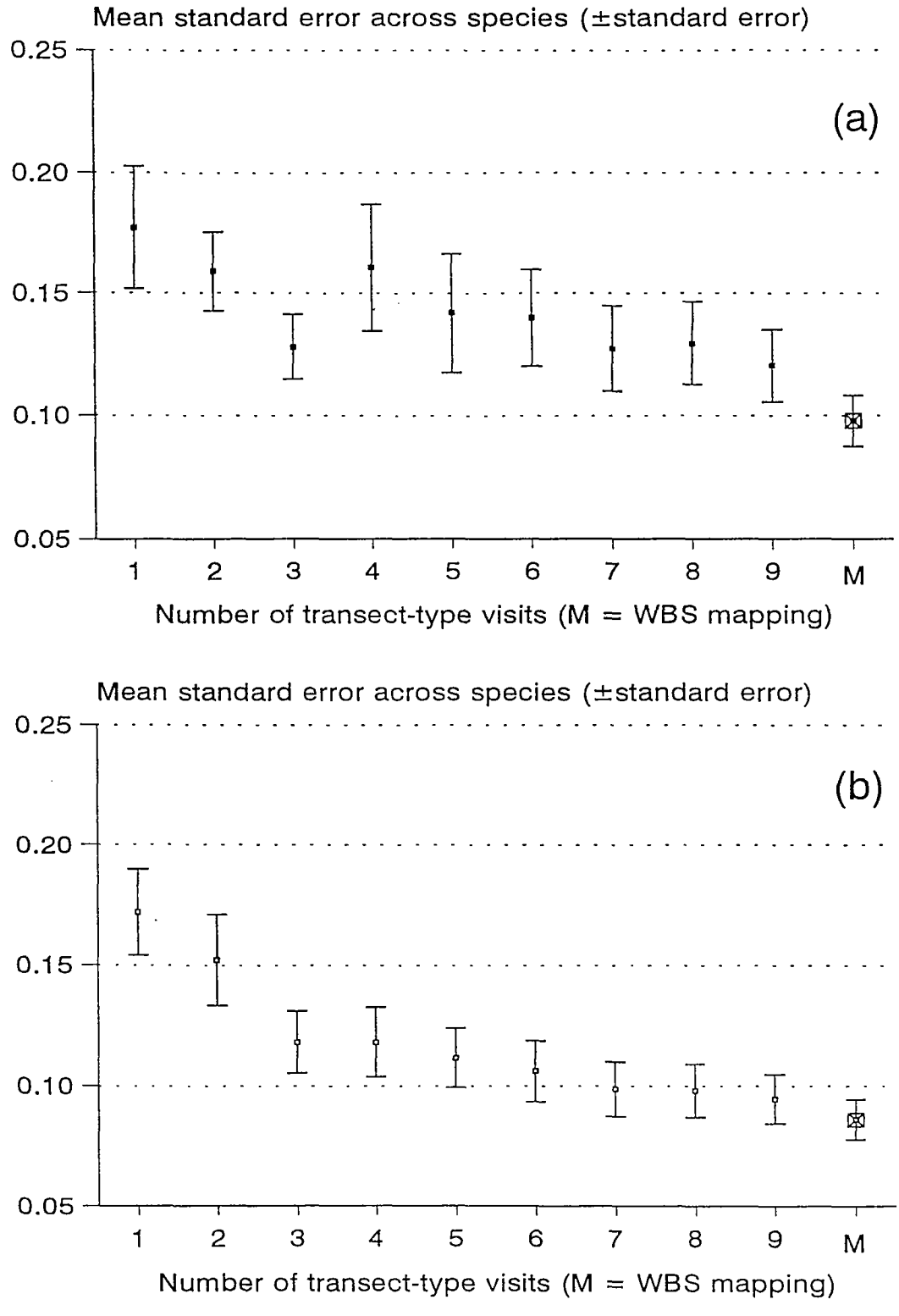


Figure 4. **Comparison of survey results from REDs and WBS for 4.5 kilometres of the River Stour, Essex, in 1990. The dotted line represents the expected result of two birds seen per WBS territory.**

Key As for Figure 2: also **GP** Golden Plover; **SN** Snipe; **YW** Yellow Wagtail.

Table 1. **Numbers of Waterways Bird Survey plots surveyed in Environment Agency Regions, and elsewhere in Britain and Ireland, separately in each year from 1989 to 1994, and in total during 1989-94 (since NRA was formed) and 1974-94 (since WBS began).**

Environment Agency region	1989	1990	1991	1992	1993	1994	1989-94	1974-94
Anglian	6	6	11	11	12	10	15	39
Northumbria & Yorkshire	13	13	21	21	17	14	31	50
North West	16	19	20	20	19	20	30	60
Severn-Trent	20	23	31	33	33	27	44	80
Southern	5	4	7	7	6	5	8	20
South Western	8	8	9	7	10	10	16	41
Thames	14	13	13	14	15	16	25	68
Welsh	7	5	5	5	6	9	14	26
Scotland	8	7	12	15	15	13	16	42
Northern Ireland	4	3	2	1	1	1	5	17
Irish Republic	.	.	.	.	.	.	.	3
Isle of Man	.	.	.	.	.	.	.	3
Total	101	101	131	134	134	125	183	449

Table 2. **Numbers of Waterways Bird Survey plots surveyed in Environment Agency regions in England and Wales during 1989-94, tabulated by water quality. Grades A-F are the Chemistry GQA grades from the NRA General Quality Assessment for 1990 (by courtesy of Dr A E Warn).**

Environment Agency region	A good	B good	C fair	D fair	E poor	F bad	not known	Total
Anglian		1	5	6		1	2	15
Northumbria & Yorkshire	8	13	4				6	31
North West	4	6	6	3	8	1	2	30
Severn-Trent	3	14	12	6	3		6	44
Southern	3	1	2		2			8
South Western	6	5	3	1	1			16
Thames		8	9	3	5			25
Welsh	6	6	1				1	14
Total	30	54	42	19	19	2	17	183

Table 3. General comparisons of survey methods for rivers and for waterbirds in the United Kingdom.

Method	Coverage	Recording units	Survey season	Visits	Fieldworker status
River Corridor Survey	England & Wales; physical features; complete river corridors	500 metres; features mapped precisely	end April to early October	1	professional (NRA)
River Habitat Survey	UK; physical features; random river sites	500 metres; 50-metre spot checks	May to June	1	professional (NRA)
Rivers Environmental Database: Linear Bird Survey	NRA Anglian Region; all bird species; complete river corridors	500 metres for birds; habitat features mapped precisely	April to June	3	professional (NRA/ EcoSurveys)
Waterways Bird Survey: standard mapping census	UK; waterbirds only; habitats mapped; observer-selected sites	river or canal; lengths mostly 3-5 km; bird territories mapped precisely; 500-metre stretches for habitat data	late March to early July	normally 9; each of 1-2 hours	volunteer (BTO)
Waterways Bird Survey: mapping visits treated as transects	(see above)	river or canal; mostly 3-5 km for birds; 500-metre stretches for habitat data	variable within late March to early July	variable in range 1-9; each of 1-2 hours	volunteer (BTO)
Breeding Bird Survey	UK; all bird species; all habitats; habitats coded; random sites	1-km squares of National Grid; 10 200-metre transects	April to June	2; each about 1½ hours	volunteer (BTO)

Table 4. Summary of WBS counts for waterside birds in 1994.

Species	Number of plots	Mean territories per plot	Standard deviation	Total count of territories
Little Grebe	28	1.79	2.03	50
Great Crested Grebe	18	2.72	3.43	49
Cormorant	37	0	0	0
Grey Heron	97	0.77	3.64	75
Mute Swan	75	1.69	1.42	127
Greylag Goose	23	1.13	1.77	26
Canada Goose	63	3.70	11.78	233
Shelduck	27	3.15	4.73	85
Gadwall	7	0.29	0.49	2
Teal	24	0.42	1.06	10
Mallard	122	18.41	19.58	2246
Pochard	5	0.20	0.45	1
Tufted Duck	42	1.60	2.13	67
Goldeneye	10	0	0	0
Red-breasted Merganser	16	0.56	0.81	9
Goosander	47	2.21	2.21	104
Moorhen	110	8.02	7.93	882
Coot	62	5.94	7.46	368
Oystercatcher	37	6.78	8.18	251
Ringed Plover	7	2.14	1.68	15
Lapwing	66	3.03	3.97	200
Dunlin	0	0	0	0
Snipe	24	0.33	0.92	8
Curlew	43	1.51	1.99	65
Redshank	28	2.64	3.15	74

Species	Number of plots	Mean territories per plot	Standard deviation	Total count of territories
Green Sandpiper	8	0	0	0
Common Sandpiper	61	3.23	4.26	197
Black-headed Gull	67	0	0	0
Common Gull	10	0	0	0
Lesser Black-backed Gull	30	0	0	0
Herring Gull	18	0	0	0
Common Tern	22	0	0	0
Kingfisher	77	0.64	0.81	49
Sand Martin	54	32.46	76.71	1753
Yellow Wagtail	22	1.50	1.50	33
Grey Wagtail	87	2.09	1.57	182
Pied Wagtail	98	2.84	2.99	278
Dipper	44	2.93	2.13	129
Grasshopper Warbler	9	0.33	0.71	3
Sedge Warbler	67	6.70	8.40	449
Reed Warbler	33	8.88	16.63	293
Whitethroat	70	3.21	3.49	225
Reed Bunting	82	3.71	4.05	304

Other species recorded on fewer than 5 plots: Shag *Phalacrocorax aristotelis*, Whooper Swan *Cygnus cygnus*, Pink-footed Goose *Anser brachyrhynchus*, Bar-headed Goose *Anser indicus*, Barnacle Goose *Branta leucopsis*, Egyptian Goose *Alopochen aegyptiacus*, Mandarin *Aix galericulata*, Wigeon *Anas penelope*, Pintail *Anas acuta*, Garganey *Anas querquedula*, Shoveler *Anas clypeata*, Smew *Mergus albellus*, Osprey *Pandion haliaetus*, Water Rail *Rallus aquaticus*, Avocet *Recurvirostra avosetta*, Little Ringed Plover *Charadrius dubius*, Golden Plover *Pluvialis apricaria*, Ruff *Philomachus pugnax*, Jack Snipe *Lymnocryptes minimus*, Woodcock *Scolopax rusticola*, Black-tailed Godwit *Limosa limosa*, Whimbrel *Numenius phaeopus*, Greenshank *Tringa nebularia*, Great Black-backed Gull *Larus marinus*, Cetti's Warbler *Cettia cetti*.

Table 5. **Summary of counts for waterside birds recorded by the Breeding Bird Survey in 1549 randomly selected 1-km squares in 1994.**

Species	Number of squares	Mean count per square	Standard deviation	Total count of birds
Little Grebe	28	2.25	1.73	63
Great Crested Grebe	42	3.17	3.49	133
Cormorant	80	2.70	4.80	216
Grey Heron	337	1.58	1.33	534
Mute Swan	112	5.52	13.93	618
Greylag Goose	49	8.00	14.99	392
Canada Goose	183	6.16	9.80	1128
Shelduck	85	8.61	23.33	732
Gadwall	17	2.06	9.67	35
Teal	12	2.33	2.19	28
Mallard	656	5.20	8.84	3414
Pochard	11	6.20	7.29	68
Tufted Duck	94	4.86	4.06	457
Goldeneye	5	1.60	0.89	8
Red-breasted Merganser	6	1.67	0.52	10
Goosander	21	2.29	1.18	48
Moorhen	368	1.99	1.78	733
Coot	126	3.94	6.71	496
Oystercatcher	175	8.17	22.23	1430
Ringed Plover	24	3.88	5.64	93
Lapwing	487	5.92	9.57	2884
Dunlin	22	8.64	23.36	190
Snipe	103	1.92	1.69	198
Curlew	350	5.09	10.48	1782
Redshank	57	4.68	6.51	267

Species	Number of squares	Mean count per square	Standard deviation	Total count of birds
Green Sandpiper	2	1	0	2
Common Sandpiper	54	2.20	1.61	119
Black-headed Gull	369	19.58	184.95	7224
Common Gull	104	8.08	13.78	840
Lesser Black-backed Gull	292	6.85	16.38	1999
Herring Gull	317	10.49	19.67	3324
Common Tern	28	3.54	5.50	99
Kingfisher	23	1.26	0.69	29
Sand Martin	54	10.06	23.58	543
Yellow Wagtail	126	2.79	2.47	351
Grey Wagtail	112	1.46	0.79	163
Pied Wagtail	658	1.96	1.40	1290
Dipper	32	1.25	0.57	40
Grasshopper Warbler	39	1.31	0.57	51
Sedge Warbler	160	3.19	3.45	511
Reed Warbler	56	4.61	7.21	258
Whitethroat	667	2.98	2.66	1988
Reed Bunting	271	2.41	2.23	653

Table 6. **Incidence of bodies of fresh water on BBS transect stretches in 1994. Observers were asked to describe the main habitat type present within the central band of each transect stretch (first habitat) and the most important second habitat if one was present. Habitat codes (following Crick 1992) were recorded for the stretches actually counted and for the ideal, straight-line transects.**

Habitat category		First habitat		Second habitat	
		Actual transects	Ideal transects	Actual transects	Ideal transects
STANDING WATERS					
G1	Pond (less than 50m^2)	5 0.03	9 0.09	117 1.35	36 0.87
G2	Small water-body (50-450 m^2)	14 0.09	24 0.23	107 1.23	49 1.18
G3	Lake/unlined reservoir	20 0.13	40 0.38	65 0.75	23 0.56
G4	Lined reservoir	9 0.06	15 0.14	15 0.17	8 0.19
G5	Gravel pit, sand pit, etc	13 0.09	18 0.17	11 0.13	9 0.22
LINEAR WATERWAYS					
G6	Stream (less than 3m wide)	37 0.25	20 0.19	413 4.76	184 4.45
G7	River (more than 3m wide)	112 0.75	46 0.44	165 1.90	91 2.20
G8	Ditch with water (less than 2m wide)	4 0.03	1 0.01	214 2.47	81 1.96
G9	Small canal (2-5m wide)	9 0.06	6 0.06	42 0.48	18 0.43
G10	Large canal (more than 5m wide)	34 0.23	4 0.04	15 0.17	15 0.36

H LAND USE WITHIN 50m OF BANKTOP *Use E (≥ 33% banklength) or ✓ if present*

	L	R		L	R
Broadleaf/mixed woodland *(BL)*			Rough pasture *(RP)*		
Coniferous plantation *(CP)*			Improved/semi-improved grass *(IG)*		
Orchard *(OR)*			Tilled land *(TL)*		
Moorland/heath *(MH)*			Wetland (eg bog, marsh, fen) *(WL)*		
Scrub *(SC)*			Open water *(OW)*		
Tall herbs ~ *rank vegetation* (TH)			Suburban/urban development *(SU)*		

I BANK PROFILES *Use E (≥ 33% banklength) or ✓ (present)*

Natural/unmodified	L	R	Artificial/modified	L	R
Vertical/undercut			Resectioned		
Vertical + toe			Reinforced - whole bank		
Steep (>45°)			Reinforced - top only		
Gentle			Reinforced - toe only		
Composite			Artificial two-stage		
			Poached		
			Embanked		
			Set-back embankments		

J EXTENT OF TREES AND ASSOCIATED FEATURES

TREES *(tick one box per bank)*

	Left	Right
None	☐	☐
Isolated/scattered	☐	☐
Regularly spaced, single	☐	☐
Occasional clumps	☐	☐
Semi-continuous	☐	☐
Continuous	☐	☐

ASSOCIATED FEATURES *(tick one box per feature)*

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

K EXTENT OF CHANNEL FEATURES *(tick one box per feature)*

	None	Present	E		None	Present	E *(≥33%)*
Waterfall(s)	☐	☐	☐	Marginal deadwater	☐	☐	☐
Cascades(s)	☐	☐	☐	Exposed bedrock	☐	☐	☐
Rapid(s)	☐	☐	☐	Exposed boulders	☐	☐	☐
Riffle(s)	☐	☐	☐	Unvegetated mid-channel bar(s)	☐	☐	☐
Run(s)	☐	☐	☐	Vegetated mid-channel bar(s)	☐	☐	☐
Boil(s)	☐	☐	☐	Mature island(s)	☐	☐	☐
Glide(s)	☐	☐	☐	Unvegetated side bar(s)	☐	☐	☐
Pool(s)	☐	☐	☐	Vegetated side bar(s)	☐	☐	☐

Indicate predominant flow sequence (*select up to three features*):

Table 8. **Standard errors of population change estimates derived from WBS mapping for each of the 19 species normally monitored plus Reed Warbler. These data are summarised across species in Figure 3.**

Species	1991-92	1992-93
Little Grebe	0.11	0.11
Mute Swan	0.13	0.07
Mallard	0.03	0.04
Tufted Duck	0.13	0.17
Moorhen	0.04	0.04
Coot	0.07	0.08
Oystercatcher	0.07	0.08
Lapwing	0.06	0.07
Curlew	0.11	0.12
Redshank	0.10	0.09
Common Sandpiper	0.07	0.06
Kingfisher	0.15	0.13
Yellow Wagtail	0.18	0.17
Grey Wagtail	0.08	0.07
Pied Wagtail	0.07	0.06
Dipper	0.04	0.05
Sedge Warbler	0.09	0.07
Reed Warbler	0.17	0.06
Whitethroat	0.19	0.09
Reed Bunting	0.07	0.07

Table 9. **Numbers of WBS transect visits required to achieve a certain minimum standard error for the ratio estimator of year-to-year change. Species are listed taxonomically within the categories.**

(a) Minimum standard error of 0.1: an expected standard error smaller than 0.1 would allow a 20% change in numbers between years to be detectable.

Number of visits	1991/92	1992/93
1	Mallard Moorhen Coot Pied Wagtail	Mallard Moorhen Coot Sedge Warbler
2	Mute Swan Dipper	Mute Swan Dipper Reed Bunting
3	Common Sandpiper Reed Warbler Reed Bunting	Oystercatcher Reed Warbler
4	Grey Wagtail	Redshank Common Sandpiper
5	Little Grebe Redshank Sedge Warbler	Little Grebe
6		
7		Whitethroat
8		
9		
(9+): not achieved with 9 visits	Tufted Duck Oystercatcher Lapwing Curlew Kingfisher Whitethroat Yellow Wagtail	Tufted Duck Lapwing Curlew Kingfisher Pied Wagtail Grey Wagtail Yellow Wagtail

(b) **Minimum standard error of 0.15: an expected standard error smaller than 0.15 would allow a 30% change in numbers between years to be detectable.**

Number of visits	1991/92	1992/93
1	Mute Swan Mallard Moorhen Coot Oystercatcher Lapwing Common Sandpiper Dipper Sedge Warbler Pied Wagtail Grey Wagtail Reed Bunting	Mute Swan Mallard Moorhen Coot Oystercatcher Sedge Warbler Reed Bunting
2	Redshank	Little Grebe Redshank Common Sandpiper Dipper Reed Warbler
3	Little Grebe Reed Warbler	Tufted Duck Whitethroat Pied Wagtail Grey Wagtail
4		Kingfisher
5		
6	Yellow Wagtail	
7	Kingfisher	Lapwing Yellow Wagtail
8	Tufted Duck	
9		
(9+): not achieved with 9 visits	Curlew Whitethroat	Curlew

Table 10. **River stretches where both WBS and REDs surveys were carried out in the same year.**

River	Year	WBS upstream limit	WBS downstream limit	WBS plot code	REDs transect codes
Cam	1989	TL470600	TL502644	305	CCAM023-035
Stour	1990	TL965332	TL985343	347	ESTO157-159, 161-164, 167, 169
Ivel	1990	TL158501	TL156519	196	CIVE059-065
Witham	1991	TF060715	TF090710	296	WITH171-175

Table 11. Comparison of REDs bird counts and numbers of WBS territories along 4.5 kilometres of the River Stour, Essex, in 1990.

Species	REDs Linear Bird Survey bird counts, summed across transects				WBS territory counts
	1st visit	2nd visit	3rd visit	Highest counts	
Little Grebe	1	1	1	1	0
Cormorant	1	0	0	1	0
Grey Heron	1	0	1	2	0
Mute Swan	0	0	5	5	2
Canada Goose	8	2	0	10	0
Mallard	32	17	6	38	17
Tufted Duck	6	5	2	10	4
Moorhen	20	14	12	24	14
Coot	8	1	4	9	3
Golden Plover	3	0	0	3	0
Lapwing	2	2	2	3	3
Snipe	1	0	0	1	0
Redshank	3	2	4	7	2
Kingfisher	0	1	1	2	1
Sand Martin	2	2	8	10	0
Yellow Wagtail	12	3	3	13	2
Pied Wagtail	0	0	0	0	2
Sedge Warbler	3	13	18	22	9
Reed Warbler	0	23	29	34	17
Whitethroat	1	2	5	5	1
Reed Bunting	11	4	4	11	7

Appendix 1. Glossary of abbreviations

BBS	Breeding Bird Survey
BOD	Biochemical oxygen demand
BTO	British Trust for Ornithology
CBC	Common Birds Census
CMP	Catchment Management Plan
DoE	Department of the Environment
ECN	Environmental Change Network
ECS	Evaluated Catchment Section
EU	European Union
GQA	General Quality Assessment
HQI	Habitat Quality Index
IFE	Institute of Freshwater Ecology (formerly Freshwater Biological Association)
ITE	Institute of Terrestrial Ecology
JNCC	Joint Nature Conservation Committee
NRA	National Rivers Authority
NWC	National Water Council
PPA	Post-Project Appraisal
RCS	River Corridor Survey
REDs	Rivers Environmental Database
RHS	River Habitat Survey
RIVPACS	River Invertebrate Prediction and Classification System
RQO	River Quality Objective
RSNC	Royal Society for Nature Conservation
RSPB	Royal Society for the Protection of Birds
SERCON	System for Evaluating Rivers for Conservation
SNH	Scottish Natural Heritage
SSSI	Site of Special Scientific Interest
SWQO	Statutory Water Quality Objective
WBS	Waterways Bird Survey

Appendix 2. Scientific names of bird species mentioned in the text

Little Grebe	*Tachybaptus ruficollis*
Great Crested Grebe	*Podiceps cristatus*
Cormorant	*Phalacrocorax carbo*
Grey Heron	*Ardea cinerea*
Mute Swan	*Cygnus olor*
Greylag Goose	*Anser anser*
Canada Goose	*Branta canadensis*
Shelduck	*Tadorna tadorna*
Gadwall	*Anas strepera*
Teal	*Anas crecca*
Mallard	*Anas platyrhynchos*
Pochard	*Aythya ferina*
Tufted Duck	*Aythya fuligula*
Goldeneye	*Bucephala clangula*
Red-breasted Merganser	*Mergus serrator*
Goosander	*Mergus merganser*
Moorhen	*Gallinula chloropus*
Coot	*Fulica atra*
Oystercatcher	*Haematopus ostralegus*
Ringed Plover	*Charadrius hiaticula*
Golden Plover	*Pluvialis apricaria*
Lapwing	*Vanellus vanellus*
Dunlin	*Calidris alpina*
Snipe	*Gallinago gallinago*
Curlew	*Numenius arquata*
Redshank	*Tringa totanus*
Green Sandpiper	*Tringa ochropus*
Common Sandpiper	*Actitis hypoleucos*
Black-headed Gull	*Larus ridibundus*
Common Gull	*Larus canus*
Lesser Black-backed Gull	*Larus fuscus*
Herring Gull	*Larus argentatus*
Common Tern	*Sterna hirundo*
Kingfisher	*Alcedo atthis*
Sand Martin	*Riparia riparia*
Swallow	*Hirundo rustica*
Yellow Wagtail	*Motacilla flava*
Grey Wagtail	*Motacilla cinerea*
Pied Wagtail	*Motacilla alba*
Dipper	*Cinclus cinclus*
Grasshopper Warbler	*Locustella naevia*
Sedge Warbler	*Acrocephalus schoenobaenus*
Reed Warbler	*Acrocephalus scirpaceus*
Whitethroat	*Sylvia communis*
Rook	*Corvus frugilegus*

Appendix 3. River Habitat Survey recording forms and spot check key (NRA 1995)

A BACKGROUND MAP-BASED INFORMATION

Altitude(m)	Slope (m/km)	Flow category (1-10)
Solid geology code	Drift geology code	Planform category
Distance from source (km)	Significant tributary ?	Navigation ?
Height of source (m)	Water Quality Class	

B FIELD SURVEY DETAILS

Reference network site number:

Mid-site grid reference of network site if different from designated location:

Grid Reference: River:

Date ..../..../1996 Time: ..... Surveyor name . . . . . .

Accredited Surveyor? No ☐ Yes ☐ *If yes, state number* . . . . . .

Adverse conditions affecting survey? No ☐ Yes ☐ *If yes, state* . . . . . .

Bed of river visible? No ☐ partially ☐ entirely ☐ *(tick one box)*

Duplicate photographs: general character? No ☐ Yes ☐ *(tick one box)*

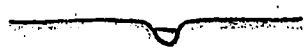
Site surveyed from: left bank ☐ right bank ☐ channel ☐ *(tick as appropriate)*

C PREDOMINANT VALLEY FORM *(tick one box only)*

☐ shallow vee

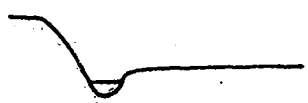
☐ concave/bowl
(If U-shaped glacial valley - add "U")

☐ deep vee



☐ symmetrical floodplain

☐ gorge



☐ asymmetrical floodplain

Terraced valley floor? No ☐ Yes ☐

D NUMBER OF RIFFLES, POOLS AND POINT BARS *(indicate total number)*

Riffles	Unvegetated point bars
Pools	Vegetated point bars

SEND COMPLETED FORM TO HUGH DAWSON, IFE, RIVER LABORATORY, EAST STOKE, WAREHAM, BH20 6BB

Spot check 1 is at: upstream end ☐ downstream end ☐ of site *(tick one box)*

E PHYSICAL ATTRIBUTES *(to be assessed across channel within a 1m wide transect)*

[1] = one entry only	1	2	3	4	5	6	7	8	9	10	
LEFT BANK											
Material [1] *NV,BE,BO,CO,GS,EA,PE,CL,CC,SP,WP,GA,BR,RR,BW*											
Bank modification(s) *NK,NO,RS,RI,PC,BM,EM*											
Bank feature(s) *NV,NO,EC,SC,PB,VP,SB,VS*											
CHANNEL											
Channel substrate [1] *NV,BE,BO,CO,GP,SA,SI,CL,PE,AR*											
Flow type [1] *FF,CH,BW,UW,CF,RP,UP,SM,NP,NO*											
Channel modification(s) *NK,NO,CV,RS,RI,DA,FO*											
Channel feature(s) *NV,NO,RO,MB,VB,MI,TR*											
RIGHT BANK											
Material [1] *NV,BE,BO,CO,GS,EA,PE,CL,CC,SP,SW,GA,BR,RR,BW*											
Bank modification(s) *NK,NO,RS,RI,PC,BM,EM*											
Bank feature(s) *NV,NO,EC,SC,PB,VP,SB,VS*											

F BANKTOP LAND USE AND VEGETATION STRUCTURE *(to be assessed over a 10m wide transect)*

Land use: choose one from BL, CP, OR, MH, SC, TH, RP, IG, TL, WL, OW, SU

LAND USE WITHIN 5m OF BANKTOP (L)										
LEFT BANK-TOP *(structure within 1m)* *B/U/S/C*										
LEFT BANK FACE (*structure*) *B/U/S/C*										
RIGHT BANK FACE (*structure*) *B/U/S/C*										
RIGHT BANK-TOP *(structure within 1m)* *B/U/S/C*										
LAND USE WITHIN 5m OF BANK TOP (R)										

G CHANNEL VEGETATION TYPES *(assessed over a 10m wide transect: use E (≥ 33% area) or ✓ (present)*

NONE											
Liverworts/mosses/lichens											
Emergent broad-leaved herbs											
Emergent reeds/sedges/rushes											
Floating-leaved (rooted)											
Free-floating											
Amphibious											
Submerged broad-leaved											
Submerged fine/linear-leaved											
Filamentous algae											

Use end 'catch-all' column for types not occurring in spot checks as well as overall assessment over 500m (use E or ✓) ↑

H LAND USE WITHIN 50m OF BANKTOP *Use E (≥ 33% banklength) or ✓ if present*

	L	R		L	R
Broadleaf/mixed woodland *(BL)*			Rough pasture *(RP)*		
Coniferous plantation *(CP)*			Improved/semi-improved grass *(IG)*		
Orchard *(OR)*			Tilled land *(TL)*		
Moorland/heath *(MH)*			Wetland (eg bog, marsh, fen) *(WL)*		
Scrub *(SC)*			Open water *(OW)*		
Tall herbs ~ *rank vegetation* (TH)			Suburban/urban development *(SU)*		

I BANK PROFILES *Use E (≥ 33% banklength) or ✓ (present)*

Natural/unmodified	L	R	Artificial/modified	L	R
Vertical/undercut			Resectioned		
Vertical + toe			Reinforced - whole bank		
Steep (>45°)			Reinforced - top only		
Gentle			Reinforced - toe only		
Composite			Artificial two-stage		
			Poached		
			Embanked		
			Set-back embankments		

J EXTENT OF TREES AND ASSOCIATED FEATURES

TREES *(tick one box per bank)*

	Left	Right
None	☐	☐
Isolated/scattered	☐	☐
Regularly spaced, single	☐	☐
Occasional clumps	☐	☐
Semi-continuous	☐	☐
Continuous	☐	☐

ASSOCIATED FEATURES *(tick one box per feature)*

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

K EXTENT OF CHANNEL FEATURES *(tick one box per feature)*

	None	Present	E		None	Present	E *(≥33%)*
Waterfall(s)	☐	☐	☐	Marginal deadwater	☐	☐	☐
Cascades(s)	☐	☐	☐	Exposed bedrock	☐	☐	☐
Rapid(s)	☐	☐	☐	Exposed boulders	☐	☐	☐
Riffle(s)	☐	☐	☐	Unvegetated mid-channel bar(s)	☐	☐	☐
Run(s)	☐	☐	☐	Vegetated mid-channel bar(s)	☐	☐	☐
Boil(s)	☐	☐	☐	Mature island(s)	☐	☐	☐
Glide(s)	☐	☐	☐	Unvegetated side bar(s)	☐	☐	☐
Pool(s)	☐	☐	☐	Vegetated side bar(s)	☐	☐	☐

Indicate predominant flow sequence (*select up to three features*):

L CHANNEL DIMENSIONS *(to be measured at one site on a straight uniform section, preferably across a riffle)*

LEFT BANK		Banktop width (m)		RIGHT BANK	
Banktop height (m)		Water width (m)		Banktop height (m)	
Embanked height (m)		Water depth (m)		*Embanked height (m)*	

If trashline lower than banktop break in slope, indicate: height (m) = width(m) =

Bed material at site is: consolidated (compact) ☐ unconsolidated (loose) ☐ unknown ☐

Location of measurement is: **riffle** ☐ run or glide ☐ other ☐ *(tick one box)*

M ARTIFICIAL FEATURES *(indicate total number or tock appropriate box)*

None ☐ Number of Culverts= Weirs= Outfalls= Fords =
Footbridges = Roadbridges = Other=

Is water impounded by weir/dam? No ☐ Yes, <33% of site ☐ >33% of site ☐

N EVIDENCE OF RECENT MANAGEMENT *(tick appropriate box(es))*

None ☐ Dredging ☐ Mowing ☐ Weed-cutting ☐
Enhancement ☐ Other ? State . . . . . .

O FEATURES OF SPECIAL INTEREST *(tick appropriate box(es))*

None ☐

Waterfalls > 5m high	☐	Artificial open water	☐	Bog ☐	Other (state) . . . . .
Braided/side channels	☐	Natural open water	☐	Carr ☐	
Debris dams	☐	Water meadow	☐	Marsh ☐	
Leafy debris	☐	Fen	☐	Flush ☐	

P CHOKED CHANNEL *(tick one box)*

Is 33% or more of the channel choked with vegetation? NO ☐ YES ☐

Q NOTABLE NUISANCE PLANT SPECIES *Use ✓or E (≥ 33% banklength)*

None ☐ Giant Hogweed ☐ Himalayan Balsam ☐ Japanese Knotweed ☐ Other? State . . . . .

R OVERALL CHARACTERISTICS *(Circle appropriate words, add others as necessary)*

Major impacts: landfill - tipping - litter - sewage - pollution - drought - abstraction - mill - dam - road - rail -industry -housing mining - quarrying - overdeepening - afforestation - fisheries management - silting

Land Management: set-aside - buffer strip - headland - abandoned land - parkland - MoD

Animals: otter - mink - water vole - kingfisher - dipper - grey wagtail - sand martin - heron - dragonflies/damselflies

Other significant observations:

S ALDERS *(tick appropriate box(es))*

Alders? None ☐ Present ☐ Extensive ☐ Diseased Alders? None ☐ Present ☐ Extensive ☐

PHYSICAL ATTRIBUTES (SECTION E)

BANKS

Predominant bank material

NV = not visible

BE = bedrock
BO = boulder
CO= cobble
GS = gravel/sand
EA = earth (crumbly)
PE = peat
CL = sticky clay

CC = concrete
SP = sheet piling
WP = wood piling
GA = gabion
BR = brick/laid stone
RR = rip-rap
BW = builders' waste

Bank modifications

NK = not known
NO = none

RS = resectioned
RI = reinforced
PC = poached
BM = berm
EM = embanked

Bank features

NV = not visible (eg far bank)
NO = none

EC = eroding earth cliff
SC = stable earth cliff

PB = unvegetated point bar
VP = vegetated point bar

SB = unvegetated side bar
VS = vegetated side bar

CHANNEL

Predominant substrate

NV = not visible

BE = bedrock
BO = boulder
CO = cobble
GP = gravel/pebble
SA = sand
SI = silt/mud
CL = clay
PE = peat
AR = artificial

Predominant flow *(see below)*

FF = freefall
CH = chute
BW = broken standing waves (white-water)
UW = unbroken standing wave
CF =chaotic flow
RP = rippled
UP = upwelling
SM = smooth boundary turbulent
NP = no perceptible flow
NO= None (dry)

Channel modifications

NK = not known
NO = none

CV = culverted
RS = resectioned
RI = reinforced
DA = dam/weir
FO = ford (man-made)

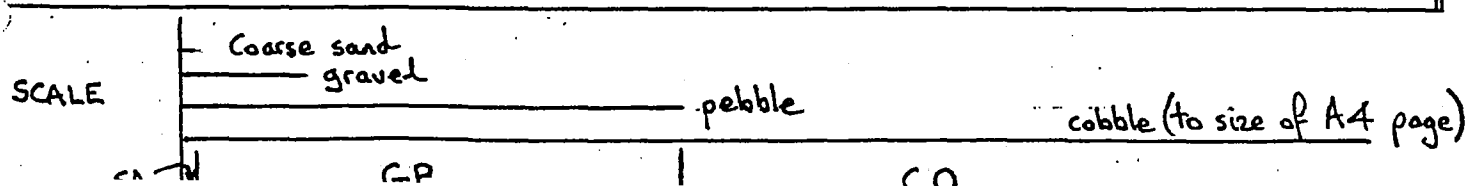
Channel features

NV = not visible
NO = none

RO = exposed bedrock/boulders
MB = unvegetated mid-channel bar
VB = vegetated mid-channel bar
MI = mature island

TR = urban debris (trash)

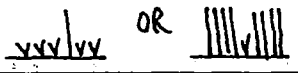
FLOW TYPES	ASSOCIATED CHANNEL FEATURES
FF: Free fall	clearly separates from backwall of vertical feature ~ associated with ***waterfalls.***
CH: Chute	low curving fall in contact with substrate ~ associated with ***step*** of ***step-pool cascade.***
BW: Broken standing waves	***white-water*** tumbling wave must be present ~ associated with ***rapids.***
UW: Unbroken standing waves	upstream facing wavelets which are not broken ~ associated with ***riffles.***
CF: Chaotic flow	a mixture of rough flow types in no organised pattern.
RP: Rippled	no waves, but general flow direction is downstream with disturbed rippled surface ~ Associated with ***runs.***
UP: Upwelling	heaving water as upwellings break the surface ~ associated with ***boils.***
SM: Smooth boundary turbulent	perceptible downstream movement is smooth (no eddies) ~ associated with ***glides.***
NP: No perceptible flow	no net downstream flow ~ associated with ***pools*** and ***deadwater.***
NO: No flow	***dry.***



LAND USE WITHIN 5m OF BANKTOP (SECTION F)

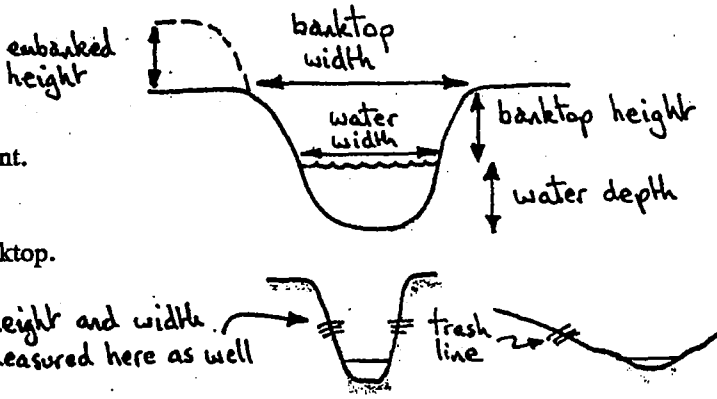
BL =	Broadleaf/mixed woodland	SC =	Scrub	TL =	Tilled land
CP =	Coniferous/plantation	TH =	Tall herbs	WL =	Wetland
OR =	Orchard	RP =	Rough pasture	OW =	Open water
MH =	Moorland/heath	IG =	Improved grass	SU =	Suburban/urban

BANKTOP AND BANKFACE VEGETATION STRUCTURE To be assessed within a 10m wide transect (SECTION F)

bare	B	bare earth/rock etc	Vegetation types
uniform 	U	predominantly one type (no scrub or trees)	bryophytes short herbs/ creeping grasses tall herbs/ grasses scrub/brambles etc saplings and trees
simple 	S	two or three vegetation types	
complex 	C	four or more types	

Channel dimensions guidance (Section L)

- Select location on uniform section.
- If a riffle is present, measure there.
  If not, measure at straightest and shallowest point.
- Banktop = first major break in slope.
- Trashline level to be recorded if lower than banktop.
  (Height and width to be measured.)



WORKING ALONE: CHECKLIST

- PREPARATION
- IMPLEMENT REPORTING-IN PROCEDURE
- WEAR PROTECTIVE CLOTHING
- DO NOT RUSH
- NEVER ENTER CONFINED SPACES
- OBSERVE HYGIENE RULES
- REPORT IN AS AGREED
- WATCH FOR CHANGING CONDITIONS

WEIL'S DISEASE

INSTRUCTIONS TO CARD HOLDERS

1. As infection may enter through breaks in the skin ensure that any cut, scratch or abrasion is thoroughly cleansed and covered with a waterproof plaster.
2. Avoid rubbing your eyes, nose and mouth during work.
3. Clean protective clothing, footwear and equipment etc, after use.
4. After work and particularly before taking food or drink wash hands thoroughly.
5. Report all accidents and/or injuries however slight.
6. Keep your card with you at all times.

ENVIRONMENT AGENCY EMERGENCY HOTLINE

0800 80 70 60
24-hour free emergency telephone line.

Appendix 4. Waterways Bird Survey instructions (Taylor 1982)

BTO WATERWAYS BIRD SURVEY INSTRUCTIONS

Text — Kenneth Taylor
Figures — Elizabeth Murray

WBS logo by Crispin Fisher.

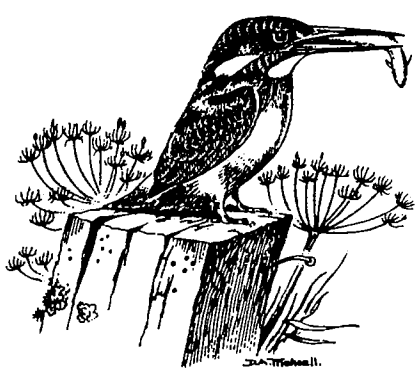
Introduction

Britain's waterways provide breeding, feeding and resting places for many different species of birds. Some, like the Kingfisher and Dipper, are exclusively associated with flowing water and could be classed as fully 'riparian' birds. The Kingfisher is thus aptly described as the 'secret splendour of the brooks', but the question is, which brooks? If a farmer in central Scotland decided to 'manage' a stream running through his land by deepening and straightening the water channel, might this have an effect on Kingfishers? If the stream froze in winter or flooded in spring, what influence would this have on birds breeding there? These are the types of questions which the BTO hopes to answer over the next few years through its Waterways Bird Survey (WBS).

WBS history and achievements

The WBS began as a national survey in 1974. Its aims were to provide an 'annual index' of population levels for several species not already covered by the BTO's national Common Birds Census, and to produce the data on habitat requirements and regional distribution needed to assess the influence of waterways management and pollution on riparian birds.

Since 1974 over 250 different stretches of waterways between Ross and Cromarty and Devon have been surveyed. This work has already allowed regional variations in territory densities of waterways birds to be documented and indicated how densities are influenced by waterway altitude and gradient. For



example, no Kingfisher territories have been recorded on Scottish WBS plots, and elsewhere in Britain Kingfisher densities are highest on slow rivers at low altitude. Data from the 1980 WBS also showed how quickly some waterways birds recovered from the effects of the harsh 1978/79 winter. There were fewer Kingfisher territories on WBS plots in the breeding season following this cold weather than in any previous survey year. Kingfisher territories increased between 1979-80 to a level similar to that in many years prior to the hard winter, and remained at this level in 1981 (see Fig. 1). For conservationists, WBS data could thus help determine whether an individual waterway was especially valuable as a bird habitat at a regional or national level, and provide a means of monitoring population trends in different habitats, for example managed and unmanaged rivers.

Sedge Warbler carrying food to its young. Photo: C. J. Smale.

The survey work

The survey work is simple to carry out, and many birdwatchers consider the WBS an excellent way to add extra structure and enjoyment to their field trips. Having chosen a stretch of waterway to survey (a minimum of 3 km or around 2 miles in length) the observer makes nine or ten visits to the survey plot during the breeding season. On each visit the positions of birds seen are recorded on a 6": 1 mile scale map of the waterway.

At the end of the breeding season data from these 'visit maps' are transferred to 'species sheets' by observers and analysed by BTO staff. Analyses provide information on the number of territories of individual species. If a plot is surveyed for more than a year, this territory information can be used to calculate indices of population change. A number of observers have been participating in the scheme every year since 1974, and many comment that each new survey year holds its own rewards as they gain a progressively more intimate knowledge of the birdlife on their plot.

WBS potential

WBS documentation of the effects of watercourse management and pollution on birds has been limited until recently, partly due to the small number of observers (usually 50-60) participating in any one year. As a result of appeals for more survey workers, over 80 new WBS plots were surveyed in 1981-82, in addition to those plots where long term monitoring continued. (The map on page five illustrates the geographical position of plots surveyed in 1981). This means that the WBS now has a greater potential than ever before for monitoring the changing fortunes of riparian birds. To help reap the full benefits of increased observer coverage, WBS workers are now being asked to submit detailed information about their plots by completing a 'tick list' of habitat features. Details of habitat recording are given on pages four to six. These habitat data can be readily stored on the BTO computer, increasing the potential for comparison of riparian bird populations in different regions or under different management regimes. The RSPB is also currently studying the effects of river management on birds, and is assisting the WBS with publicity and technical advice.

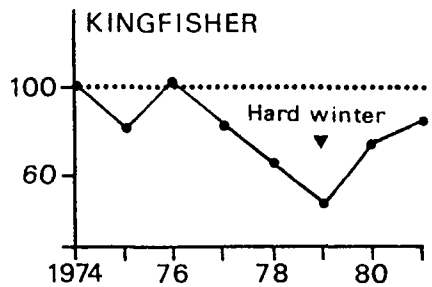


Fig 1. Changes in WBS Kingfisher index between 1974-1981, showing the rapid recovery from the effects of the hard 1978-79 winter.

WBS information has also helped the RSPB to prepare material for training Water Authority personnel. One of the RSPB's 1982 films *'The Vital River'* illustrates many of the techniques which are being developed to integrate the needs of wildlife with those of river management.

The WBS has great potential as a tool for conservation. With improved observer coverage and habitat recording techniques, the survey should be able to realise this potential in the near future. For the Kingfisher and other waterways birds it is certainly about time the secrets of the brooks were made public.

HOW TO CONDUCT A SURVEY

Contributions are welcome from anyone interested in the welfare of waterways birds. However, in order that the results can be incorporated into the scheme, the following two points should be noted: **1. The survey should be carried out as far as possible *according to the methods described in these Instructions*; 2. At least two consecutive seasons' work should be intended by the observer, along the same stretch and employing the same amount of effort, so that the results can be used in the calculation of population indices.**

Most contributors are individuals but work can be shared among the members of a local or school society. More extensive work can be organised by local societies, covering for example the whole length of a river, or a variety of different waterways within the society's recording area.

An average survey involves about 15-20 hours of fieldwork spread throughout the breeding season, and a further 2-8 hours compiling and checking species and habitat maps.

Selecting a plot

The selection of the waterway to be covered is left to the observer, although Populations Section staff will be happy to give advice if required. The following points should be borne in mind:

1. **Waterways which can be clearly classified as either rivers or canals will be of maximum use (although hybrid plots can be accommodated);**
2. **A tidal or partly tidal waterway is likely to be unsuitable, as few of the riparian birds will be territorial;**
3. **The observer should ensure that there is ready access to one or both banks throughout the reach, and should obtain permission beforehand if the survey requires entry to private land.**

River habitats showing all states of management will be welcomed, from little or none through management in progress to rivers after extensive deepening and straightening, so that a full picture of the effects of the bird-life can be compiled. **A length of about 5 km is considered ideal.** Longer or shorter **(minimum 3 km)** reaches are acceptable.

Obtaining maps

Experience has shown that for the relatively few species concerned, the 6-inch Ordnance Survey (1:10560 or 1:10000) provides a suitable base-map for the survey.

Most public libraries have copies of local 6-inch maps and permission should be sought to trace the outline of the waterway and its immediate topographical features, so that a number of blank maps can be duplicated. Features of the waterway which will help to pinpoint the observer's position (and thus accurately locate observations) should be included; these might be weirs, bridges, fords, belts of trees, buildings, or field hedgerows, for example. Useful features of recent origin noted on any preliminary visit may also be included. However, it is important that the clarity of the map outline should be retained, and features tending to obscure the registrations or cause them to be displaced from their accurate position on the map should be left out.

Any observer who has difficulty duplicating sufficient copies should send the completed tracing to the Popualtions Section at Beech Grove for copying. Similarly, should it prove impossible to obtain the 6-inch OS map locally, the appropriate map references (from the one-inch or 2½-inch editions) should be sent to the Populations Office, where all possible assistance will be given.

About 20-25 copies will be needed for each season's work, depending on the number of visits intended and the density and variety of the riparian species present.

The survey method

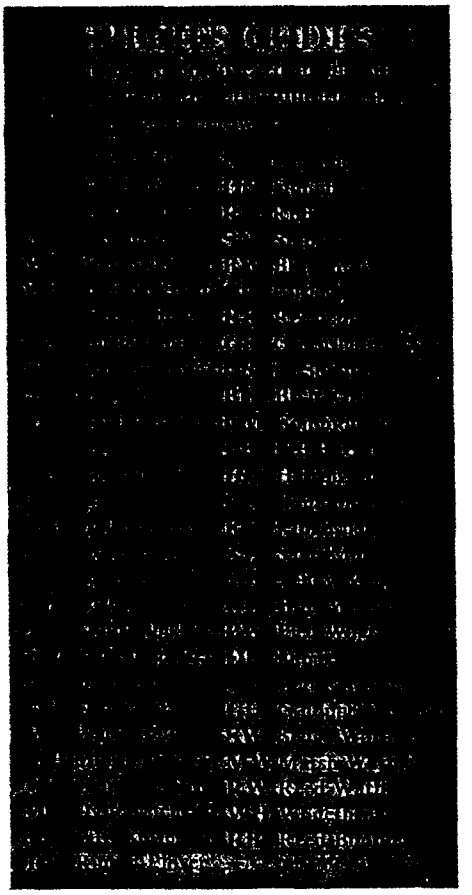
The WBS is a 'mapping census' conducted along the lines established by the Common Birds Census (CBC) which has been in operation since 1962. Observations plotted on successive visits during the breeding season are used to give evidence of the number and extent of occupied territories.

Ideal coverage comprises nine full field recording visits to the plot during the course of the breeding season, between mid-March and mid-July (in accordance with the recommendations of the International Bird Census Committee). **Observers should strive to achieve the optimum nine visits if possible.** Surveys with fewer than six visits cannot be used in computing WBS indices. Ten to 12 visits are acceptable if a higher level of coverage can be maintained. **The visits should be well spread throughout the season.** They should also be spaced out so that, if possible, no three sequential visits span a period of less than ten days. For example, three visits made on May 1st, May 7th and May 11th would be acceptable, but three on May 1st, May 7th and May 10th would be less so.

The reason we ask that visits be spaced out relates to the international rules which BTO analysts follow when interpreting mapping census reults. These rules require that for resident species mapped in a nine visit census each territory should at minimum contain registrations from three different visits made in a period of at least ten days.

Additional observations clearly relating to territory-holding birds but outside the period of the full census (perhaps relating to early nests of Little Grebes or late Tufted Duck broods) are welcome. These can be included as additional notes on a separate sheet or map when submitting maps for analysis.

Visits should be planned in such a way that similar numbers of visits, numbers of hours spent in the field and temporal patterns of visits can be maintained between seasons throughout the period of coverage of the plot.



Except for Coot and Goosander these codes are the same as those shown on the cards used for *Winter Atlas* recording. Any other clearly relevant species (for example rarer species of ducks and waders) should be written in full to avoid confusion.

Use of the standard code symbols ensures that the registrations can be clearly understood by the Populations Section staff, and permits the checking of species maps and transfer of any registrations missed by the observer once the returns have reached Beech Grove.

Although not strictly a riparian species, Whitethroat is included in the survey because it is now so scarce that data supplementing those provided by the Common Birds Census are particularly useful.

FIELD RECORDING

A separate map should be used for each visit and these maps should be titled A,B,C, etc. in chronological order. If it is not practical to cover the whole reach in a single expedition to the area, it is possible to assemble a full visit from a series of partial visits. If this is done, it is essential that the coverage achieved on each partial visit can be clearly seen on the visit map (different coloured pens are the best method) and that a different visit letter suffix is allocated to each partial visit (e.g. B_1 - green, B_2 - red). **Partial visits should be avoided if at all possible.** They can be used as a last resort if, for example, rain interrupts a normal visit.

For each visit or partial visit, the following information should be recorded:

Visit letter
date
***times* of starting and finishing the visit**
a brief note of the weather
observer

The weather information need only be qualitative rather than quantitative, and mention should particularly be made of the wind strength and direction, temperature, precipitation and cloud cover. For example, suitable summaries might be "strong cold NE wind, heavily overcast, occasional light showers" or "mild, light SW wind, ⅜ high clouds." **(It is important that visits are made whenever possible in favourable weather,** when bird activity is not depressed by strong wind, heavy rain etc. We realise, however, that constraints imposed by the observer's other activities, by the average British summer, and by the need to space out visits may make visiting in less than ideal weather a necessity).

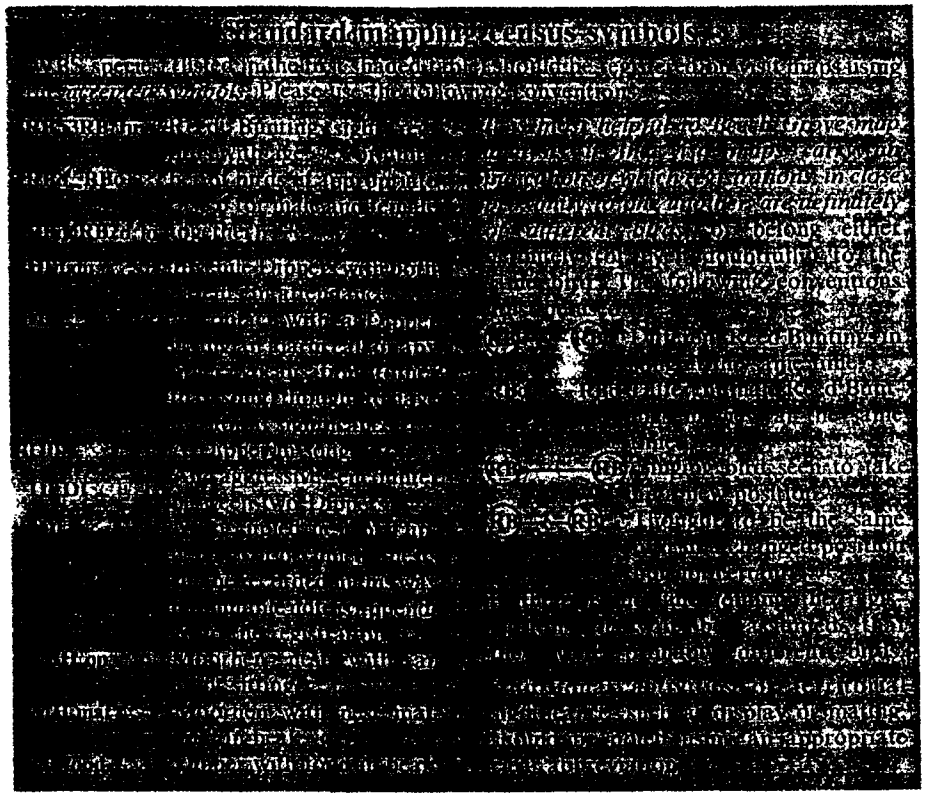
In the field, the blank map can be secured to a piece of hardboard with elastic bands or a bulldog clip. It is a good idea to carry a pencil as a reserve — a biro may run out or fail to write in showery weather. Registrations written in red or green biro tend to show up more clearly on duplicated maps than those written in black or blue ink.

Each encounter with a species on the WBS list should be registered on the visit map, using the appropriate abbreviation for the species and the appropriate symbol for any activity observed (given in the shaded tables). Except where an individual bird is under observation for some time (when a summary can be given of its activities and the registrations joined by solid lines), **it is intended that each bird should be registered once only. Dotted or dashed lines** between birds known to be different (seen or heard simultaneously) or nests in simultaneous occupation **are among the most useful registrations to map analysts** (e.g. SW- - - - -SW). Registrations of clear territorial significance (song, chasing intruders, display etc.) are also of great value in delimiting territories.

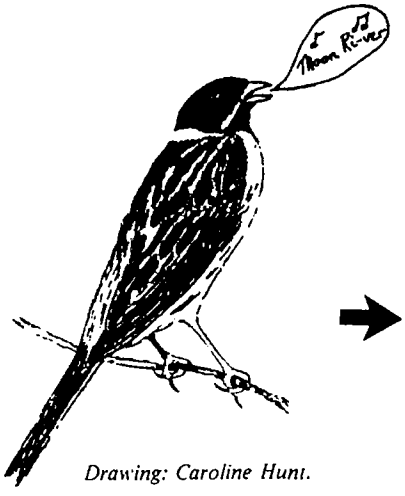
It is important that the plotting of registrations on the visit map should be as accurate as possible. Where the exact spot for a registration is obscured by a feature of the blank map, or by another registration, plotting should be as close as possible to the appropriate spot. Do not use lines or arrows to indicate where the registrations should be.

COMPLETING SPECIES MAPS

After the final walk of the season, the visit maps should be arranged in their chronological order, A,B,C, etc. and a set of species maps should be drawn up. Taking a clean outline map, all observations referring to, say, Dipper should be entered on it in exactly the same locations as shown on the visit maps

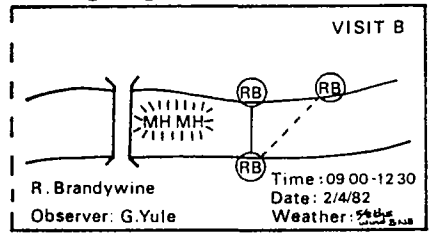


The story of a Reed Bunting registration

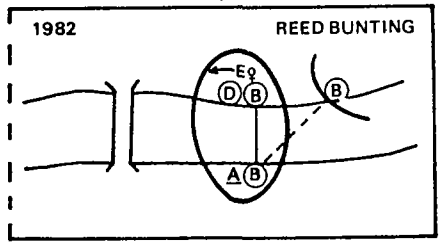


Drawing: Caroline Hunt.

1. *A Reed Bunting is seen singing on a tree near an old bridge (the scene of a fight between two Moorhens) on the second visit of the season (visit B). As you watch, the bird flies to another tree across the channel and resumes singing. You can now hear a second Reed Bunting singing against the first.*



2. *The information relating to the fighting Moorhens and singing Reed Buntings is entered on the* **visit map,** *using the appropriate species codes and activity symbols.*



3. *At the end of the season, Reed Bunting registrations from all visits are transferred to a Reed Bunting* **species map.** *Song registrations from visit B now appear as* **B** *on the species map. The map is analysed at Beech Grove, where Reed Bunting registrations near the old bridge are awarded one territory.*

(or as close as possible) but with the appropriate visit letter replacing the DI of Dipper for all entries. For example, DI on visit A becomes A on the Dipper species map, and MA3♂ on visit H becomes H3♂ on a Mallard map. The asterisk indicating a nest should only be entered once to avoid confusion, but if the nest is plotted on more than one visit the appropriate visit letters can be listed next to the nest symbol on the species map. *(An example of transferring Reed Bunting registrations from a visit map to a species map is given on page 3).*

It is important that each visit map registration should be cancelled as soon as it has been transferred to the species map. This is best done by a simple stroke of pen or pencil, so that the registration is still legible. The purpose of this is to enable checking of the visit maps to ensure that all registrations have been transferred. It is all too easy to miss some out on the first or even second time round.

Brightly coloured ballpoint pens are ideal for species sheets — please do not use pencil. Where registrations are few, more than one species can be plotted on the same map. **If this is done, it is very important to use a different coloured pen for registrations of each different species plotted on the same map** (e.g. Blue for Kingfisher, Red for Little Grebe etc). Preparation of the species maps can be done concurrently with the field work if so desired.

HABITAT DESCRIPTIONS

A habitat map and a completed set of habitat forms are required for each survey plot, ideally in the first year of coverage. Details of forms and map are given on the next three pages. Once full habitat information has been lodged at Beech Grove, only subsequent changes in topography, management, disturbance or pollution need be recorded.

SUBMISSION OF RESULTS

Visit, species and habitat maps and habitat forms should be submitted as soon as possible after completion to the Populations Section at Beech Grove for territory analysis and filing of habitat data. *Maps should be returned by early October,* or handed over at the BTO Annual Conference at the very latest. Maps returned after this date may not be used in index calculations for that year.

For consistency, map analysis is performed by BTO staff analysts according to written guidelines. The basis for the analysis is the territory-holding bird; any territory where a bird was seen two or three times in a period of ten days or more may be included. Nesting may or may not have occurred and birds known to have nested elsewhere may still be included if a part of the plot was apparently a major part of the territory. *(An example of a territory on part of an analysed Reed Bunting species map is shown on page 3).*

WBS HABITAT RECORDING

There is a need for conservationists to identify good wildlife habitats along waterways and suggest ecologically appropriate techniques for watercourse management to assist land drainage engineers. Guidelines produced recently by the Water Space Amenity Commission are a welcome attempt to suggest appropriate drainage schemes for different areas but hard data illustrating the effects of management on birds, or the national importance of a site, are likely to carry more weight than general suggestions in the event of drainage proposals being contested. WBS data may yet be needed to contest proposals for watercourse development or drainage (only two rivers are currently listed as SSSIs) and now have added importance in documenting river pollution after recent Regional Water Authority cut-backs in pollution monitoring.

The new WBS habitat recording method has been designed to help survey workers provide data which will be useful in monitoring the effects of watercourse management, pollution and disturbance on waterways birds. The method, which basically involves 'ticking' relevant habitat, management, pollution and disturbance boxes on forms specially designed for the WBS, will supplement, not replace, current habitat maps.

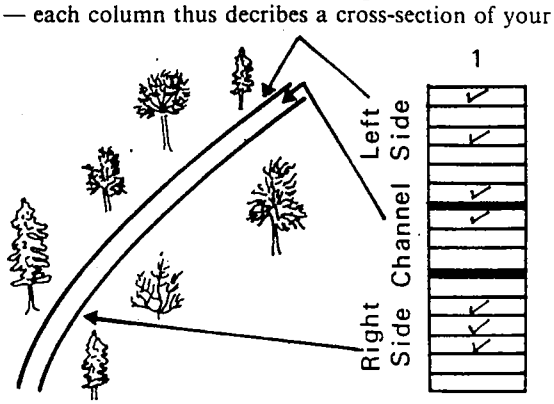
The Habitat Form

The habitat form is split up into columns numbered 1,2 etc. These columns represent different sections of your waterway, each 500 metres long. Each column is divided up into rows. These rows are where you enter information about the habitat along each section, and are labelled at the left hand side to indicate the type of information which will be recorded by making an entry into that row. Most information is entered by merely 'ticking' a box in a row. For example, for a river flowing through grazed farmland, part of the information about one bank along two sections might look like the following illustration. (There is grazed grass with scrub along one section; rough grass and hedge along the other):

	1	2	3
Adjacent land use (code number)	27	27	27
Bankside vegetation (tick)			
Conifer wood			
Deciduous wood			
Mixed wood			
Line of trees			
Scattered trees			
Hedge		✓	
Scrub	✓		
Scattered bushes			
Tall herbs			
Grass - grazed	✓		
Grass - rough		✓	

This illustrates how the form is not as laborious to fill in as might be expected at first glance — many of the boxes will be left blank because the habitat label for a number of rows does not apply to your own survey plot.

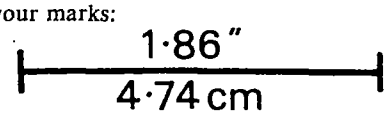
The order in which information is entered on the form is like a model of part of the waterway. The first information entered is about land use adjacent to one bank along a section, and the last information entered is about land use adjacent to the other bank. In between, information about the one bank, bank edge, channel, other edge, and other bank is filled in — each column thus decribes a cross-section of your waterway:



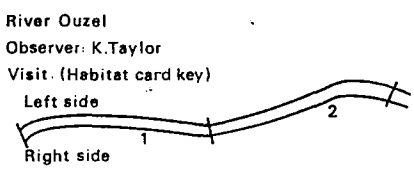
The length of 500 metres has been chosen as a sampling unit because this should give good detail about the habitat use of many WBS species, without making the job of filling in the habitat form too laborious in the field. Many of you will have a plot which can be split into about ten 500 metre sections.

First steps — marking out recording sections on a map

The first step is to take a fresh map of your plot and mark out 500 m sections along it, the first section beginning where you normally begin your walks. On the normal 6″ to 1 mile map 500 m is represented by a length of 1.86″. The easiest way to mark out your map is to take a thin piece of string 3-4″ long, and put marks on it to represent the start and finish of a 1.86″ length. This line is 1.86″ long and can be used as a standard for your marks:



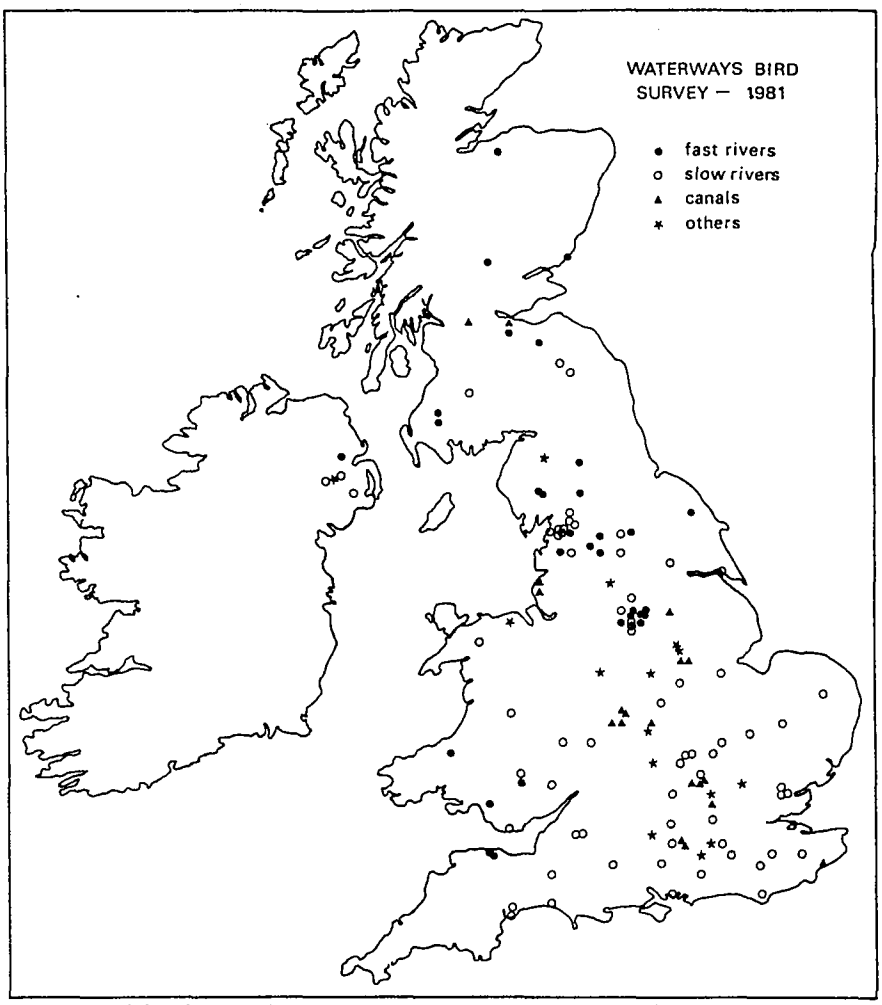
Then carefully place the first string mark at the start of your plot and let the string lie along the course of your waterway, curving with any meanders. At the point where the second string mark falls, make a mark on the map. This is the end of the first section. Repeat the procedure used for marking the first section, using the mark at the end of the first section as the start of the second section, and so on until your plot has been completely marked out in 500 m lengths. If the plot 'stops short' of the end of the last 500 m section, still mark the complete length of the section on your map. Now number the sections 1,2,3 etc., section 1 being the section where you normally begin your walks. These numbers will now indicate which column of the habitat card will contain information about a particular 500 m stretch. Now label the opposite banks of your waterway 'left side' and 'right side'. Part of a map marked out in this way is shown here:



You are now ready to fill in the habitat form in the field.

Habitat recording should be carried out in June or July, when the growth of vegetation along your plot is well advanced.

Un-managed section of the River Ouzel, Buckinghamshire. Photo: K. Taylor.



Geographical distribution of WBS plots in 1981. The WBS achieved a record level of coverage in 1981-82, but more plots are still needed, especially in areas where the survey is poorly represented. If you would like to help, write to Kenneth Taylor (WBS) at Beech Grove.

ADJACENT LAND USE NUMBER CODES

WOODLAND AND SCRUB 01 Broad leaved plantations (even aged). **02** Broad leaved woodland (uneven aged), **03** Conifer plantation (even aged). **04** Conifer wood (uneven aged). **05** Mixed woodland. **06** Orchard. **07** Pioneer scrub. **08** Carr.

'FIELD' VEGETATION: 09 Bracken. **10** Chalk downland and similar grasslands. **11** Upland heather moor. **12** Upland grassland.

WETLANDS: 13 Bog. **14** Fen and Marsh. **15** Reed bed. **16** Water meadow.

WATER BODIES: 17 Ditch. **18** Canal. **19** Pond. **20** Pool or tarn. **21** Lake or reservoir. **22** Gravel pit.

OPEN HABITATS: 23 Exposed mud. **24** High montane. **25** Cliff and crag.

MISCELLANEOUS: 26 Farmland — arable. **27** Farmland — grazing. **28** Farmland — mixed. **29** Grass with scattered trees (parkland, golf course etc.). **30** Sewage farms or purification works. **31** Buildings and constructions — continuous. **32** Buildings and constructions — scattered. **33** Gardens/allotments. **34** Waste land.

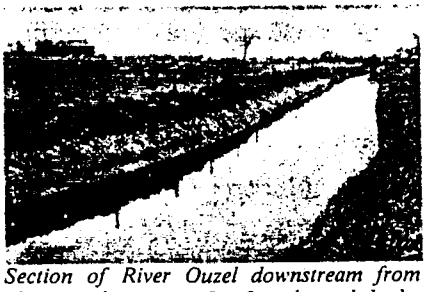
Adjacent land use code notes:

WOODLAND AND SCRUB: ' Pioneer scrub' is all scrub except young plantations and carr. 'Carr' includes fenland carrs, alder woods in water-logged situations and willow scrub in marshy places. **'FIELD VEGETATION':** 'Upland heather moor' refers to Calluna 'grouse moors'. 'Upland grassland' includes the whole range of basic and acidic upland grasslands. **WETLANDS:** 'Bog' or moss includes all wet acid peatlands — valley, raised and blanket bogs. *Sphagnum* mosses are characteristic. 'Fens and marshes' are not associated with acid peat. The vegetation of these two habitats is similar — mainly reeds and other tall grasses, rushes and sedges. **WATER BODIES:** Each category refers to open water and not to associated habitats, such as reed beds, which have separate codes. **OPEN HABITATS:** Record areas above 2,000' exhibiting 'mountain tundra' conditions with short vegetation and exposed surfaces as 'High montane'. **MISCELLANEOUS:** 'Waste land' includes despoiled areas where there is no vegetation that can be adequately described by any other code. **N.B. These number codes are not the same as those used in the BTO Sites Register.**

In the field

Equipped with the map showing numbered 500 m sections, begin to walk your waterway from your normal starting point. For section 1, habitat features should be ticked in the column numbered 1, and so on until you have covered all the sections numbered on your map. A habitat feature should be ticked if it occurs at all along a section. For example, scrub, hedge and scattered trees may all occur along one section. If so, all these features would be ticked for that section. This also applies to adjacent land use — if more than one type of land use flanks a section, enter more than one land use code number in the land use box for that section e.g. 4:32. Adjacent land use refers to land use within 100 metres of the bank only. If a habitat category does not apply to a particular section along your plot, leave the box for that category blank. Otherwise, enter all other information by a tick, except for 'adjacent land use' and 'channel type', where a number code is required, and 'vegetation overhanging channels?', where a Yes/No answer is required.

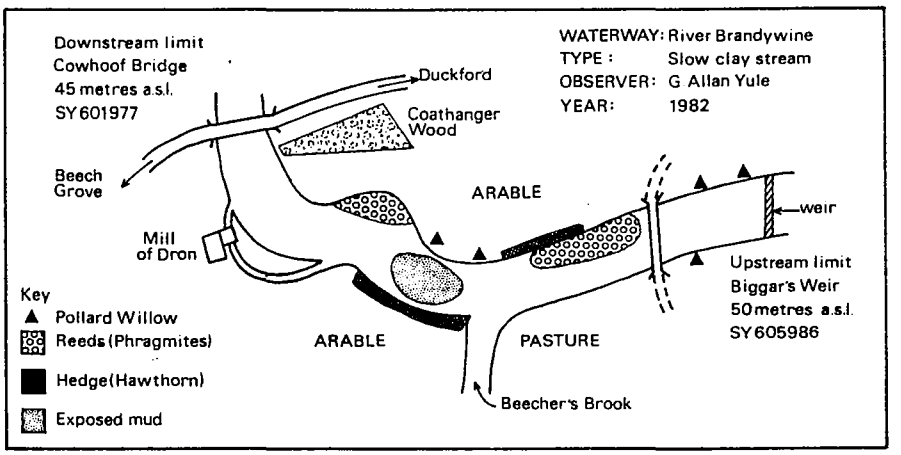
There is space at the foot of each column to enter additional information you may think useful — for example, the names of fringe vegetation species such as rushes, plantains and the like.



Section of River Ouzel downstream from photograph on page 5, after channel dredging and bank clearance by Water Authority in 1981. Photo: K. Taylor.

Once the habitat form has been completed, send the results to Mrs. E. Murray at Beech Grove, together with the map showing section numbers. We will return a copy of this map and file the original. Any photographs of your plot are welcome and would make a useful addition to our habitat records.

HABITAT MAP



To aid interpretation of information recorded on the habitat forms observers should also submit a simple habitat map at the end of the first season's fieldwork. A specimen habitat map is shown above. The following information should be entered on the habitat map:- **1) location, six-figure grid references and altitudes for the upstream and downstream limits of the plot 2) description of waterway type (e.g. fast-flowing rocky stream, navigated canal, deep meandering river) 3) approximate extent of vegetation such as hedge, woodland etc., along the banks and other features of ornithological importance (e.g. reedbeds, shingle banks, sand cliffs, bridges, backwaters).** *The map above illustrates how to map such features using a key to avoid clutter. Features on this map have been exaggerated. The normal WBS plot would include a longer stretch of river then the one shown here.*

CHANNEL TYPE CODES

Types 1 and 2 will apply to many upland rivers and un-managed lowland rivers.

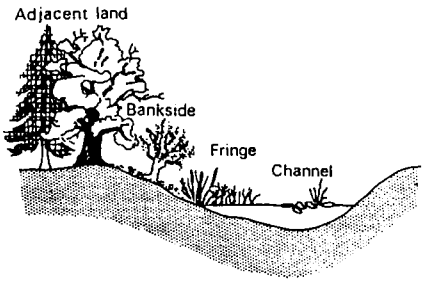
Types 3 and 4 will apply to managed rivers.

Types 5 and 6 will apply to rivers with flood banks (dotted lines indicate a varient of type 6).

Types 7 and 8 will cover canals as well as rivers.

ADDITIONAL NOTES

1. **'Bankside vegetation'** is vegetation growing near and on the channel bank, not vegetation in the channel itself.
2. **'Vegetation overhanging the channel'** refers to bankside vegetation e.g. overhanging hawthorn bushes.
3. **'Fringe vegetation'** is vegetation growing from the bank outwards into the channel.



Drawing: Caroline Hunt.

4. **'Channel vegetation'** is vegetation growing in the channel itself, not necessarily from the bank outwards and often in mid-channel.
5. **'Rapids'** are regions with white water in fast flowing rivers or streams, often caused by boulders.
6. **'Riffles'** are ripples on the water surface caused by boulders etc., disturbing flow below the water surface. Both rapid and riffle categories refer to the 'normal' state of your waterway, *not* to spate conditions.

AFTER ANALYSIS

A WBS summary sheet listing the number of territories recorded will be sent to the observer after completion of the year's analysis batch. The original maps will be stored at Beech Grove to help future research. In special cases it may be possible for us to make copies of the species maps if the observer needs to keep the originals.

In addition to the summary sheet, WBS workers receive *WBS News*, a newsheet prepared exclusively for supporters of the survey. This gives details of recent population changes in waterways birds determined from WBS data (in advance of these details being published elsewhere) and other news of WBS progress.

If you have any queries about carrying out the survey or about habitat recording contact Kenneth Taylor or Mrs. Elizabeth Murray at The WBS, BTO, Beech Grove, Tring, Herts, HP23 5NR.

Last but not least, thanks for your help!

(1978 instructions revised 7th July 1982).