Pond Survey 1996

Stage 1 Scoping Study

Pond Action
Institute of Terrestrial Ecology

R&D Technical Report W51

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POND SURVEY 1996

STAGE 1 SCOPING STUDY

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EXECUTIVE SUMMARY

1. Aims of the report

This report describes the findings of a Scoping Study for Pond Survey 1996.

The overall aim of the Pond Survey 1996 is to monitor the number and quality of ponds in Great Britain. The aim of this Scoping Study is to provide a design for the Pond Survey. It includes the development of a practical definition for the term 'pond' and recommendations for:

- a system which can be used to assess changes in the number of ponds and the reasons for any trends observed;
- a system which can be used to assess the quality of ponds in terms of their ecological, landscape, historical and amenity value; and,
- an information strategy for the collection, analysis, storage and presentation of data from the survey.

Data collected in Pond Survey 1996 needs to be compatible with pond information derived from two, more general, countryside surveys: the 1984 ITE survey of rural Britain (Barr *et al.* 1985) and the 1990 Countryside Survey (Barr *et al* 1993).

2. Definition of the term 'pond' to be used in the survey

A review of existing pond definitions revealed some 30 alternative definitions developed specifically for ponds. A further 45 definitions describing other wetland habitats (lakes, rivers, fens, etc.), into which ponds grade, were also gathered. The review indicated that:

1. No definition of a pond can be entirely satisfactory and the precise divisions used to distinguish ponds from other wetland habitats will inevitably be arbitrary.

2. The recent definition developed by the Pond Conservation Group (PCG) probably offers the most widely accepted set of criteria for defining a pond. This definition is '*a body of standing water between 1m² and 2 ha in area which usually holds water for at least 4 months of the year*' (PCG, 1994).

The PCG definition was examined in more detail to determine whether it could be used for Pond Survey 1996.

Lower size limit for ponds
The PCG's lower size limit (1m²) is very small. Limited field trials in Oxfordshire and the New Forest suggest that use of this small size limit could considerably increase the numbers of small pools identified, especially seasonal waterbodies recorded in semi-natural areas.

In the 1984 and 1990 Countryside Surveys lower pond size limit was not defined. However consultation with previous surveyors indicates that the lower size limit recorded was ca. 25 m^2. It is therefore suggested that a 25m^2 lower size limit should be retained for Pond Survey 1996 and future surveys. The upper PCG pond size limit of 2 ha can be implemented with little difficulty.

Seasonal ponds
Seasonal ponds are an ecologically important pond type and it would be valuable to include them in Pond Survey 1996.

Presence of water in spring, and absence in summer, is the only certain way of identifying seasonal ponds. This means that a reliable survey of seasonal ponds would require a minimum of two visits in a year.

This suggests that:

- A summer pond survey should be undertaken during the period June-September, which will be fully compatible with other Countryside Surveys.

- An additional winter/spring survey would be desirable to provide estimates of temporary pond numbers. It is possible that such a survey could be undertaken as:
  (i) a small trial using a sub-sample of squares, or
  (ii) a more extensive survey undertaken in association with future Countryside Surveys.

3. Assessing changes in pond number

Amongst the most important outputs from Pond Survey 1996 will be accurate estimates of pond numbers and the comparison of these data with previous survey results.

Estimating pond numbers requires:

- development of a suitable *survey strategy* for assessing pond numbers (see Section 9);
- development of methods to ensure that *new* ponds are consistently located; and,
- development of methods which will enable pond *loss to be identified and explained.*

Identifying and quantifying new ponds
The principal methods which may be used for locating new ponds are: (i) remote sensing, (ii) interviews and questionnaires, and (iii) field surveys. Evaluation of these methods suggests that:

1. Aerial photographs are unlikely to be suitable because they are not sufficiently detailed to show small ponds, they are expensive and are not uniformly available for all countryside survey squares.

2. Field and/or questionnaire surveys could both be effective techniques for identifying the existence of new ponds. However a site visit would still be necessary in order to gain accurate data about the size and precise location of new ponds.

3. Questionnaires are likely to be the best source of information for identifying the *reasons* for creating new ponds.

60% of Countryside Survey 1 km squares supported 'no waterbodies' in 1984 and 1990. Ideally all these non-pond squares should be re-surveyed in Pond Survey 1996 to give an accurate indication of the rate of pond creation.

4. Identifying and explaining pond loss

Describing pond loss

Only one form of pond 'loss' (complete elimination of all physical traces of a pond) constitutes a complete loss under all four themes of the proposed survey (ecology, history, landscape, amenity). All other changes, whether due to lowering of water levels or succession, are better described as changes in state, which may eventually lead to the loss of the pond. They are of varying significance to the four themes of the survey.

As noted previously, ultimately the only *reliable* indicator of the existence of a pond is the presence of water. Thus, the best time to record maximum numbers of ponds is in late winter/early spring. A second survey visit in summer provides information about more permanent ponds.

Climatic variation between years means that the number of ponds which are wet at the time of survey will always vary between years. Thus estimates of pond loss/gain are only likely to be resolvable as long term *trends*, with relatively broad error bars.

Since climatic variation cannot be controlled the rationale for Pond Survey 1996 (and subsequent surveys) should be to minimise variation in other factors, such as survey timing and duration. For example, sampling should be undertaken 'south to north' and over as short a period of time as possible.

Reasons for pond loss

Pond loss is complex and may be caused by a number of factors. Essentially, these can be divided into two categories:

1. *factors which result in lower water levels*, such as drainage, abstraction, climate change and failure of dams or pond linings; and,

2. *factors which cause the pond basin to fill in*, particularly natural sedimentation and planned infill for agriculture or urbanisation.

In practice, however, it is often difficult to tell whether a pond is drying-out because *its water level is going down or its sediment levels are rising*. In many cases both will occur together. For example, agricultural drainage and regional abstractions may both lower pond water levels, while successional changes gradually raise base levels. In addition, these changes often occur gradually and over long periods of time.

In the majority of cases, therefore, it will not be possible to assess the reasons for pond loss in a single field visit in 1996.

Questionnaire surveys may be useful in some circumstances to help distinguish reasons for change. However, overall, there is no reason to expect that farmers and land owners will have sufficiently detailed knowledge of the hydrology and ecology of their ponds to enable them to assess factors responsible for water level changes with any degree of precision.

To provide information about pond loss therefore requires either:

1. more indirect approaches using analysis of existing data. For example, correlations of ITE land use codes with pond loss data to assess whether pond loss is more prevalent under certain land use types

2. more detailed monitoring of ponds to assess future changes.

In practice, detailed monitoring of sediment and water levels requires installation of fixed gauge boards at which the relatively subtle year to year changes in levels can be accurately measured. Data derived from gauge board measurements would also allow predictions to be made of the rate of infill, and the rate of senescence, of ponds in Britain. This would, in turn, facilitate the development of strategies to counter future pond loss effectively.

5. Ecological value

Ponds are important wildlife habitats collectively rich in species and supporting populations of about half of Britain's Red Data Book wetland plant and animal species.

The ecological quality of ponds may be summarised using standard indicators of biodiversity, such as species richness, species rarity and community type. Measurements of pond 'condition factors', such as pond size, water depth or degree of shading cannot, at present, be used to assess the ecological quality of ponds.

Ecological surveys of ponds have, increasingly, dealt with a combination of plant and animal groups. *Ideally*, therefore, Pond Survey 1996 should obtain information on (at least) wetland plants, aquatic macroinvertebrates and amphibians. However, collecting a wide range of data (particularly for invertebrates) normally requires highly trained staff and a considerable amount of time, and is, therefore, relatively expensive.

'Rapid' survey methods
The feasibility of survey methods which either (a) reduce the range of taxa surveyed or (b) use 'rapid' environmental indicators of biodiversity has been investigated for Pond Survey 1996.

Analysis of data from the National Pond Survey and Oxfordshire Pond Survey suggests that wetland plants alone (aquatic and marginal species) could provide a reasonable estimate of the *existing* ecological value of ponds. Family level invertebrate surveys would not improve the estimates of value. Similarly, amphibians (though important in their own right) are, in isolation, unlikely to be good indicators of general biological quality.

Assessing ecological quality
Pond Survey 1996 sites may be ranked either internally (using only data collected during the survey) or in comparison to an external reference. Reference data sets are being used increasingly in the water industry for biological monitoring and it would be preferable to use this approach for Pond Survey 1996. Placing sites within the context of a national classification would ensure that:

(i) comparisons of quality were made between similar types of site; and,

(ii) pond quality was assessed with reference to 'undamaged' sites of similar types.

The National Pond Survey provides a framework for classification of ponds and a reference set of relatively undisturbed, high quality, ponds with which the quality of Pond Survey 1996 sites could be compared.

Reasons for change in ecological quality
Although wetland plants provide an acceptable indication of general ecological value, they are poor descriptors of *change* in ecological quality. Essential criteria for effective biotic monitoring groups are that they are sensitive and respond rapidly to changes in environmental quality. In contrast, many marginal plants appear to be rather tolerant of water pollutants, and their communities change slowly, whilst aquatic plants are naturally absent from some sites (e.g. wooded ponds, seasonal ponds).

Environmental factors influencing pond communities (such as shade or nutrient pollution) are not yet well enough understood for them to be identified unequivocally as causing specific changes. Consequently, to identify the reasons for change in pond communities (and to explain existing quality patterns) it would be necessary to:

1. monitor taxa such as invertebrates (and/or diatoms) which are known to respond relatively clearly to water quality changes;

2. monitor environmental condition variables (depth, nutrient levels, etc.) and correlate these with community quality variables, such as plant and macroinvertebrate Species Rarity Scores; and,

3. measure both anthropogenic impacts (e.g. nutrient pollution) *and* normal condition factors (e.g. shade), because both influence quality parameters, such as species-richness.

Ecological quality recommendations
There are two major options for the ecological assessment of ponds in the 1996 Pond Survey:

1. The 1996 survey includes only wetland plants, and these are used as indicators of the *existing* value of other biological components and, through analysis, to give an indication of the environmental influences on plant community quality.

2. The 1996 survey includes a wider range of taxa (plants, aquatic macroinvertebrates and amphibians) recorded using standard methods which can be used to assess existing ecological quality *and* explain quality change

A third alternative would be for the assessment of ecological quality to be postponed until 1998, when rapid assessment methods may be available from the results of other projects including:

(i) current Environment Agency R&D to identify biological methods for assessment of still water quality; and,

(ii) Pond Action's NERC funded study of the effect of agricultural pollution on ponds.

Whatever the choice of assessment methods, collaboration with these projects should be encouraged.

6. Landscape features

The landscape areas associated with ponds fall into two categories:

1. *The micro landscape of the pond* (the small scale landscape created by the character of the pond and its banks)

2. *The macro landscape* (the broader landscape of the pond surrounds, including the visual envelope of the pond).

Landscape assessment techniques appropriate to Pond Survey 1996 can also be divided into two:

1. *Landscape description*: systematic documentation of landscape character
2. *Landscape evaluation*: a subjective judgement of the relative value of landscape features.

Micro landscape description can be relatively simply undertaken using a field-based structured survey sheet. *Macro landscape assessment* could be undertaken using features routinely described in Countryside Surveys, within a prescribed distance from the pond.

A review of existing landscape methodologies indicates that landscape *evaluation* is a more contentious and poorly developed area of landscape assessment, and there is no one method of evaluation which is ideal for Pond Survey 1996.

Credible landscape evaluation requires, at some point, an input of professional judgement or public consensus. It is suggested that by calibrating aesthetic value and micro landscape features (using photographic material judged by professional landscape surveyors), it would be possible to use measurements of simple field variables (e.g. shade, visibility) to evaluate the landscape value of ponds.

7. Historical value

Many ponds have an acknowledged historical interest in their own right. In addition, many historic sites include ponds as part of their archaeological/historical importance. There are, however, no *specific* criteria for assessing the historical or archaeological value of ponds.

In the absence of an already well-developed set of evaluation criteria, a pragmatic selection of indicators for defining pond value at national, regional and local level have been suggested. It is not possible to quickly evaluate the historic importance of a pond from contemporary field and map evidence alone. At virtually all sites of known historical importance the assessment of the interest of the site is based on a wide range of field, documentary or literary research.

Bearing these points in mind the following recommendations are made for assessing historical value in the 1996 Pond Survey:

1. All 1 km squares chosen for survey in Pond Survey 1996 should be checked against the National Monuments Record and relevant Sites and Monuments Record. Checking of databases should be undertaken by the appropriate local expert (usually the County Archaeologists), who will have contact with other local and national experts.

2. The opportunity to provide field surveyors with some basic knowledge of historical assessment skills should be investigated. This could consist of interpretation of contemporary maps and field observation of site structure, morphology, etc.

3. Assessment of historical value should use database information to place sites in regional or national categories, and other information to note ponds likely to be of local importance.

4. A brief landowner questionnaire would be a valuable addition, especially if a questionnaire survey is considered for other aspects of the project.

5. Further investigation of pond sites by means of a map and document desk study and professional field surveys by archaeologists and historians should be encouraged. The 1996 (and subsequent) surveys represent a good opportunity to stimulate research in a neglected area of cultural and environmental history.

A full historical survey at each site would undoubtedly provide considerable additional information, but may not be feasible within the budget of Pond Survey 1996.

8. Amenity value of ponds

The amenity value of ponds is primarily related to their use and this may be informal or formal.

Informal value

The main use of ponds is likely to be their *informal* amenity value as a landscape feature.

A broad approximation of informal amenity value can be made on site using criteria such as visibility from highways and proximity to areas of habitation or 'honeypot' areas.

Obtaining more detailed information about informal amenity value is likely to be prohibitive in terms of resources.

Formal amenity value
Formal amenity value will sometimes be evident from field evidence. However, effective assessment is likely to require farmer/landowner questionnaires.

On a cost-benefit basis, postal questionnaires are likely to be preferable to site visits. Telephone questionnaires are unlikely to be viable.

Overall the most appropriate and viable means of assessing ponds is likely to be a rapid assessment made by fieldworkers on site.

The main disadvantage of field methods is that they are likely to underestimate the more formal amenity uses, such as shooting and fishing. A farmer/landowner questionnaire is likely to be the best means of assessing this. However, note that it is unlikely that more than 30% of questionnaires will be returned without a follow up of some kind.

Suggestions for rapid field assessment questions and examples of postal or interview questions are given.

9. Sampling strategy

A representative survey strategy
An ideal sampling strategy for Pond Survey 1996 requires selection of ponds which adequately represent:

1. variations in pond density across Britain;

2. the distribution of ponds on different land use types and of different ecological, historical, landscape and amenity types;

3. 'sufficient' ponds in different administrative regions; and,

4. ponds located so as to represent the range of reasons for pond loss.

The 1984 and 1990 Countryside Surveys were based on samples of 384 and 508 1 km squares, respectively, selected from the 32 ITE Land Classes. The location of 1 km survey squares was not designed to be optimal for individual landscape features, such as ponds. However, the squares are considered to be characteristic of most general land types in Great Britain and are likely to represent areas of high, intermediate and low pond density, a wide range of land uses with different ecological, historical, landscape and amenity types, and areas having different reasons for pond loss.

Increased sampling may, however, be necessary in some areas to ensure adequate representation of areas of high pond density (e.g. East Anglia and the Welsh Borders) and to obtain adequate representation of certain administrative regions.

To be fully compatible with the Countryside Survey, it is recommended that the basic sampling strategy should be to survey the 381 1 km squares that were surveyed in both 1984 and 1990. By reference to this *core sample* of squares, time series data from three dates would (i) allow trends in pond numbers to be calculated, and (ii) be representative of Great Britain.

A targeted additional sample

If a more efficient sampling strategy is to be devised, which builds on the basic sample, further squares should be allocated in a way which:

- gives better (more statistically robust) estimates of pond numbers; and,
- ensures that the survey includes a more representative range of pond types.

It is recommended that the 381 squares which form the core sample should be supplemented by a further sample of squares which are allocated optimally, according to the frequency and constancy of ponds occurring in a given Land Class (and the Scotland estimates). It is anticipated that the inclusion of this *targeted, additional sample* would reduce the Coefficients of Variation of the estimate further than would visiting the 508 squares used in CS1990. Thus, better placement of samples is likely to be more important than increasing the sample size.

Other options and their consequences

Option 1. Recommended.

Option 2. Reduce effort by only surveying the core sample of 381 squares surveyed in 1984 and 1990. This will reduce costs but will give no better statistical confidence than from earlier estimates, especially for Wales and Scotland.

Option 3. Survey only the ca. 40% of squares in the 1984 and 1990 sample that contained ponds (=153 squares) and undertake a rapid assessment of 'non-pond' squares.

This is unlikely to greatly reduce survey costs, if the 'non-pond' squares are checked by field visits, as a large proportion of the cost of fieldwork is associated with travel and access. A different source of information (such as a questionnaire survey) would be necessary to reduce costs significantly.

Option 4. Re-deploy additional samples in different ways. The way the additional samples are placed will have effects on the overall costs. If, for example, additional information was required from only the lowlands, then survey costs are likely to be reduced as travel and access may be easier than in the uplands. However, the main source of the statistical variation in the sample lies in the uplands and any sacrifice of effort in the uplands will be at the expense of improved statistical confidence overall.

Ponds surveyed within each 1 km square

The 1984 and 1990 Countryside Surveys excluded 1 km squares which were >75% urban. They also excluded all ponds within curtilage (i.e. boundaries of farms, houses, etc.). The omission of ponds in these areas may have led to an underestimate of the total number of waterbodies recorded in Great Britain. Clearly, an improved estimate of total pond numbers is likely to be obtained if areas within curtilage and urban areas are included in the survey.

In practice, the time needed to obtain permission to survey areas within curtilage and urban areas may be prohibitive for Pond Survey 1996 (and later follow-up surveys).

10. An information strategy for Pond Survey 1996

All information collected for Pond Survey 1996 needs to be fully compatible with previous Countryside Survey data including, for example, digitised base maps, entry codes and software used.

Data collection
The following data collection protocol is recommended:

1. Field data collection should, as far as possible, follow existing Countryside Survey methodologies. Where *additional* data are collected (e.g. surrounding land use information) the data should be fully compatible with CS information in terms of method of collection, form of data (e.g. entry codes) and quality.

2. Additional survey information should be entered on a simple well structured survey sheet.

3. Data could potentially be entered onto field sheets or straight into hand-held data loggers. However, it is unlikely that there is sufficient time to specifically customise data logger software for the approaching field season.

4. Quality assurance will be critical to ensure high, consistent quality of survey results.

Quality assurance
The quality assurance protocol which has been undertaken in previous Countryside Surveys should provide the basis for Pond Survey 1996. These include measures undertaken pre-, during and post-survey.

Data entry, storage and analysis
Data storage and analysis will require use of hardware and software compatible with existing ITE data bases i.e. a Geographical Information System compatible with ARC/INFO and access to ORACLE data bases.

Data presentation
The Countryside Survey Project is intended to provide datasets which are widely available to appropriate agencies with an interest in rural land-use. Data from the survey therefore need to be provided in at least the following forms:

- A written report describing survey results and summarised data.
- Raw data available on databases for other agencies.
- Computer-based data, summarised within the format of the Countryside Information System.

KEYWORDS

Ponds; Scoping Study; Survey; Sampling; Definition; Pond Ecology; Landscape value; History; Amenity and Recreation

1. INTRODUCTION

1.1 Aims of the report

This report describes the findings of a Scoping Study for Pond Survey 1996. The survey was a joint venture between the Department of the Environment (DOE) and National Rivers Authority (NRA), now part of the Environment Agency structure, with NRA/Environment Agency funding the Scoping Study and DOE the main Survey.

The overall aim of Pond Survey 1996 was to monitor the number and quality of ponds in Great Britain. The aim of this Scoping Study is to provide a rationale for the Pond Survey and specifically to recommend:

1. A practical definition for the term 'pond' to be used in the Survey.
2. A system which can be used to assess changes in the number of ponds and the reasons for any trends observed.
3. A system which can be used to assess the quality of ponds in terms of their ecological, landscape, historical and amenity value, and where possible, reasons for any future trends observed.
4. A practical survey design which can be used to assess ponds in the Survey.
5. An information strategy for the collection, analysis, storage and presentation of data from the survey.

The data collected in Pond Survey 1996 need to be compatible with pond information derived from two, more general, countryside surveys: the 1984 Institute of Terrestrial Ecology (ITE) survey of rural Britain (Barr *et al.* 1985) and the 1990 Countryside Survey (Barr *et al.* 1993).

1.2 Background

Recent surveys investigating trends in the number of Britain's ponds have given somewhat contradictory results. In their report on amphibian communities, Swan and Oldham (1989) estimated that pond loss since the Second World War was in the order of 38%. ITE's analysis of Countryside Survey results for DOE suggested similar rates of loss (ca. -1% per annum) in the period 1984 to 1990 (Barr *et al.* 1994a). In contrast, the 1985 Ministry of Agriculture Fisheries and Food (MAFF) Survey of Environmental Topics on Farms, investigating trends during the period 1980 to 1985, concluded that there had been a net increase in ponds in England and Wales of approximately 3% (ca.+0.5% per annum) (MAFF 1985).

Concomitant with interest in the number of Britain's ponds, conservation organisations have expressed concern that ponds may be facing threats through a decline in their quality. With their small areas and volumes, ponds are likely to be especially vulnerable to nutrient enrichment, acidification and agricultural xenobiotics (PCG, 1993). If climate change follows predicted patterns this may result in additional impacts to pond plant and animal communities.

In recent years, changes to the Common Agricultural Policy and the introduction of environmental management schemes (such as Countryside Stewardship), may have brought some benefits to ponds, particularly those located on agricultural lands. However the effect of these policies on pond numbers or quality are, as yet, unknown.

The aim of Pond Survey 1996 is to build on previous data collected for the Countryside Surveys to provide more detailed information which will in particular:

- clarify trends in pond numbers;
- provide information about the reasons for any losses or gains; and,
- provide a baseline from which trends in the quality of ponds can be assessed.

1.3 Approach to the 1996 Pond Survey and constraints from previous surveys

An important consideration for development of the sampling strategy for Pond Survey 1996 is that the results from this survey must be compatible with the earlier 1984 and 1990 data sets. Compatibility is particularly important for data relating to *pond numbers* and to a lesser extent *pond area*, where comparisons with earlier results will enable long term trends in pond gains and losses to be evaluated.

In contrast, aspects of *pond quality* were not specifically addressed during the two earlier surveys, and new methodologies need to be developed as part of this Scoping Study.

It is currently intended that Countryside Surveys will be carried out every decade, with more specialised thematic surveys (e.g. ponds, hedgerows) between. As a thematic survey, Pond Survey 1996 must conform to the essential Countryside Survey rationale, so as to provide compatible data. However, there is some scope to include additional elements where appropriate. These might, for example, take the form of additional survey squares, additional data from each site, or, in certain circumstances, different survey timings.

1.4 Summary of previous Countryside Survey methods and results

The structure, methods and outputs of previous Countryside Surveys are important considerations through all sections of this report. A brief summary of the 1984 and 1990 survey methods is therefore given below.

1.4.1 Survey dates and rationales

ITE have undertaken two major countryside surveys of Britain, the first in 1984, the second in 1990. Following difficulties interpreting results of the 1990 waterbody data (there was a drought in southern England that year), waterbodies were also surveyed as part of a smaller, thematic survey of hedgerows in 1993 (Barr *et al.* 1994b).

1984 Survey of Rural Britain: In 1984, ITE completed a survey of 384 1 km squares. The survey formed a stratified random sample of Great Britain, based on the ITE Land Classification system (Bunce *et al.* 1983). The survey was designed to answer questions on land use issues and so concentrated on land cover and landscape feature mapping. Records on waterbodies were made using combinations of attributes to define size and associated vegetation cover. The field methodology is given in Barr *et al.* (1985).

Countryside Survey 1990: In 1990 DOE and the Natural Environmental Research Council (NERC), with support from the Nature Conservancy Council, funded a further field survey of Great Britain, carried out by ITE (Barr *et al.* 1993). The sample number was increased, resulting in 508 rural 1 km squares being visited with an additional 25 urban squares surveyed as a separate survey. Waterbodies were mapped as part of the field survey.

Hedgerow Survey 1993: Inland waterbodies were recorded as part of Hedgerow Survey 1993 in England and Wales (Barr *et al.* 1994b). This included a re-survey of 108 1 km squares of which 62 contained waterbodies.

1.4.2 Methods used for surveying waterbodies in previous Countryside Surveys

The methodology used to survey ponds in the 1984 and 1990 Countryside Surveys is briefly outlined below. Appendix 1 shows the range of attributes which were used in the analyses of waterbody data.

- *Summary of Countryside Survey 1990 Fieldwork:* Fieldwork for Countryside Survey 1990 (CS1990) was undertaken from June to September. Prior to survey, letters giving details of the work of ITE and the aims of CS1990 were sent to land-owners in each square. On arrival at a square, surveyors visited land-owners to get permission to survey. This helped surveyors to gain local knowledge about accesses (using footpaths, gates or bridges). Each survey team consisted of two surveyors who worked together to ensure safety, as well as to maintain a quality check on field recording.

- Before starting to record information, the surveyors would examine the square using OS maps and aerial photographs to identify the most efficient way of walking the whole square. The land cover was mapped systematically starting at one edge of the square and working round each field or land parcel in turn. Recording land cover and landscape features for the whole square could take up to five days. Each cover area or feature was mapped on to one of five thematic maps (physiography, agriculture/semi-natural vegetation, boundaries, forestry/woodland/trees and built environment and recreation) and described using a variety of pre-determined codes. After mapping, a check was carried out to ensure that the five thematic maps were complete.

- After mapping the land cover, surveyors recorded information in up to 27 vegetation plots. Some of these plots were at previously visited points whilst others were randomly located in semi-natural habitats, or along roads and streams.

- All mapped linework from field survey maps was digitised using an ARC/INFO Geographical Information System and all descriptive data codes were entered into an ORACLE database.

- Areas of water were mapped, either as a point (if it measured less than 0.04 ha) or as an area, using OS 1:10,000 scale maps.

- In the 1984 survey, waterbodies were divided into ponds (< 1 ha) and lakes (>1 ha). In 1990 no distinction between ponds and lakes was made in the field. However, for analytical purposes, waterbodies were divided into five size categories. These categories are listed in Appendix 1.

- Areas not included in the surveys included:
  - areas of curtilage (i.e. land associated with buildings),
  - urban areas (1 km squares >75% built up).

  In essence, therefore, surveys would not have included waterbodies on golf courses, in school grounds, gardens, farm yards or in highly urban areas. In addition, smaller waterbodies were not consistently surveyed in areas of woodland.

1.4.3 Results of waterbody analyses from previous Countryside Surveys

Barr *et al.* (1994a) summarised the results of waterbody recording for the 1984,1990 and 1993 surveys. The main findings were:

1. A total of 760 waterbodies were recorded in the sample squares, during 1984 and/or 1990. Approximately 60% of the 1km squares surveyed had no waterbodies recorded.

2. Comparison of 1984 and 1990 waterbody numbers indicated a loss of between 4% and 11.5%. More precise figures could not be obtained because drought conditions in the south and east of Britain resulted in many ponds drying out in summer 1990. As a result it was not always possible to distinguish whether ponds without water were seasonally dry or permanently lost.

3. Most 'losses' in 1990 were of smaller waterbodies: 'losses' in the smallest size class represented some 20% of the 1984 total stock. There was no change in numbers in the largest two pond categories.

4. Surveys of waterbodies made during the 1993 hedgerow survey (Barr *et al.* 1994b) indicated that some of the small waterbodies which dried out in 1990 were reinstated by 1993. Overall, loss of waterbodies between 1984 and 1990 was estimated to lie within the range 4 - 9%.

5. Many 'dried up' waterbodies in 1990/93 were in parts of the country used mainly for arable agriculture (20% of the 1984 arable total were dry in 1990). This contrasted with pasture land where about 6% of the 1984 waterbodies were recorded as 'dried up' in 1990. This could have been due to the coincidence of arable land with the 1990 drought area. However, land use practices or other influences, such as more intensive land drainage in arable area, could also have influenced the 'loss' of waterbodies.

6. The 1993 survey recorded a large number of newly created waterbodies (at least 20% of waterbodies were recorded for the first time in 1993). This suggested very high turnover rates in small waterbodies with around a quarter of the total number being lost and replaced over a three year period.

7. Pond area data were not analysed in detail. However, only a very few waterbodies, present in both 1984 and 1990, were recorded as having changed in size category. Of the sample of 760 waterbodies, two had increased in size and six decreased in size.

1.5 Other current work in related areas

Three other research projects, currently in progress may have a bearing on Pond Survey 1996 and are briefly described below.

1. NERC ROPA (Realising Our Potential Award)

Pond Action has been awarded a NERC funded ROPA award (1995 - 1998) to investigate the effects of agricultural biocides on ponds in the UK.

Data collected for this project will be compatible with existing National Pond Survey results, which includes detailed surveys of the plant and invertebrate communities of 200 ponds across the UK, together with data on their physical and chemical condition.

Field surveys for the ROPA project will be undertaken in June to September 1996 and 1997 (100 ponds each year), largely in agricultural areas of the UK.

2. Environment Agency R&D Project 642: *Biological techniques of still water quality assessment*

The objective of this Environment Agency R&D Project is to develop a biological assessment method which will enable the Agency to monitor the quality of still waters (ponds, lakes, canals and ditches) in England and Wales.

The project has three phases: Phase I is a scoping study which will recommend potential methods of assessment. This phase is currently underway and being undertaken by Pond Action. Results are due in March/April 1996. Phases II and III include detailed evaluation and testing of methods recommended in the Scoping Study. These phases are likely to be undertaken during the period 1996-1998.

3. Scottish Natural Heritage Botanical Survey of Scottish Freshwater Lochs

The Scottish Loch Survey, organised by Scottish Natural Heritage and currently in progress, is describing the wetland plant communities of about 3000 waterbodies of 0.1 ha or more.

2. DEFINITION OF THE TERM 'POND' TO BE USED IN THE SURVEY

2.1 Introduction

In order to estimate both pond numbers and pond area in the 1996 survey, it is necessary to develop a clear and practicable definition of the term 'pond'.

The aim of this chapter is to discuss existing pond definitions and some of the more problematic areas of defining a pond, and from this, to make recommendations for a pond definition for Pond Survey 1996.

2.2 Review of existing definitions

No definition of a pond can be entirely satisfactory; ponds grade in size, depth and rate of water flow into all other types of waterbody and wetland, and the precise divisions used to distinguish these habitats will inevitably be arbitrary.

In the sections below, pond definitions are approached from two perspectives:

1. definitions developed specifically for ponds; and,
2. definitions of the other waterbodies into which ponds merge.

2.2.1 Brief review of existing pond definitions

Biologists, hydrologists and geographers have been proposing definitions of ponds for over a century. Appendix 2 gives a selection of 30 different definitions which have been suggested. The main themes evident in these definitions are outlined below:

- **It is difficult (if not impossible) to define a pond**
  This view, often expressed, reflects the difficulty in drawing boundaries between ponds and other waterbodies. It provides little help, however, to those who require a working definition of a pond for practical purposes.

- **Ponds are small and shallow**
  The one component of existing pond definitions that all authors agree on is that ponds are small. They are frequently also defined as relatively shallow, although in fact many large lakes are no deeper than ponds. Definitions based on depth are not ideal in practice, because deriving depth measurements can be time consuming.

- **Ponds are shallow enough for rooted plants to grow throughout**
  A variation on the pond depth theme, many authors agree that an abundance of rooted aquatic vegetation is also a clear characteristic of ponds. This does not always distinguish ponds from shallow lakes, however, and it provides no way of separating ponds from swamps or marshes (see Appendix 2).

- **A miscellany of other physical characteristics**
  A miscellany of physical attributes are regarded as important by authors and have been described as characteristic features of ponds.

  Ponds are often said to be stagnant, although in fact many ponds have ditch, stream or groundwater inputs which maintains a strong through-flow of water.

  Some authors comment on the temperature regime of ponds and, in some cases, the definitions proposed are mutually exclusive. For example, ponds are "often thermally stratified" (Horne and Goldman 1994) and "a fairly even temperature throughout" (Fitter and Manuel 1986). Both conditions can probably be found, but there are no data to suggest which is more common.

  Occasionally authors develop more speculative theories as part of their definition - for example the belief that ponds are less 'stable' because, variously, they are small, their temperatures vary more quickly than lakes, and some dry out. Clearly the notion of stability is far more complex than this, since a seasonal pond which has dried and filled annually for a 1000 years may be just as (if not much more) stable than a gravel-pit lake 50 years old.

- **The maximum size of ponds**
  The maximum *size* of waterbodies regarded as a pond varies considerably within the range 0.2 to 2 hectares.

- **The minimum size of ponds**
  A minimum size for ponds is rarely specified, however Elton and Miller (1954) suggested that small ponds were between tree-hole size (maybe 20cm diameter) and 20 square yards.

2.2.2 Definitions of other freshwater habitats

Ponds merge into all other types of freshwater wetland habitats, and a viable definition for a pond needs to be able to distinguish ponds from these other habitats.

Appendix 2 lists approximately 45 of the major definitions currently used to define lakes, flowing waters and wetlands.

In general, definitions of flowing water habitats are surprisingly vague, and the observation of natural historians Fitter and Manuel (1986), that rivers and streams have, as yet, no scientific definition, is fairly just.

Traditionally, freshwater biologists have separated lakes from rivers on the basis of water movement, assuming that the difference between the two habitats was so great that no further discussion was necessary. However, like all other distinctions this one is also gradational. In this sense Macan's (1973) definition is not as flippant as it may at first appear:

"A lake is a bulge in a drainage system, where the flow is so slow that certain processes that would not otherwise be possible can take place."

At present, there is no clear boundary which defines the difference between flowing and standing water. Strictly, some measure of the average residence time of the water at a particular location would be necessary. In the absence of such a measure for most small waterbodies, attempts to provide a precise definition would be no more than guesswork.

Broad wetland definitions, such as that used by the Ramsar Convention (see Appendix 2) include all ponds. Many others which are specifically intended to refer to 'terrestrial' wetlands will also include most ponds.

The terminology of mires, fens, bogs, marshes and swamps is confused by differences in North American and European usage. However, all can grade into ponds, and some mires may have water levels at the surface for much of the year.

2.2.3 Towards a new definition of a pond

Most existing pond definitions have two main limitations:

1. until recently, none were derived from consistent observations of large numbers of ponds; and,

2. nearly all aimed to distinguish ponds from lakes, ignoring the need to separate ponds from other freshwater habitats into which they grade, such as mires, streams and marshes.

It was against this background that the Pond Conservation Group (PCG) proposed a new definition which drew on data available from the National Pond Survey. This definition is '*a body of standing water between $1m^2$ and 2 ha in area which usually holds water for at least 4 months of the year*' (PCG, 1993).

The PCG definition has been used by a wide range of environmental organisations including the Council for the Protection of Rural England (CPRE), English Nature, the World Wide Fund for Nature (WWF-UK) and Pond Action. It has also been used by the NRA nationally (NRA 1993b) and is being adopted regionally (e.g. LCC 1995).

The PCG definition has two features which distinguishes it from most previous definitions:

- it includes a minimum size limit; and,
- it includes a term for permanence - one of the most effective ways of distinguishing ponds from other wetland habitats such as marshes.

The PCG definition is deliberately broad and encompasses even very small waterbodies, such as garden ponds and the many tiny pools found in semi-natural landscapes. These are included within the definition because (i) small waterbodies, even one metre square, can support freshwater communities of high nature conservation value, and (ii) small ponds, such as those in gardens and school grounds, are often of great interest to people involved in wildlife conservation and education.

2.2.4 Conclusion of the literature review

The recent definition developed by the Pond Conservation Group offers a relatively well considered and accepted set of criteria for defining a pond.

In the development of a definition for Pond Survey 1996, however, it is essential that the definition used has both:

1. good compatibility with previous Countryside Survey results; and that
2. the definitions are practically feasible and reliable in the field.

In the following section the viability of the PCG definition is scrutinised with these points in mind.

2.3 Viability of the PCG definition for Pond Survey 1996

Two areas are likely to be of particular concern if the PCG pond definition is used for Pond Survey 1996: (i) the size limits given - particularly the small lower size limit ($1m^2$), and (ii) the inclusion of seasonal ponds in the survey.

2.3.1 Pond size: upper and lower limits

- **Compatibility with existing ITE data and survey techniques**

For the 1984 ITE survey and 1990 Countryside Survey, waterbody area was used to divide standing waters into broad categories appropriate to the surveys. In 1984, the term 'pond' was used to include waterbodies less than 1ha in area. In 1990, no distinction was made in the field between lakes and ponds, but in later analysis small waterbodies were divided into five size classes (between 0.04ha and 5ha), with 5ha the maximum thought likely to be regarded as a pond.

Surveyors were required to map the area of all waterbodies greater than 0.04ha. The area of smaller ponds was not recorded.

The upper size limit for ponds: Confining the upper limit of a pond to 2ha presents few analytical and comparative difficulties. Existing Countryside Survey data for larger ponds are held as a specific area for each pond. Existing data could therefore be reanalysed to exclude ponds >2ha.

Lower size limit for ponds: Although waterbodies of less than 0.04ha were recorded in the 1984 and 1990 surveys (as point features), the area of these very small ponds was not specifically measured. Neither was the lowest pond size limit defined. In practice, therefore, the smallest size limit recorded depended on field surveyor interpretation.

- **Likely minimum pond area recorded in previous surveys**

In order to estimate the likely minimum area recorded in previous surveys members of the CS1990 field team were contacted. In total, ten surveyors responded, of whom four gave measurements. Three of the surveyors specified that they recorded ponds down to a minimum limit of approximately 5m diameter (i.e. ca. $25m^2$). The fourth surveyor gave a lower limit of 2-$3m^2$. It was noted, however, that in practice field surveyors were more likely to record a small pond located in agricultural land than if it were one small pond amongst many in the Flow Country.

ITE data compatibility: conclusions

It is clear, that for the 1996 Survey, a lower pond size limit should be implemented. The results of consultation with surveyors from previous surveys suggests that, on pragmatic grounds, a lower limit of $25m^2$ would be sensible.

2.3.2 Feasibility of a $1m^2$ lower and 2ha upper pond limit

A potentially more intractable difficulty with the $1m^2$ lower size limit is that it might include too many tiny pools to be practicable for Pond Survey 1996.

- **Preliminary trial survey to assess the number of small waterbodies in the countryside**

In order to investigate the practical implications of instating a $1m^2$ limit, a small number of field trials were carried out in February 1996.

Two 1km Countryside Survey squares in lowland Oxfordshire were surveyed:

- Square 241 - predominantly intensively managed grassland with some woodland.
- Square 270 - a mixture of woodland and arable land.

Of the total of six waterbodies recorded in these squares, only one fell into the size category $1m^2$ - $25m^2$. This was a very shallow temporary pool almost certainly filled only after recent heavy rains, and it would not be evident as a waterbody during normal Countryside Survey periods.

A second field survey was carried out in a semi-natural area - the New Forest. There are no Countryside Survey squares in the New Forest, so here a field survey was undertaken in four 0.25ha areas, randomly selected from a 10km square in the south-east of the Forest (squares SU2802, SU2600, SU2800 and SU2504). The results of field surveys indicated that:

1. Surface water pools were very common: On average squares contained open water areas totalling ca. $1240m^2/km^2$.

2. Small pools were very common: approximately 30% of the total area of water was contained in pools $1m^2$ - $25m^2$ in area. Note, however, that some of these pools were likely to be temporary and would not have been present during a summer Countryside Survey.

If necessary, further field trials will be carried out to extend these findings over a wider range of land uses. However, the implications to date suggest that :

1. Surveying small pools in intensively farmed agricultural areas *may* have relatively little time and resource implications for Pond Survey 1996,

2. Surveying small ponds in semi-natural areas *might* have greater resource implications for Pond Survey 1996. Resource implications would certainly be considerable if early surveys (e.g. spring) were undertaken so as to include counts of temporary ponds.

2.3.3 Recommendations for a size limit for ponds

It is evident from the discussion above, that there are three main options relating to upper and lower size limits for waterbodies in Pond Survey 1996:

1. Retain existing Countryside Survey limits: $25m^2$ - 100ha.
2. Instate the PCG upper limit but retain the ITE lower limit: $25m^2$ - 2ha.
3. Use both PCG limits: $1m^2$ - 2ha.

On the basis of current evidence, options 1 and 2 appear to be the most pragmatic choices. Option 1 would be fully compatible with existing ITE data. Option 2 is also compatible, but would exclude larger waterbodies (lakes) greater than 2ha.

2.4 Seasonal ponds

2.4.1 Importance of seasonal ponds

It is now clear that seasonal ponds (ponds which dry out annually) are distinct and important freshwater habitats which hold an important component of UK freshwater biodiversity, including uncommon and rare species (Bratton 1990, Collinson *et al.* 1995).

Seasonal ponds are not, as often believed, a very rare pond type. Any permanent pond which fills in and dries-up naturally as a result of succession will pass through a seasonal stage. Even 'dried up' ponds that have become seasonal over a relatively short period of time (e.g. 10 - 30 years) can provide valuable seasonal pond habitats, particularly where they are not damaged by chemical pollutants.

The considerable ecological value of many seasonal ponds suggests that it is important to consider whether a 'seasonality' component could be included in the definition of a pond for the 1996 survey.

2.4.2 Which seasonal waterbodies should be surveyed?

In terms of their water permanence, ponds can be divided into three types (Collinson *et al.* 1995):

- Permanent: ponds which always hold water.
- Seasonal: ponds which dry out every year.
- Semi permanent: ponds which dry only in drought years.

There are, of course, all gradations between these three categories. Like permanent ponds, seasonal ponds vary greatly in size, and some are extremely small. Tiny pools, such as tree rot holes and hoof prints which may hold water for only weeks at a time, may still retain their own specialised fauna (Elton and Miller 1954; Kirby 1992). However, in terms of the PCG definition of a pond, the cut-off used is waterbodies which hold water for 4 months of the year.

This in effect, excludes areas of surface water which collect after rain, but includes seasonal waterbodies which support wetland plants through the growing season (see below).

Although world-wide there has probably been more work on seasonal pools than on permanent ponds, there are no published criteria by which they are defined, other than the seasonal presence/loss of water.

2.4.3 The ideal method for surveying seasonal ponds

The ideal method for identifying seasonal ponds is to visit each pond on a number of occasions over a number of years including both wet and dry summers.

Identifying all *three* categories of pond (seasonal, semi-permanent and permanent) requires a minimum of *three* visits: once in winter/spring when water levels are high and again in late summer when net water loss is usually greatest. An additional summer visit in a dry year is necessary to distinguish typically semi-permanent ponds from their seasonal and permanent relatives.

For Pond Survey 1996, therefore, simply distinguishing *two* categories (temporary and permanent ponds) would require a minimum of two visits: the first visit in winter/spring (February, March, April) when most seasonal ponds will be wet, the second in mid summer (July, August, September) to identify ponds which had dried out.

2.4.4 Other options for identifying seasonal ponds

If it is not possible to undertake a winter/spring survey of temporary pools as part of the 1996 Pond Survey, would it be possible to identify seasonal ponds in a summer survey when these ponds are dry?

As experienced in Countryside Survey 1990, distinguishing a pond that is seasonally dry, from one that is completely lost, can be very difficult for field surveyors making only a single visit (Barr *et al.* 1994a).

In practice the only consistently applicable alternative method to the presence of water is likely to be evidence from the presence of wetland plants.

2.4.5 The use of wetland plants to identify seasonal ponds

There is some evidence that seasonal ponds typically have vascular wetland plants[1] associated with them if they hold water for over four months of the year (Bevercombe *et al.*, 1973, Pond Action unpublished observations). It is likely that this is due to the duration of the plant growing season: where water remains standing in March/April during the early growing season, this is sufficient to give wetland plants a competitive advantage and enable their colonisation and growth (Moss 1988).

However the occurrence of wetland plants is not always a *reliable* guide to the existence of a temporary pond. For example, ponds with shaded surrounds may have few, or no, vascular wetland plants. The occurrence of wetland plants is also a poor guide in areas of extensive marsh, swamp or mire (fen and bog) where water is consistently near, but not at, the surface for much of the year.

2.4.6 Constraints from previous ITE surveys

If the results of Pond Survey 1996 need to be fully compatible with past and future Countryside Survey data this constrains the timing of the 1996 survey to a summer site visit between the months of June and September.

Summer *is* ideal for identifying ponds which are permanent and/or semi-permanent (depending on the year's prevailing climate regime). It is *not* an ideal time for identifying seasonal ponds since it would not be possible to tell with sufficient *consistency* whether a dry basin is a seasonal pond or an ex-pond which no longer holds water at any time.

2.4.7 Practical constraints

With the time left available for Pond Survey 1996, it would not be possible to make a late winter/early spring visit, however a survey could be undertaken in spring 1997. It would also be possible to undertake a field visit in early to mid summer (i.e. [May], June, July [August]). However, this is a half-way house which fulfils no aim fully. It does not catch most of the seasonal ponds (significant seasonal ponds can be dry by May) and, although some months of the data collection period would overlap, the results would not be fully compatible with previous (or future) summer Countryside Surveys.

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[1] i.e. those listed on the National Pond Survey recording form.

2.4.8 Other options

The most likely potential alternative to a field survey is use of remote sensing techniques (aerial photographs and satellite imagery). The use of remote sensing techniques is discussed further in Chapter 3. However, in essence, these methods are unlikely to have sufficient resolution to be able to identify many smaller seasonal ponds, or to distinguish them from wet grassland, marshes and other damp ground habitats.

2.4.9 Seasonal ponds - some conclusions and options

Summary points from the discussion above are:

1. Seasonal ponds are an ecologically important pond type and it would be valuable to include them in Pond Survey 1996.

2. Seasonal ponds may often be identified by the occurrence of wetland vegetation but, this is not a sufficiently reliable parameter to ensure identification of all seasonal ponds. Presence of water in spring, and absence in summer, is the only sure way of identifying seasonal ponds.

3. A reliable survey of seasonal ponds needs a minimum of two visits in a year. A single visit between spring and mid summer, for example, would not be adequate to identify seasonal ponds.

The main options for assessing seasonal ponds are therefore:

1. A survey in mid summer 1996 - giving data compatible with the 1984 and 1990 Countryside Surveys, with a second survey in spring/winter 1997.

2. Similarly spaced temporal surveys but undertaken in other years.

3. Surveys only undertaken in mid summer omitting fully seasonal ponds from the survey.

Discussions of seasonal, semi-permanent and permanent ponds has implications for pond loss statistics and is discussed further in the next chapter.

2.5 Defining the outer boundary of the pond

A final practical aspect of defining a pond is the necessity for an adequate definition of the outer pond boundary (effectively the 'size' of the pond).

This definition is required in order to:

- describe changes in pond area
- map the outer boundary of new ponds
- define limits for measuring other environmental parameters e.g. extent of pond vegetation, width, length, extent of seasonal water drawdown, etc.

2.5.1 Previous boundary definitions

Although many pond surveys have made estimates of pond size, only rarely is a definition given of what constitutes the outer boundary of the pond. Unfortunately, the most widely used boundaries (area of standing water at the time of survey, OS map outline, top of bank slope) give relatively unreliable estimates of the true area of the pond.

In practice *map* outlines probably use a mixture of the outer break of slope (i.e. top of the pond bank) for smaller features and the water's edge for larger pond and lakes. Pond Action's experience during the National Pond Survey has been that map outlines often bear very little relation to the wetland area of the pond.

Standing water area at the time of survey, although sometimes used, is also a poor estimate of pond area because of short-term seasonal and between-year variations. Even when surveys are repeated in the same season, natural climatic differences are such that 30 - 40 cm differences in average pond water depth can be expected between years. In ponds which are small and have low bank angles, therefore, the surface water area of a pond may vary by over 50% year on year (Pond Action unpublished information).

To assess pond size, it is clear that evidence in addition to 'standing water area' should ideally be used.

In practice, the best estimate of pond area is generally *average maximum water level*. The most reliable estimate of average maximum water level comes from regular monitoring of water levels over a number of years. However, this boundary is usually identifiable from marginal vegetation, particularly the presence of *Juncus* spp. at the pond edge, or physical evidence - such as water marks on trees and stones, or the height of overflows where present.

This method is not dependent on water levels at the time of survey and, although partly subjective, gives a good base from which to measure long-term changes in pond area. The method has been successfully and extensively used in the National Pond Survey (PA 1994b), but may require further development if it is to be used consistently by a range of surveyors.

2.5.2 Compatibility with existing ITE survey data and techniques

In previous Countryside Surveys field surveyors used map outlines as a base (modified occasionally by ITE's aerial photographic re-interpretations). Where appropriate, these outlines were redrawn in the field using the categories listed in Appendix 2 (e.g. deliberate infilling, vegetation encroachment, low water levels). Outlines were only likely to be modified if they were significantly different from the map outline.

2.5.3 Conclusions

1. Ordnance Survey maps often differ from the 'real' pond outline. By using this outline it can be difficult to identify even large year on year changes in pond area.

2. The ideal solution for obtaining accurate boundaries would be to map all the ponds using vegetation criteria. This would provide a good baseline from which future changes could be properly assessed. It would, however, be time consuming to get this information in the field (average of ca. 40 minutes per pond for a tape, pace and compass check).

3. In practice, the need to record accurate pond areas depends on the use to which the data will be put; in previous Countryside Survey comparisons only gross changes were analysed (e.g. obvious filling in or enlargement of waterbodies). Gathering of information for this purpose could be done using the existing ITE method of noting new gross changes from the existing (map based) outline.

4. If pond area data are needed for more subtle analyses, (such as calculating the area of wetland vegetation) - perhaps as a subset of the main survey - then a re-drawn boundary is likely to be a necessary part of this field work.

2.6 General summary and conclusions

General conclusions from the three main sections of this chapter are:

1. Pond definition

- The Pond Conservation Group (PCG) definition of a pond is currently the most widely accepted. This definition is, however, broad. If applied to Pond Survey 1996, it could impose size and seasonal limits which may not be appropriate.

- In particular, the lower size limit of the PCG definition ($1m^2$) has the potential to considerably increase the number of ponds included in the survey. This would be most likely to affect ponds located within semi-natural areas.

- The lower size limit used in previous Countryside Surveys is likely to have been approximately $25m^2$.

Overall it is suggested that:

- A $25m^2$ lower size limit is specified for Pond Survey 1996 and future surveys.
- The *area* of *all* waterbodies included in the survey is recorded, including those below 0.04ha.
- The upper PCG pond size limit of 2ha could be implemented with little difficulty.
- These limits are compatible with Countryside Survey 1990

2. Seasonal ponds

- Seasonal ponds may often be identified by the occurrence of wetland vegetation but, this is not a sufficiently reliable feature to ensure identification of all seasonal ponds.

- Presence of water in spring, and absence in summer, is the only sure way of identifying seasonal ponds.

- A reliable survey of seasonal ponds needs a minimum of two visits in a year. A single visit *between* spring and mid summer would not be adequate to identify seasonal ponds.

From this it is suggested that:

- A summer pond survey should be undertaken during the period June-September, which will be fully compatible with other Countryside Surveys.

- An additional winter/spring survey is recommended in order to provide estimates of temporary pond numbers. If necessary this could be undertaken as either (i) a small trial carried out in a sub-sample of squares, or (ii) a more extensive survey undertaken in association with other Countryside Surveys in future years.

3. Defining pond area and the outer boundary

- If pond area calculations are only required to estimate gross changes to pond areas since previous Countryside Surveys, then the existing ITE method of noting new gross changes from the existing (map based) outline is probably adequate.

- If pond area data are needed for more subtle analyses, such as calculating the area of wetland vegetation, then a re-drawn boundary is a necessary part of this field work (this is discussed further in Chapter 4).

- It is recommended that any new pond boundaries are marked on as 'outer pond water level' using all field information available.

3. ASSESSING CHANGES IN THE NUMBER OF PONDS

3.1 Introduction

Amongst the most important outputs from Pond Survey 1996 will be accurate estimates of pond numbers and the comparison of these data with previous survey results.

In this chapter three areas fundamental to the assessment of pond numbers are discussed:

1. development of a suitable *survey strategy* for assessing pond numbers;
2. development of methods to ensure adequate identification of *new* ponds; and,
3. development of methods which will enable pond *loss to be identified and explained.*

3.2 Development of a sampling strategy to assess pond loss

An accurate assessment of changes in pond numbers requires the development of a survey strategy which is:

- 'representative' of pond loss throughout Great Britain; and,
- comparable with the datasets created in the 1984 and 1990 countryside surveys.

3.2.1 Survey strategy approaches

- **Background: census or sample surveys?**

Ponds may be counted and their attributes described either by undertaking a census survey (all ponds recorded) or a sample survey.

The most precise estimate of pond numbers would be obtained in a census survey in which *all ponds* were recorded. Such a survey is, for all practical purposes, impossible. With approximately 250,000 1 km squares in Great Britain, field surveys undertaken at a rate of 2 km squares per day by a two person team, a complete census survey would take about 1,000 person years effort. Use of other survey methods, such as aerial photography, would be considerably quicker, but the cost in time and materials would still be prohibitive.

A practical survey strategy therefore needs to reduce the numbers of ponds/areas that are surveyed. An entirely random survey could be undertaken (with, for example, all 1 km squares equally likely to be selected), but would clearly run the risk of over-sampling very uniform areas, and under sampling of areas of particular interest to the survey.

An option, therefore, is a *stratified random sample*. This has been the approach taken by ITE in previous Countryside Surveys (See Section 3.3.1). With respect to Pond Survey 1996, however, the crucial question of survey design then becomes "What is the basis on which the sample should be stratified?" i.e. what are the critical pond loss/gain questions that need to be answered?

- **Critical pond loss/gain questions**

In terms of pond gains and losses, questions that the 1996 Pond Survey might ideally answer are:

- How many ponds are there (e.g. in Great Britain)?
- How does this compare with previous surveys?
- What are the most significant causes of pond loss/gain?
- Are there pond losses or gains associated with different land use types or farming practices (including the effect of CAP changes etc.)?
- Are any important pond types at particular risk (e.g. ponds of high ecological or historical value)?

3.2.2 Ideal stratification of ponds

An ideal sampling strategy to answer the questions above, requires selection of ponds which adequately represent:

1. Variations in pond density across Britain.
2. The distribution of ponds on different land uses and of different ecological, historical, landscape and amenity types.
3. 'Sufficient' ponds in different administrative regions.
4. Ponds located so as to represent the range of reasons for pond loss.
5. Consistency with previous surveys.

Each of these areas is reviewed briefly below. The extent to which the existing Countryside Survey sampling strategy adequately represents them is outlined in Section 3.3.

- **Pond densities**

To make accurate estimates of pond numbers and losses, it is necessary to survey locations which adequately represent the range of pond densities in Great Britain. Comprehensive documentary evidence of pond densities in Britain is very poor.

The most authoritative national review remains Rackham's distribution map of ponds in England and Wales, which was estimated from 1920's OS 1:25,000 scale maps. The distribution shown, indicates hot-spots of high pond densities in East Anglia and in the north-west England/Welsh Borders area, and areas with low densities of ponds in the moorlands of Dartmoor and the Pennines (Rackham 1986).

More recent research, undertaken by volunteer field surveyors for the National Amphibian Survey (Swan and Oldham 1993), suggests that the density pattern identified by Rackham still persists, at least in some areas. The high pond densities remain evident in Suffolk (no data was available from Norfolk) and a trace of Rackham's 'hot spot' can still be identified in north-west England and the Welsh Borders. Overall, differences between the two maps may be due either to differential rates of pond loss across Britain, with particularly high losses in the English Midlands, or to variations in survey techniques.

- **Ponds in different land-use categories**

Since land-use is likely to have a considerable influence on numbers of ponds, the 1996 Pond Survey should, ideally provide a separate estimate of pond numbers for at least the four ITE Landscape Types (arable, pastoral, marginal upland and upland). For example there may be different reasons for pond loss in upland and lowland Britain (see below and Table 3.1), and it would be useful to be able to analyse and identify these reasons clearly within each land use type. Finer resolution (for example the 32 ITE Land Classes) would be ideal, but probably impractical at present.

- **Ponds in different administrative regions**

Policies for rural land use management and pond conservation are applied at a variety of administrative levels (e.g. national, county). Ideally therefore, it would be valuable to obtain estimates of pond numbers, and the reasons for losses and gains, for each of these levels. Combined with data relating to different land uses this would give sufficient spatial resolution to enable analysis of subsets of the data within each country or county (e.g. reasons for pond loss in the upland land classes of Wales as opposed to England). At present, it is only likely to be feasible to obtain estimates sub-divided at national level, since the sampling effort needed to provide data for individual counties is likely to be considerable.

Table 3.1 Reasons for changes in pond numbers and main areas of impact

Causes of pond 'loss'	**Main areas of impact**
Deliberate infilling	Intensive farmland and urban areas
Drainage	Everywhere, though especially lowland agriculture
Abstraction	Especially lowlands
Climate change	Variable effect across Britain.
Natural succession	Everywhere - but probably especially high in ungrazed lowlands.
Reasons for pond creation	**Main areas of impact**
Fish ponds	Farmland
Irrigation ponds	Farmland
Conservation ponds	Anywhere
Education	School grounds, public places
Visual amenity	Anywhere, but especially within private grounds.
Fire ponds	Forestry areas
Others	Golf courses, often in semi-urban areas.

- **Ponds of different ecological, historical, amenity and landscape types**

Ideally, the survey should be stratified to ensure inclusion of the range of *pond types* (in terms of ecological, historical, amenity and landscape value). In practice, there are no national classifications for ponds on historical, amenity or landscape grounds. On ecological grounds, however, the National Pond Survey provides potential data for this assessment. The National Pond Survey has classified a sample of ponds from England, Wales and Scotland on the basis of their plant and invertebrate communities. A provisional classification of the ponds has identified 10 major types and any sample of ponds for the 1996 Pond Survey should aim to represent this variation (Pond Action, unpublished data).

- **Reasons for changes in the number of ponds**

The main causes of pond loss and gain are outlined in Table 3.1. In practice, most vary according to the type and intensity of land-use, and are therefore likely to be well represented by existing ITE major Landscape Types.

3.3 Comparisons of optimal strategies with existing ITE survey methodologies.

Differences between the 1984 and 1990 survey strategy and the ideal strategy for a pond stratification need to be investigated in two areas:

1. The distribution of 1km squares in relation to national density patterns, pond types, etc.
2. The areas surveyed within 1 km survey squares (e.g. the exclusion of ponds within curtilage).

3.3.1 Overall distribution 1 km squares

The 1984 and 1990 countryside surveys were based on samples of 384 and 508 1 km squares, respectively, selected from the 32 ITE Land Classes. Both surveys were designed to describe the broad characteristics of the countryside.

The location of 1 km survey squares was not designed to be optimal for individual landscape features, such as ponds, but the squares are considered to be characteristic of most general land types in GB and are likely to broadly represent areas of high, intermediate and low pond density, a wide range of land uses with different ecological, historical, landscape and amenity types, and areas having different reasons for loss.

However, increased sampling may be necessary in some areas to ensure adequate representation of areas of unusually high pond density (e.g. East Anglia and the Welsh Borders) and to obtain adequate representation of administrative regions.

Sampling strategies to optimise the location of survey squares for Pond Survey 1996 are discussed further in Chapter 8.

3.3.2 Ponds selected for survey within each 1km square

The 1984 and 1990 surveys excluded 1km squares which were >75% urban (and any ponds in these areas). They also excluded all ponds within curtilage (i.e. boundaries of farms, houses, etc.).

Because of the difficulties of surveying in woods these were often incompletely surveyed for ponds, and it is likely that smaller waterbodies were not consistently recorded.

The omission of ponds in these areas (e.g. garden ponds, ponds in farm yards, school grounds and golf courses) may have led to a underestimate of the total number of waterbodies.

Clearly, an improved estimate of total pond numbers is likely to be obtained if all of these areas are included in the survey.

Surveys of ponds in woodland are particularly important because woodlands can have high densities of ponds. Rackham (1986) notes, for example, that '*Ancient woods...may have vastly more ponds...than the same area of non-woodland*'.

The inclusion of golf courses would also be valuable, because golf courses seem likely to be important areas for the creation of new ponds. Farmyards, and particularly gardens and school grounds, are also areas where changes (presumably often increases) in pond number are of interest.

In practice, the time needed to obtain permission to survey all areas within curtilage and urban areas may be prohibitive for Pond Survey 1996 (and later follow-up surveys). It might, however, be appropriate to undertake a survey of a sub-sample of ponds in curtilage and urban squares.

3.3.3 Compatibility with previous data

In terms of compatibility with previous data, the 1996 data set options suggested above only *add* to the existing ITE data sets. Any additions will be fully compatible as long as additional areas of survey are noted and distinguished during analysis.

3.3.4 Within-square survey options

There are three main options for the additional within-square areas which could be included in the survey:

1. survey only those 1km squares and areas within squares which are currently surveyed in the Countryside Surveys;
2. survey all additional squares and areas within squares (as outlined above);
3. survey those areas which are likely to be most cost-effective, and in keeping with the broad Countryside Survey rationale (i.e. woodlands and if possible, golf courses); and,
4. undertake separate/additional surveys in curtilage and urban areas.

3.4 Identifying and quantifying new ponds

Changes in pond numbers clearly depend on the balance between pond loss and pond creation. It is therefore important that accurate estimates can be made of the numbers of new ponds created.

3.4.1 Available methods

Methods which may potentially be used for locating new ponds are:

1. Remote sensing
2. Interviews and questionnaires
3. Field surveys

- **Remote sensing**

Two types of remote sensing data are potentially applicable to the location of new ponds: aerial photography and satellite imagery.

The usefulness of air photographs in locating new ponds depends firstly on the ratio between the size of pond and the scale of photography. On aerial photographs at a scale of 1:10,000 20m x 20m waterbodies would be 2mm x 2mm on the photograph. There is a slightly better than 50% chance of locating features this small on photographic prints. It is unlikely that smaller waterbodies could be detected with consistency.

In the context of Pond Survey 1996, the difficulties of identifying small ponds on aerial photographs is particularly important because the 1993 hedgerow survey (Barr *et al.* 1994b) showed that most new ponds were <0.04ha (i.e. ca. 20m x 20m).

Some indication of other limitations of aerial photographs for locating ponds can be gathered from McCartney (1990), who undertook a sample survey of ponds in Cornwall for the NRA. The sample was based on inspection of 1:10,000 scale colour aerial photographs. The following comments by McCartney (1990) are of particular relevance:

1. ponds in woodland could be obscured by trees (although it is not known what proportion fell into this category);
2. photographs only showed the pond at the time of the survey, when they might have been dry;
3. pond with shallow muddy areas or densely vegetated ponds, were often difficult to identify; and,
4. ponds in areas of shadow (for example in valleys) were often impossible to see.

In addition to the specific problems of photographic interpretation, air photographs have a number of more general drawbacks:

1. It is highly unlikely that there will be sufficient photographic coverage to enable air photographs to be used for all (or even most) ITE survey squares.

2. To get the best coverage would necessitate using photographs taken at different times of year, probably over a number of years.
3. Aerial photographs, where available and current, are expensive: ca. £18-£20 per photograph, and it is likely that an average of three photographs would be necessary to cover each 1km square.

Overall, it is likely that the best use of aerial photography is to provide additional data for field checking. ITE, for example, used aerial photographs to help update their 1984 field survey maps for Countryside Survey 1990.

Aerial photographs alone, however, are not likely to provide sufficiently reliable information for identification of new sites.

We are not aware of any published accounts of attempts to identify small waterbodies from satellite imagery. However, limited trials by Pond Action in Oxfordshire suggest that small water bodies are harder to locate on satellite images than aerial photographs.

- **Interviews / questionnaires**

Questionnaires have been used in at least three studies to obtain information about the construction and uses of new ponds (MAFF 1985; Potter and Lobley *personal communication*; Gee *et al.* 1994).

MAFF (1985) sent postal questionnaires to 8,800 farms in England and Wales. About three quarters of the forms were returned and could be used in the survey.

Data from the questionnaire gave results which, however, conflicted with pond loss data derived from all other map and field evidence (e.g. Swan and Oldham 1993, Barr *et al.* 1994a and other regional surveys). It is not known if this was due to a bias in the accuracy of the questionnaire returns or to differences in the areas surveyed.

Potter and Lobley asked farmers (as part of a much broader socio-economic study) if they had dug ponds between 1984 -1990. The results indicated that 63 (12.5%) out of 504 farmers interviewed claimed to have created or restored a pond, with the majority of those making ponds in England (87%) (Potter and Lobley *personal communication*).

Gee *et al.* (1994) undertook a postal questionnaire to about 400 pond owners in Wales, of whom approximately 30% returned the questionnaire. Questionnaire responses were of very variable quality and it was concluded that they could not provide reliable results. However, the questionnaire supplied by Gee *et al.* was very detailed and was probably unsuitable for a postal survey where interviewers could not explain the information that was required.

The practical advantages and disadvantages of using different questionnaire surveys (postal, telephone, interview) for Pond Survey 1996, are discussed in Chapter 7 (Sections 7.6.3, 7.6.4).

However, the findings essentially suggests that there may be difficulties with:

- the typically low response rates; and,

- the potential for questionnaires to be a 'politically' untenable option if they risk alienating farmers/landowners who have given *permission* for Countryside Survey work on their land.

In addition, Pond Survey 1996 will require at least some information about new ponds (such as accurate location, size, shape etc.). It is not likely that this information could be reliably provided by landowners, or be provided in a form consistent with previous Countryside Surveys.

Used alone, it is unlikely that questionnaires would be a reliable method of identifying *and* describing new ponds. It might be possible, however, to use them as a precursor to a field survey, to increase the likelihood of a field surveyor recording a new pond.

The most cost-effective questionnaire survey is likely to be undertaken by telephone, since it does not entail the expense of a site visit, and involves fewer biases than postal surveys (where there could be a greater likelihood of landowners/farmers who had created ponds returning questionnaires).

No questionnaire type is ideal however. Telephone surveys themselves have the major disadvantage that it is unlikely that a farmer will be able to specifically locate any new pond he has created within the ITE 1 km square. The greatest likelihood is that such a survey could identify farmers who had created ponds on their land in the recent past. A field survey would be necessary to ascertain whether the pond was created in the ITE survey square.

- **Field surveys**

Field surveys are likely to be a relatively reliable method both for locating new ponds and providing accurate data about them. In terms of time and effort, however this method is fairly labour intensive, requiring field surveyors to travel to, and walk across, the whole 1 km survey square.

Where a 1 km survey square already contains at least one pond (and would therefore already receive a site visit to check on its current status), the extra time necessary to search that square may be relatively cost effective.

However, 60% of all Countryside Survey squares had no waterbodies recorded in any year. Additional field surveys of these squares has considerable resource implications.

3.4.2 Searching for new ponds in previously 'empty' 1 km squares

As noted above, 'no waterbodies' were recorded from a large numbers of squares surveyed in 1984 and 1990 (60%).

Re-surveying these squares has considerable resource implications and there is a temptation to only revisit squares in which ponds were present in 1990. However, there is no evidence to suggest that these squares would be less likely to hold new ponds than would existing 'with pond' survey squares.

In order to derive accurate pond creation data, therefore, some or all of these 'no pond' squares need to be assessed by one or more survey methods.

The main options here are:

1. Undertake a field survey of all pond and 'non-pond' squares.

2. Survey a subset of squares. Note however, that by surveying only a subset, statistical confidence limits on the pond gain data will be reduced.

3. Undertake a questionnaire survey amongst farmers/landowners of 'non-pond' squares to estimate the number of new ponds constructed. If this was carried out prior to the field survey the results could also be used to identify squares requiring a field visit to locate and describe the new ponds.

3.4.3 Reasons for creating ponds: some conclusions (see Table 3.1)

The *reasons* for the creation of new ponds *may* be identified in the field in some instances. However a questionnaire survey is likely to provide the most conclusive data.

It is possible that a full questionnaire survey is not required and a sub-sample of landowners could provide an adequate indication of the reasons for pond creation.

Whether a questionnaire survey is deemed worthwhile will depend on the importance of obtaining information determining reasons for pond creation.

3.4.4 Conclusions and recommendations for surveying new ponds

1. Field and/or questionnaire surveys are both likely to be effective techniques for identifying the *existence* of new ponds. However a site visit is likely to be necessary in order to gain accurate data about the size and location of new ponds.

2. Questionnaires are likely to be the best source of information for identifying the *reasons* for creating new ponds however.

3. 60% of survey squares supported 'no waterbody' in 1984 and 1990. All, or a proportion of these, need to be monitored in some way in Pond Survey 1996 to give accurate pond gain data.

3.5 Identifying and explaining pond loss in the field

One of the main difficulties in analysing 1990 Countryside Survey data was identifying whether ponds had been lost, or were just seasonally dry as a result of the summer drought in parts of southern England. Deciding at what point a pond should be regarded as 'lost' remains a critical question for the 1996 Pond Survey. The 1996 survey also needs to clearly establish the *reasons* for any pond loss.

What constitutes pond 'loss' is, in practice, a difficult question. The answer depends considerably on perspective, and would, for example, vary considerably depending on whether concern is for ecological, historical or landscape/amenity reasons.

3.5.1 Pond loss from differing perspectives

- **The ecological perspective**

In recent years ecologists have begun to change their attitude to 'natural' pond loss. In particular, complete loss due to anthropogenic infilling or drainage is now recognised as much more damaging than the relatively slow infilling associated with natural succession, which *may eventually* lead to ponds drying out completely.

The main effect of succession is to reduce the average depth of ponds, so that permanent ponds first become semi-permanent (drying up in the summer in drought years) and later seasonal (drying up every summer). This gradual transition is entirely natural. From an ecological viewpoint this change is not necessarily damaging.

With infilling through *natural* processes, the damp or seasonally wet phase may be very long-lived, often much longer than the original open water phase of the pond, with ponds sometimes persisting in this state for hundreds and, more exceptionally, thousands of years (Gray 1988).

Thus, as Figure 3.1 shows, all other factors being equal, the process of succession results in a natural increase in the number of temporary ponds with time. Thus, pond management, or better, pond creation are required to maintain numbers of permanent ponds. The fact that temporary ponds are not extremely common in Britain today, reflects widespread anthropogenic influences such as agricultural drainage, ploughing-out of hollows, abstraction, urbanisation etc. Temporary ponds are, in contrast, still widespread and a common feature of many semi-natural landscapes (Collinson *et al.* 1995).

Seasonal ponds are usually relatively species-poor habitats, but may hold rare and specialised plants, invertebrate and amphibians - and taken together (i.e. in terms of overall conservation value) recent research indicates that they are likely to be of equal conservation value to permanent ponds (Collinson *et al.* 1995).

Ponds that dry out occasionally ('semi-permanent' ponds) may be just as species rich as permanent ponds and some species, such as the Great Crested Newt are known to benefit from occasional drying out, mainly because of the absence of fish predation (Swan and Oldham 1989, Biggs *et al.* 1994).

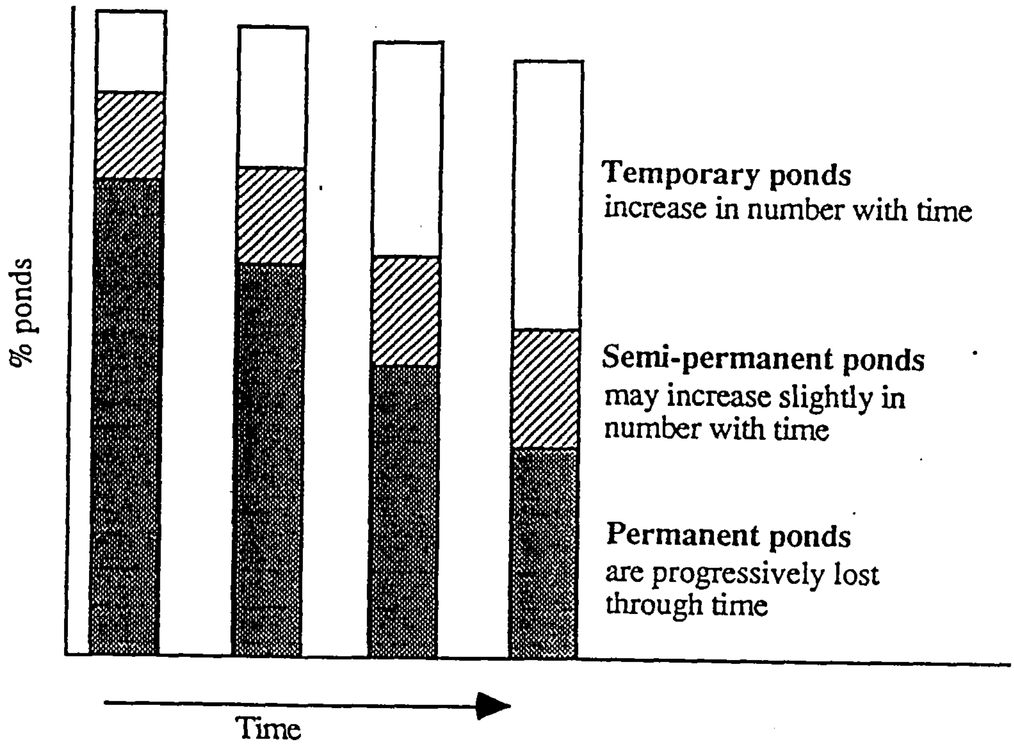


Figure 3.1 Changes in pond state resulting from successional processes

With time, the process of natural succession reduces the number of permanent ponds, creating temporary ponds. Under natural conditions many temporary ponds can persist for long periods of time (hundreds of years to millennia). Where not affected by drainage or infilling, temporary ponds will therefore increase in number over time. Creation or management of ponds is required to maintain the number of permanent ponds.

- **Landscape and amenity**

In aesthetic terms much of the value of a pond disappears once there are no longer views of open water. From the point of view of public amenity, even a pond which is dry in summer is likely to be regarded as all but lost even though it may still be functioning quite normally ecologically.

- **The historical perspective**

The effects of succession and drying out on the historic interest of ponds are more complex.

For example, silting-up is unlikely to be damaging unless it changes the historical meaning of the site and many historic pond sites are now dry, but retain their historic interest. Indeed, pond sediments themselves may be of significance for environmental archaeology. In contrast, anthropogenically induced changes, such as water table lowering (for example as a result of regional water-table lowering), could dry-out and permanently destroy the archaeological record of accumulated sediments.

3.5.2 Information needed to describe pond loss

Loss of ponds needs to be interpreted from a number of perspectives. Ideally therefore the following information is required:

- **Ecological status**
  1. The numbers of ponds in the different permanence categories (permanent, semi-permanent and temporary)
  2. The reasons for change between categories

This information is needed to ensure that all the categories are well represented in the survey and that there are not undue threats to any of them. For example, to ensure that:

1. there is not excessive net loss of permanent ponds due to succession and insufficient pond creation; and,
2. factors such as climate change do not result in unacceptable changes in the water regime of seasonal ponds .

- **Historical status**

Information is required to assess:

1. The existing historical interest of the site
2. Threats to which the site may be exposed as a result of silting up, drying out or management.

From an historical perspective it is necessary to ensure that important sites are not permanently damaged or destroyed, and that sediment records are not degraded (e.g. by deliberate destruction, de-silting or, more subtly, by impacts such as drying out due to water level changes caused by drainage or abstraction).

- **Amenity**

The number of ponds in the three ecological categories (permanent, semi-permanent, seasonal) will be a good indication of amenity value.

In general, the amenity value of a site will depend on the amount of water available.

- **Landscape value**

Area of open water and vegetation structure/density are likely to be the most important measures of landscape value, as related to 'pond loss'.

In general, the quality of ponds from a landscape perspective drops progressively with increasing amounts of vegetation and infilling. The significance of changes is likely to be different in urban areas and the wider countryside (urban ponds are more likely to need more open water).

3.5.3 Describing pond loss: conclusions

The main implication from the discussion above is that only one form of pond 'loss' - complete elimination of all physical traces of the pond - constitutes a complete loss under all four themes of the proposed survey (ecology, history, landscape, amenity).

All other changes, whether due to lowering of water levels or succession, are better described as changes in state, which may eventually lead to the loss of the pond. They are of varying significance to the four themes.

For example, a pond that was once 3 m deep but is now 0.5 m deep in winter and seasonally dry, due to regional water table changes, has not been lost but has *changed state*. In terms of ecological interest, the site may still be very valuable, but the same pond may have greatly reduced amenity value (it no longer supports a fish population perhaps). As a landscape feature it may also be less attractive than when it was permanently filled with water.

In contrast, a medieval fishpond which is completely dry and never holds water is lost as an ecological habitat. However, it may retain its full historical interest because of the preservation of banks and other structures.

In practical terms this suggests that Pond Survey 1996 (and other future surveys) should:

- monitor all the states of ponds, or at least the three main ones (i.e. permanent, semi-permanent and seasonal); and,
- look in detail at the causes and implications of change.

3.6 Assessing pond loss

The previous countryside surveys in 1984, 1990 (and 1993) were all undertaken in mid summer in conditions of varying drought stress. In 1990 there was a drought in the summer in the south and east of England, and in 1984 a drought in Wales.

Where drought occurred, semi-permanent ponds dried out and, in the field, it was not usually possible to distinguish whether a dry pond was completely lost or merely seasonally dry in that year.

The implication is that, ideally, a method is needed to distinguish complete loss of permanent ponds from the temporary drying of semi-permanent and seasonal ponds.

As discussed in Chapter 2, however, ultimately the only *reliable* indicator of the existence of a pond is the presence of water. Wetland vegetation may provide clues to whether a pond ever holds water, but ultimately it is only the known presence of water which defines a pond.

Figure 3.2 shows how time of year of survey and climatic variation affect the proportions of ponds that are likely to be recorded. In winter and early spring (roughly January-March), the largest numbers of ponds will be found - since in average years semi-permanent and most *seasonal* ponds will hold water at this time.

In late spring/early summer (April-June) semi-permanent ponds will be full in an average year, but *some* seasonal ponds are likely to be dry.

In summer, semi-permanent ponds will be dry in drought years and seasonal ponds will all be dry. Summer surveys only are likely to significantly underestimate numbers of seasonal ponds.

Thus, the best times to record maximum numbers of ponds is in late winter/early spring, A second survey visit in summer provides more information about more permanent ponds.

Unfortunately it is not possible to eliminate the effects of climatic variation (or the differences between regions in the same year). There will inevitably be year to year variations in pond depth and dryness - irrespective of the time when surveys are undertaken (see Figure 3.2).

Thus estimates of pond loss/gain are only really resolvable as *trends* - with wide error bars. To use an analogy: just as it is not possible to evaluate whether Britain's climate is getting hotter or drier except by looking at long term trends it is not possible to say how many ponds are being lost except as a trend over many years.

The main survey rationale for Pond Survey 1996 should be, therefore, to minimise variations in other factors (regionally, seasonally and between years) as far as is possible. For example:

1. minimise seasonal differences within year and between different parts of the country by: (i) sampling south to north, and (ii) sampling over as short a period of time as possible.

2. minimise inter-year variations in other factors (such as survey timing) regionally, seasonally and between years.

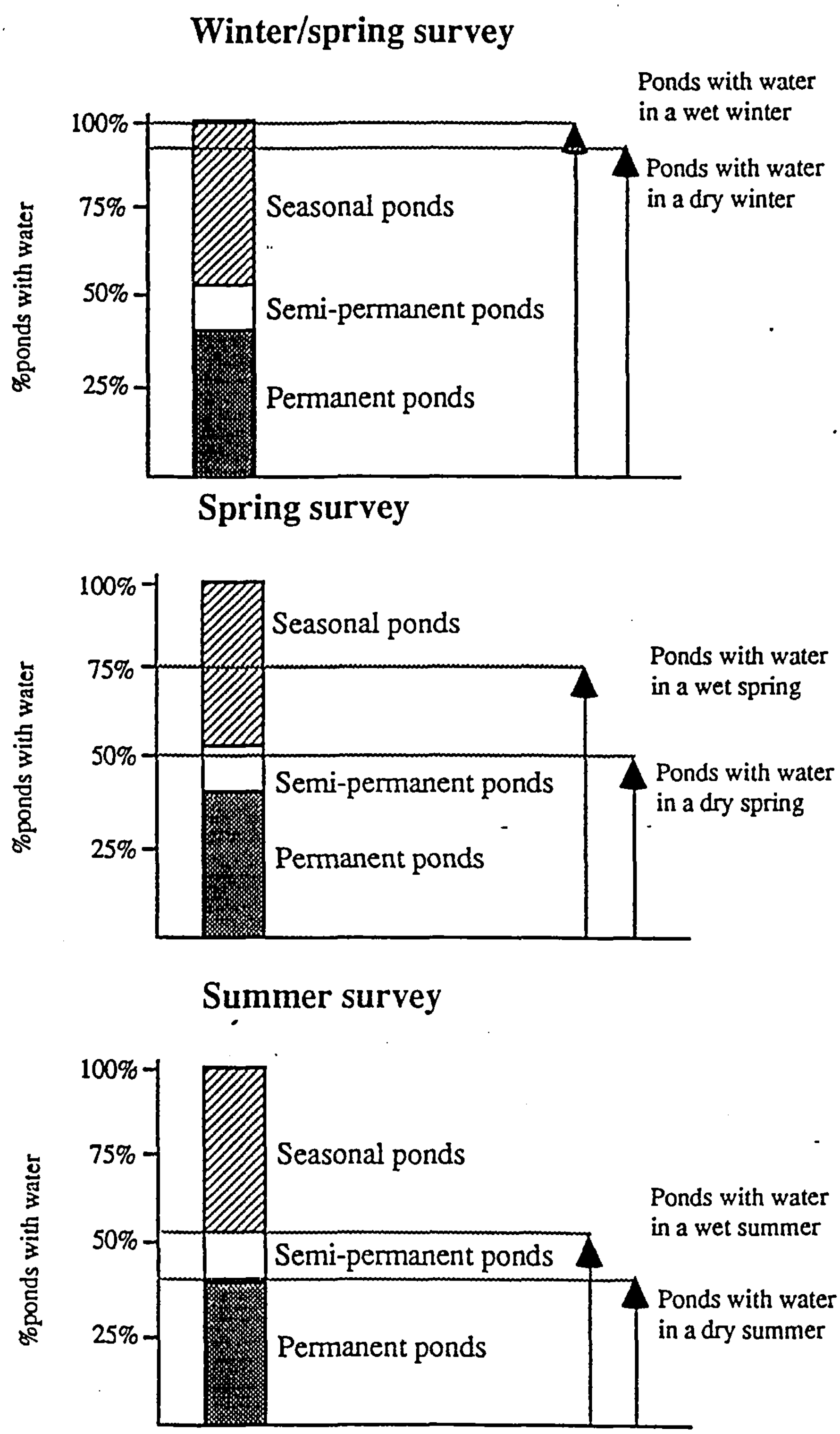


Figure 3.2 Survey timing: effect on the number of 'wet' ponds observed
A variable number of ponds (i.e. bodies containing water at the time of the survey) are recorded depending on: (i) the time of year at which a survey is undertaken, and (ii) the prevailing climate that year.

3.7 The reasons for loss and changes in state

The reasons for pond loss are often complex and involve a number of factors (listed in Table 3.2). Essentially, however, these factors can be divided into two categories:

1. factors which result in lower water levels such as drainage, abstraction, climate change and failure of dams or pond linings; and,

2. factors which result in greater infill of the pond basin; particularly natural sedimentation and planned infill for agriculture or urbanisation.

In practice it can be difficult to identify why water levels in ponds are changing and to describe the rate at which they are changing. This is for three main reasons:

1. It is frequently difficult to tell if the cause of a pond's drying-out is due to *its water level going down or its sediment depth increasing*. This is because there is rarely any *fixed level* with which to compare changes.

2. Year on year changes in water and sediment depths are typically small, making it difficult to recognise *when* there are changes in water levels or in sediment rates. As a result, it may be difficult for even regular observers to deduce the reasons for long term change.

3. In many cases a number of factors will be acting together to 'dry ponds out'. For example: in an agricultural area, drainage and regional abstraction may both cause long-term loss of water depth, whilst simultaneously, the resulting shallower water together with inputs of agricultural nutrients may lead to greater productivity and enhanced rates of succession.

3.7.1 Measuring Change in state

For Pond Survey 1996, changes in state could potentially be assessed in two ways discussed below:

1. Questionnaire surveys to landowners/ managers

Questionnaire surveys may be useful in some circumstances to help distinguish reasons for change. However, overall, there is no reason to expect that farmers and land owners will have sufficiently detailed knowledge of the hydrology of their ponds to enable them to assess factors responsible for water level change with any degree of precision. This is in part because, as stated above, long term trends in water and sediment levels are often imperceptible - particularly in comparison with year to year climate differences which may change water levels at a rate that differs by an order of magnitude.

Landowners are likely to give the best information when a particular event occurs to cause a rapid change at a pond e.g. a dam breaking or dumping/deliberate filling in. This is, however, likely to represent only a small proportion of all cases and is, in addition, the sort of change which is more easily picked up by field surveyors (especially if additional information such as previous pond depths is available).

In situations where there are still changes in pond state which remain unexplained it could be worth undertaking a personal follow-up visit to relevant landowners.

2. Measuring water and sediment levels

In theory measurement of water and sediment levels can be undertaken either: (i) in the field, or (ii) using measuring boards - with future change established from repeat visits in future years.

Measurements to *characterise* average water and sediment depths can be undertaken using *simple field measurements* to estimate maximum and average depths. However, the results produced using this method will be too variable to adequately describe the subtle long-term *changes* that will occur.

If such measurements are required, the only reliable method to separate out the different effects of changes in water and sediment levels, is to put in a *fixed gauge board* at which measurements of water level and sediment depth are read.

Data derived from gauge board measurements can also be used as the basis for long-term interpretation of changes in pond state. In particular:

1. Information about the rates of sediment infill in ponds, together with additional information on maximum pond depths, will enable *prediction* of the rate of infill and senescence of ponds in Britain. From this it would be possible to develop strategies to counter this.

2. Looking at water levels over a number of years it becomes possible to assess the importance of local and regional trends.

3. By looking at anomalies in water levels or sediment depths it is possible to alert field surveyors to other, more unusual, causes of pond loss. If necessary this could be followed up with questions to landowners to determine the causes of change more precisely.

Ideally, gauge boards would be needed in as many ponds as possible. They should also be levelled into Ordnance Survey datum points so that replacement boards can be placed in case of loss.

3.7.2 Reasons for pond loss: conclusions

It is clear, from the discussion above, that it is unlikely that it will be possible to directly assess the reasons for pond loss from an on-site visit, or questionnaire survey in 1996 alone.

To provide information about pond loss therefore requires either (i) more oblique approaches to the question using analysis of existing data or (ii) more detailed future monitoring of ponds.

The choice of method depends on the question which is asked. A number of examples are given below:

- At a very broad level, if the question is -
  'Has there been greater pond loss in lowland arable areas in recent years?'

  This requires a repeat visit to all 1984/1990 survey squares which supported ponds and comparisons of relative loss rates in different land use type (e.g. ITE Land Classes). This analysis is likely to be improved in future if further squares are placed in heterogeneous land classes.

- If the question is slightly more specific:
  'within the lowlands has high pond loss been associated with any particular land practice?'

  An indication of the relative importance of land use could be gained by correlating Countryside Survey land use codes associated with 'lost'/dry ponds and wet ponds in 1984, 1990 and 1996. Monitoring a variety of environmental factors (e.g. shade, vegetation abundance, water depth) could help to improve this analysis by suggesting causes of infilling, such as succession (e.g. simplistically: no grazing = more trees = greater rate of infill = dry ponds).

  To increase the statistical confidence of this analysis in future years, further survey squares would be stratified to reflect specific land uses which are of interest (within ESAs for example).

  Note however that this or similar analyses cannot be used to identify the specific causes of pond loss. For example, if ponds located on arable land show greater than average pond loss, this could still be caused by coincidental correlates, such as regional abstraction or regional climate differences.

To assess the reasons for 'pond loss' in more detail and to tease out the effects of succession from factors such as abstraction and drainage for example, requires:

(i) a greater level of monitoring; and,

(ii) data from future surveys to provide correlates and specific evidence of change (see Table 3.2).

This analysis requires at minimum, reliable sediment and water depth measurement. These provide information which can be used to indicate whether pond drying out is caused by potentially natural factors, such as succession, or water level changes which are more usually associated with anthropogenic influences, such as drainage and abstraction.

In addition, in order to specifically explain differential changes in sediment depths, a range of other environmental data is required including vegetation abundance, presence of inflows, overhanging trees, surrounding land use, management practices, etc.

To interpret the causes of water level change is relatively difficult and may require more detailed research (e.g. spatial and temporal analysis of regional climate and abstraction patterns, etc.).

3.8 Identifying and explaining pond loss: recommendations

Pond loss recommendations

Identifying pond loss and explaining its cause is not easy. Overall the following protocol would be likely to be necessary to achieve all objectives:

1. Monitor all 1 km survey squares supporting ponds in 1984,1990 and 1993.
2. Monitor ponds at the same time of year in all surveys (by default this should be summer to get results that are comparable with earlier surveys).
3. Undertake a second survey in early spring to get an idea of the total number of ponds.
4. Accept that the number of dry ponds in summer will vary from year to year and analyse as a trend.
5. Put in gauge boards to monitor water levels and sediment depths in as many ponds as possible.
6. Measure the depths of all ponds *approximately* (i.e. maximum sediment and water depths).
7. Make environmental measurements (e.g. surrounding land use, tree cover, sediment depths, presence of inflow).
8. Analyse relationship between pond loss (dry ponds) and environmental parameters, such as land use.
9. Using comparative results from future surveys:
    - use water level measurements and environmental correlates to assess the main causes of pond loss;
    - use anomalies in water/sediment levels to indicate ponds where follow-up information might be useful;
    - undertake further analysis to separate out the effects of impacts such a climate change, abstraction and drainage. The results could, for example, be used to look at the effect of changes in landuse or CAP schemes such as ESAs; and,
    - use information on sediment accumulation and approximate pond depth (from 5 and 6 above) to predict the future rate of infill of ponds.

Table 3.2 The causes of 'pond loss': factors and evidence

	Evidence	Survey needs/requirements
Succession through filling with sediment and/or vegetation	Increasing sediment/base levels etc.	Gauge boards
Dams and linings failing/damaged	Sudden and persistent drop in water levels independent of other local and regional trends	Previous water level data to show change. Interview (for checking).
Planned infilling	Increase in base level	Previous sediment/base levels. Interview (for checking).
Dry Year	Trends in water levels compatible with climate	Needs comparison with a wet year
Climate Change	Lower average water levels and analysis of long term changes. But difficult to distinguish these from other cause of water level drops.	Consistent monitoring, at the same time of year (twice a year if seasonal ponds are to be included). Also needs gauge boards for recording water levels and records for climate regionally. Compare with non-drought years
Water levels dropping and urbanisation	Consistent regional lowering independent of climate. Cannot be separated out further without detailed analysis of sites and regional trends.	Consistent monitoring, at the same time of year (twice a year if seasonal ponds are to be included).

4. ASSESSMENT OF ECOLOGICAL VALUE

4.1 Introduction

Ponds are important wildlife habitats, collectively supporting populations of about half of Britain's Red Data Book wetland plant and animal species (Biggs *et al.*. 1995). At a national scale they are as rich in species as rivers and probably support rather more rare and uncommon taxa (PA 1994b; Wright *et al.* 1996). However, small water bodies have been neglected by freshwater biologists world-wide and there is relatively little information available about the ecology of ponds.

Work undertaken by Pond Action on the National Pond Survey (Pond Action 1994b) and the National Amphibian Survey (Swan and Oldham 1993) has recently made it possible, for the first time, to make comparisons of the conservation value of individual ponds on the basis of their wetland plant, macroinvertebrate or amphibian communities. These assessment methods rely on detailed, species level, data being available. Methods for quickly assessing the value of ponds, a major objective of the National Pond Survey, are still being developed (PA 1994b).

The *ecological* quality of ponds does not necessarily reflect *aesthetic* quality, and turbid, shaded, heavily overgrown, dry and muddy pools, which many people find unattractive, can all have high conservation values - supporting distinctive communities with rare species.

4.2 Aims and requirements of the survey

This section of the Scoping Study aims to recommend a method of ecological assessment which will:

1. enable a baseline description of ecological quality to be made;

2. provide information which will allow significant *changes* in quality to be assessed; and,

3. where possible, provide methods which can be used to evaluate the *reasons* for any changes in ecological quality.

4.3 Background

4.3.1 What is ecological value?

Ecological value includes, by definition, the value of both the biotic and abiotic environment and the interaction between these.

Within the context of Pond Survey 1996, however, assessment of ecological value relates principally to biological quality. Abiotic parameters are primarily important because of their *effect* on biological quality. This effect may be natural (e.g. tree shade) or modified through anthropogenic influences (e.g. the effects of pollutants or drainage).

Many aspects of biological quality can be effectively summarised using four of the key concepts of biodiversity: species richness, species rarity, species abundance and community type. These four measures, and their relevance to pond surveys, are briefly described below.

4.3.2 Species richness

Species richness is simply the number of species present (or recorded) in a habitat or community. Species richness can vary considerably between freshwater habitats, with some waterbody types *naturally* species-poor. Indirect measures of species richness, such as number of families or other taxonomic groups, may also be used as a supplement to species richness.

4.3.3 Species rarity

Species rarity is essentially a means of weighting taxa to reflect the fact that some species are more threatened and vulnerable than others. Rarity is sometimes given a numerical value to indicate this (e.g. 1 = common to 64 = endangered) (PA 1994b; Collinson *et al.* 1995; Foster and Eyre 1992). These numerical values can be used to give sites (ponds) a Species Rarity Index reflecting the average rarity of species at the site.

4.3.4 Community type

Plant and animal communities in ponds vary considerably in response to the physical and chemical environment. For example, small shallow ponds may support quite different communities to those of deep, permanent ponds. Similarly, acid ponds in the uplands support different communities to acid ponds in the lowlands. To assess ponds, therefore, a *classification* of these communities is required to identify the main pond community types. This ensures that comparisons (for example of pond species richness and species rarity) are not made between ponds with community types which are inherently dissimilar. Once classified, communities can be ranked on the basis of the standard biodiversity indicators. Diversity of community types can be used as a measure of biodiversity where relevant. For example, sites can be ranked in terms of the number of National Vegetation Classification community types they support.

4.3.5 Others measures of ecological value

In addition to the three widely used measures listed above, *abundance*, is also sometimes used to describe the status of populations. This is most relevant for groups such as amphibians, fish or birds, where the significance of a large or small population is relatively well understood. Much less is known about the significance of variations in population size in widespread plants and invertebrates, and abundance measures are correspondingly less important as a measure of biodiversity.

4.4 Review and appraisal of existing methods

4.4.1 Regional and national surveys in Great Britain

There have been a considerable number of regional surveys of ponds in Britain, many of which have attempted to assess the value of the ponds surveyed (e.g. Day 1981; HCC 1987). However, assessment methods used have varied from survey to survey and many would not now be regarded as valid.

More recently several national studies, dealing exclusively or partly with ponds, have refined the techniques available for assessing the conservation value of ponds. All have included one or all of the biodiversity measures listed in Section 4.3. Three studies of particular importance in this respect are the National Pond Survey (PA 1994b), the National Amphibian Survey (Swan and Oldham 1993) and the National Aquatic Coleoptera (water beetles) Recording Scheme (Foster and Eyre 1992).

More information about each of these surveys is given in Appendix 3.

4.4.2 Comments on the relative merits of complete species lists and sample quadrats

Few quantitative studies have been published comparing the two approaches but the ITE Scottish Coastal Survey, carried out in the early 1970s, compared lists obtained by an expert botanist with those derived from series of random quadrats. The total species number recorded were almost identical but the botanist's list contained more rare species, whereas the random procedure identified other species regarded as incidental to the coastal systems. Work on quality assurance in CS1990 for quadrat surveys showed that observer differences are largely due to experience, probably related to search ability within quadrats. Such differences observed within permanently-marked quadrats are likely to be less pronounced in comparison with whole site surveys.

It is generally accepted that sample quadrats are likely to miss rare species, which are often of conservation interest, and which may be present as small numbers of individuals within a whole site.

The use of comprehensive species lists for monitoring is not widespread, unless the accumulated lists used in BRC are considered. This is because such lists do not contain quantitative information concerning the abundance or cover of species which make up the vegetation - almost 90% of species records within a vegetation survey consist of only some 10% of the total species recorded. Changes in vegetation are most likely to concern the shifts in balance between these species and monitoring has therefore usually been concerned either with repeating large numbers of random quadrats or small numbers of fixed quadrats. However, rare species do not usually contribute much to widespread vegetation, and statistically it is difficult to compare change in rare species because of their low frequency of occurrence. They therefore need to be specifically targeted, as in long term monitoring of individual orchid species. The principal points are summarised in Table 4.1, overpage.

Table 4.1 Comparison of species lists with sample quadrats

Species Lists	Sample Quadrats
Identifies rare species	Covers widespread species, misses rare species
Relatively quick	Relatively slow
Non quantitative	Quantitative
Appropriate for individual species	Not appropriate for individual species
Not appropriate at vegetation level	Appropriate at vegetation level
Difficult to maintain consistency	Estimates of statistical reliability available. Quality control available

4.4.3 Plant and animal groups used to assess the ecological status of ponds

The review below describes the main plant and animal groups that have been used to assess the ecological status of ponds in regional and national surveys.

Methods which could be used to assess the *reasons* for change in the ecological quality of ponds are discussed in Section 4.9.

- **Macrophytes: the larger wetland plants**

The majority of pond surveys have included larger wetland plants ('macrophytes'). Most surveys consider aquatic and marginal plants together, although some (e.g. PA 1994a, b; Palmer 1989) analyse them both together and separately. Most surveys have described species richness (e.g. Gee *et al.*, 1994) and some species rarity (e.g. Day 1981). The Oxfordshire Pond Survey (PA 1994a) and National Pond Survey (PA 1994b) include species richness, species rarity, abundance and community type.

Palmer (1989) prepared a classification of lakes in Great Britain based on plant communities. Although this survey included a few small water bodies it is not generally applicable to ponds. Palmer (1989) also provided much of the information for the National Vegetation Classification of standing water plant communities. Consequently, it is not yet clear how relevant the NVC is to small water bodies.

- **Diatoms**

Diatoms have been extensively used in the reconstruction of lake histories (Charles and Smol, 1994) and have also been used to assess water quality. Diatom techniques have sometimes been applied to small waterbodies (Haworth *et al.* 1988), but diatom communities of small water bodies have not been studied in detail.

Diatoms have well-established water quality preferences and occur in virtually all freshwaters, including temporary habitats. No methods have been specifically developed for small water bodies, although many of the standard techniques applied in large water bodies could be used in ponds. Identification of diatoms requires considerable taxonomic expertise, and some groups are still relatively poorly described.

- **Macro invertebrates**

Macroinvertebrates (larger invertebrate animals such as water beetles, dragonflies, water snails, waterboatmen, pond skaters) have been included in many pond surveys.

Early surveys worked mainly at family level, or included only casual observations of species and provided limited information. Increasingly surveys of macroinvertebrates have been undertaken at species level (PA 1994b; Gee and Smith 1995; Lassiere 1993).

A number of studies have looked at invertebrate communities in terms of species richness (e.g. Gee and Smith 1995). Lassiere (1993), who broadly followed NPS methods, described macroinvertebrate communities in terms of species richness, species rarity and abundance. Species rarity has been used for national and regional surveys of water beetles (Foster and Eyre 1992) and in the Oxfordshire Pond Survey and the National Pond Survey (PA 1994a,b).

- **Microinvertebrates**

'Microinvertebrates' include a very wide range of organisms, including single-celled protozoans, rotifers and microcrustaceans such as cladocerans and copepods (popularly known as 'water fleas').

Regional and national surveys of a number of groups have been undertaken by specialists with an interest in particular groups. For example Pontin and Langley (1993) described rotifer communities in small water bodies from various parts of Britain, and Fryer (1993) described the crustaceans of small water bodies in Yorkshire.

None of these groups have been surveyed consistently in any general regional or national pond survey. In addition, assessment of the value of communities is difficult at present because there is limited information available about the distribution and status of individual species.

- **Amphibians**

Amphibians are perhaps the most widely surveyed group of pond organisms. Much of the recent survey work on amphibians has been stimulated and co-ordinated under the auspices of the National Amphibian Survey. Practically all amphibian surveys are concerned with species richness and rarity, since the concept of community structure is less relevant with only six (or seven) native species. Amphibians are one of the few groups of pond organisms where counts of individuals are regularly undertaken and provide valuable information.

Amphibians are not, at present, ideal indicators of the general status of freshwater ecosystems. Their suitability is reduced by the small number of species that occur, the fact that only four species are common and widespread, and that amphibians are *absent* from at least 25% of ponds (Swan and Oldham 1993). However, amphibians are particularly important in pond surveys because of the public interest in them and because of the legal status of the Natterjack Toad and the Great Crested Newt.

- **Fish**

There have been no systematic surveys of the fish of small water bodies in any region of Britain.

To date all regional and national pond surveys have recorded fish as 'environmental factors' rather than as species.

- **Birds**

There have been no systematic surveys of the birds of small water bodies.

4.5 Trends in survey methods

In general, earlier surveys of ponds focused on a single group of organisms. For example, Day (1981) in a regional survey of Clywd dealt with wetland plants, Swan and Oldham (1993) with amphibians and Foster *et al.* (1992), in an extensive national survey undertaken by volunteer biologists, surveyed only water beetles.

However, the trend in recent surveys has been to look at a *combination* of taxa (e.g. plants, invertebrates *and* amphibians (e.g. Lassiere 1993; PA 1994a,b)). This approach has the advantage of considering a larger proportion of the biodiversity of each pond. This is important because, for example, the factors influencing the ecology and conservation of marginal plant and amphibian communities may differ.

However, even these relatively broad surveys still consider only a proportion of the fauna and flora of most ponds. Surveys of Diptera, algae, protozoans, rotifers, and micro-crustaceans are rarely undertaken in regional pond surveys in sufficient detail to provide estimates of the standard biodiversity indicators.

4.6 Reducing the range of taxa surveyed

The general trend for pond surveys to deal with an increasingly wide range of organisms is highly desirable. However, surveying many different groups of organisms is very time consuming, and, if it is to be reliable, is costly and requires highly experienced staff. For example, for the National Pond Survey about 10 person/days per pond is required to collect, identify and process the plant, amphibian and invertebrate data required. Much of this work can only be undertaken by highly trained and experienced staff.

To obtain a true indication of the taxonomic diversity of any pond, therefore, requires a large amount of survey work. This makes methods that reduce the effort needed to obtain a measure of biodiversity highly desirable for Pond Survey 1996.

Generally there are two ways of reducing the amount of effort needed in surveys:

1. recording groups of organisms which are known to be correlated with other aspects of biodiversity; and,

2. recording environmental factors which are correlated with biodiversity.

In the following sections the validity of reducing the range of taxa recorded in pond surveys, whilst still adequately representing biodiversity, is investigated.

Section 4.7 discusses the development of 'rapid' survey methods which use environmental indicators to describe biodiversity.

4.6.1 Groups of organisms which may be indicators of biodiversity

There is little information available about the relationships between biodiversity of different groups of organisms in ponds. For the purpose of the Scoping Study, therefore, data from two surveys undertaken by Pond Action have been used to investigate the relationships between different aspects of the biodiversity of plant and animal communities in ponds.

Data used comes from the National Pond Survey, a survey of relatively unimpacted sites across Britain (PA 1994b), and the Oxfordshire Pond Survey, a detailed regional study which included ponds of all quality (PA 1994a).

The analyses were undertaken to look at the relationships between taxon richness and species rarity (calculated using a species rarity index) for the following groups:

- Aquatic plant species
- Marginal-emergent plant species
- Aquatic invertebrate species
- Aquatic invertebrate families

The results of this analysis (shown in Appendix 4) provide four main conclusions:

1. Marginal and aquatic *plant species* richness is correlated with aquatic macroinvertebrate family and species richness.

2. Aquatic macroinvertebrate family and species richness are correlated

3. In the Oxfordshire data-set. macroinvertebrate *species rarity*, an important measure of the conservation value of sites, is correlated with plant species richness (largely because of a correlation with aquatic plants), but is *not* correlated with invertebrate family richness.

4. In the National Pond Survey data-set, macroinvertebrate *species rarity* is not correlated with plant species richness or invertebrate family richness.

At high quality sites (e.g. NPS sites) factors affecting invertebrate species richness do not affect species rarity. For example, small ponds or ponds with few plant species (and therefore relatively few invertebrate species) may still support rare or uncommon invertebrates, of conservation interest.

In contrast, at sites of variable quality (i.e. Oxfordshire sites, Pond Survey 1996 sites) invertebrate communities are affected by anthropogenic disturbance (pollution, intensive land-use). In these cases sites with few species are unlikely to support uncommon species, as these are often the most sensitive to anthropogenic disturbance.

- **Practical implications for Pond Survey 1996**

If a more rapid method of assessment is required in order to assess the existing quality of ponds in terms of their plant and invertebrate communities, it could be acceptable to survey wetland plants alone (as long as aquatic plant species are included).

It would not be possible to use *family* level invertebrate information (i.e. BMWP level ID) as a surrogate of community ecological quality.

Note however that this can only be a 'best guess' suggestion based on existing information, and a number of caveats need to be added:

1. The NPS results are preliminary analyses.

2. The correlations only assess the relationship between plants and invertebrates. They do not consider the relationships with the ponds microfauna and flora (e.g. micro-crustaceans, diatoms) which also contribute to biodiversity.

4.7 Development of rapid assessment techniques

'Rapid' assessment techniques, using environmental factors which are correlates of biodiversity may eventually provide the simplest and most cost-effective method of describing biodiversity.

There is already some evidence that *species richness* may be predicted in ponds from variables such as shade, permanence or vegetation abundance (Gee and Smith 1995; PA 1994a). These relationships are the basis of much traditional advice about pond management which aims to maximise diversity (Biggs *et al.* 1994).

However, factors such as shade and permanence are not normally correlated with *species rarity* (PA 1994a). They are therefore, only partial indicators of biodiversity. The results of the Oxfordshire Pond Survey (PA 1994a) do, however, suggest that correlations may be found between species rarity values and easily measured environmental variables, such as land use and the occurrence of inflows.

Rapid assessment methods for ponds which take account of both species richness and rarity are currently under development in the NERC ROPA project "Strategic risk assessment: the relative importance of xenobiotic effects on freshwater ecosystem quality". This project builds on data collected during the National Pond Survey (NPS), bringing together data from the high quality sites surveyed during the NPS and sites from the wider countryside. Results from the project will be available in 1998.

In addition the NRA is currently planning the development of a method, or methods for monitoring the biological quality of standing waters, including ponds. The outcome of this project is also likely to be a relatively rapid assessment method. Results may be available by 1998.

Neither the NERC study or the NRA Standing Waters project is sufficiently developed for the results to be applicable during Pond Survey 1996. However field work for the ROPA project at least, will partially coincide with PS 1990 and their may be potential for some project association.

4.8 Current survey options

In conclusion, there are three broad options for the ecological assessment of ponds in the 1996 Pond Survey:

1. The 1996 survey includes wetland plants, aquatic macroinvertebrates and amphibians recorded using standard methods.

2. The 1996 survey includes only wetland plants, and these are used as indicators of the value of other biological components.

3. Assessment of ecological quality is postponed until 1998, when thoroughly tested rapid assessment methods may be available.

4.9 How should ponds be ranked in terms of their ecological value?

Whichever method, taxon or indicator group is ultimately used to assess the value of ponds, the information derived needs to allow the ponds to be ranked in order of value.

Ponds can be graded in two ways (i) internally using only the data collected in the Pond Survey 1996 or, (ii) with respect to an external reference point. In general, the latter is preferable for the reasons outlined below.

4.9.1 Internal ranking of sites with Pond Survey 1996 data

It would be possible to simply rank ponds included in Pond Survey 1996 using the results of the survey alone (i.e. ponds with high species richness/rarity are put in a 'High Value' category, those that are relatively poor in a 'Low Value' category). Change in biological value between years could then be assessed relative to the original values.

The major disadvantages with this method are:

1. It does not enable 'like to be compared with like'. For example, in describing sites as 'poor' or 'good', it may be unreasonable to compare the number of species in a small pond with the number in a large site. Each may be rich for its area/type.

2. There is no *fixed* benchmark against which to judge the quality of the ponds.

   There is now a general consensus amongst freshwater ecologists and water managers that assessments of ecological quality should be made by comparing communities or ecosystem quality with reference 'undisturbed' examples of the habitat type. This is for example, the approach recommended in the draft EU Directive on the Ecological Quality of Water. It is currently the basis of invertebrate monitoring of rivers in the UK (Sweeting *et al.* 1992) and underlies new lake classification techniques recently developed for the NRA by Johnes *et al.* (1994).

4.9.2 External benchmark

The implications from the above are that to ensure that in Pond Survey 1996 (i) sites are compared 'like with like', and (ii) quality is assessed in comparison with an external benchmark, ponds should be assessed within the framework of a national classification of relatively undisturbed sites. This is essentially the 'RIVPACS approach' which has been adopted by NRA/DOE for national river monitoring schemes.

The National Pond Survey provides such a database, with a national classification based on plant and invertebrate data derived from relatively undisturbed ponds throughout Great Britain. Analysis of this NPS dataset is still in progress and final results will be available late in 1996.

4.9.3 Assessing existing ecological status: conclusions

The main conclusions to be drawn about the ranking of sites for Pond Survey 1996 are:

1. In terms of quality, ponds need to be graded on a number of criteria (including species richness, species rarity and, preferably also, community type)

2. Ponds can be graded by ranking them internally using these criteria

3. The results are more meaningful if they are assessed within the context of a national classification, and their quality assessed in comparison to undamaged sites of similar type.

4.10 Reasons for changes in ecological quality

The second major requirement of any method for assessing the ecological quality of ponds is that it should be able to demonstrate the *reasons* for any changes in ecological quality.

Identifying the factors which affect the existing quality of ponds or which cause changes in quality, is one of the most difficult areas of ecological assessment. With respect to Pond Survey 1996, three points are critical:

1. The effects of damaging impacts on small water bodies generally are poorly understood

2. There are a very wide variety of factors which can affect pond quality

3. Components of the biotic community may respond differently to adverse environmental impacts

The implications of these points are discussed further below.

4.10.1 The effects of damaging impacts are poorly understood

It is clear that pollutants such as nutrients and biocides can damage pond communities (PA 1994a). However, the effects of these pollutants on biodiversity are not known in detail. In this respect, ponds contrast markedly with rivers and lakes, where many impacts are at least reasonably well understood. For example, in river management it is possible to use the Biological Monitoring Working Party (BMWP) score system, based on macroinvertebrate family richness, to assess the degree of organic pollution. In ponds, however, it is not possible to distinguish, between damage caused by, for example, acidification or eutrophication, simply by looking at the *community* alone.

The practical implication is that the causes of any change in pond communities can, at present, only be assessed by (i) measuring environmental condition factors (depth, nutrient levels, etc.) and, (ii) correlating these with aspects of community quality, to indicate those factors causing significant damage.

4.10.2 Factors which can affect pond quality

There are a particularly wide variety of factors which may significantly affect pond quality. Ponds have relatively small volumes of water and a close association with their sediments and surroundings. Thus, in addition to the widespread pollutants which cause acidification and eutrophication in larger bodies of water, such as lakes, ponds may be affected by more localised pollutants such as road runoff and agricultural biocides, and these may have a significant effect on their quality.

Linked with this, is the difficulty that pond quality parameters, such as species-richness, can be affected not only by damaging anthropogenic impacts, such as pollution, but by 'normal' environmental variables. Thus, with increasing tree shade, the number of invertebrate species in a pond may decline (PA 1994a). Similarly large ponds often support more species than small ponds (PA 1994a; Gee and Smith 1995). However, in the absence of water pollution, neither of these factors are related to community quality - for example the wooded pond may still be a good example of its type and support uncommon species of conservation interest (PA 1994a). Similarly, small ponds seem just as likely to support rare and vulnerable species as large ponds.

An important practical implication of this finding is that, to investigate causes of change in biodiversity (taking account of richness, rarity and community types), a wide variety of 'pond condition' variables need to be monitored, including both 'natural' factors and those thought to be indicative of environmental degradation (e.g. pollutants, drainage etc.).

4.10.3 Biotic community response to adverse environmental impacts

The available evidence suggests that individual plant and animal groups frequently respond differently to both natural environmental factors and anthropogenic impacts. Marginal plants, for example, tend to reflect the qualities of the sediments they grow in but are also relatively tolerant of pollution and slow to respond to change. For these reasons, therefore, they are often regarded as poor indicators of biological water quality. Aquatic macrophytes are likely to be better indicators of environmental quality (especially nutrient status and pH), but there are relatively few species, and they may be naturally absent from many ponds such as shaded and temporary sites (Collinson *et al.* 1995). As a result, although marginal and aquatic macrophytes may be used to indicate general environmental quality (see Section 4.6 above), they are likely to be poor at:

- indicating *changes* in environmental quality; and,
- allowing the reasons for change to be deduced by correlation with environmental variables.

Invertebrates, diatoms (algae) or a combination of taxa are likely to be a better choice for this purpose (see Section 4.4).

4.10.4 Assessing ecological change: conclusions

The implications from the points discussed above are that to identify the reasons for change in pond communities (and to explain the reasons for existing quality patterns) it is necessary to:

1. monitor groups such as invertebrates (and/or diatoms). Of the two, invertebrates are generally preferable because of the more advanced methodological, taxonomic and distributional information related to them;
2. monitor environmental condition variables (depth, nutrient levels, etc.) and correlate these with community quality variables including plants and macroinvertebrates; and,
3. measure both degradation factors (e.g. nutrients) *and* normal condition factors (e.g. shade),because both can be influential.

4.11 Limiting the number of environmental variables

A very large number of environmental parameters *could* potentially be measured in an assessment of pond quality and condition. To restrict the number of factors, the range of parameters commonly measured in pond surveys was reviewed, to identify which variables had been identified as important in determining any aspect of conservation value (richness, rarity, community type, and where relevant, abundance).

The results of this appraisal (see Table 4.2) unfortunately indicate that the number of variables identified is very large - in fact few are not relevant. Thus, at present there is little evidence of the existence of 'driving variables' (sensu Johnes *et al.* 1994) which override all other parameters and which could be used as a simplified set of environmental variables.

The implication here is that in order to determine the causes of any change in the ecological quality of ponds, a wide range of physical and chemical variables need to be measured in Pond Survey 1996.

4.12 Notes on the practicalities of monitoring

4.12.1 Field recording sheets

All pond surveys undertaken to date have used slightly different field recording sheets, although recent surveys (e.g. Waring 1991, Lassiere 1993; Gee and Smith 1995, Walker 1994) have been based on the NPS recording sheet format (PA 1994b).

It is recommended that, where appropriate, the National Pond Survey (NPS) field recording sheet is used as the basis for the study to ensure as much compatibility of environmental data as possible. A copy of the NPS sheet is shown in Appendix 5. The measurements required, including a plant species list, take up to 4 hours for a pair of experienced surveyors on a large pond which requires use of a boat and ca. 1.5 hours for a small pond.

An important practical consideration is the need for boat access to wide, deep ponds. Most pond surveys do not use boats and this leads to important measures (such as water and sediment depths and aquatic plant species) being approximated from the shoreline.

4.12.2 Recording plants

Plant surveys should be undertaken between mid July and early September (although early July to mid October is acceptable if survey work is being undertaken by botanists experienced in recording freshwater plants).

Some submerged aquatic plants (especially Charophytes and fine-leaved *Potamogeton* species) ideally require microscopic confirmation. Some provision needs to be made for expert checking and identification of those species which require laboratory checking.

In shallow ponds, plants can be recorded by grapnelling and wading. Large, deep ponds should be surveyed using a boat.

4.12.3 Recording invertebrates

The standard procedure for invertebrate recording in the National Pond Survey is for the collection of 3-minute hand-net samples of macroinvertebrates.

Table 4.2 The main physical and chemical factors correlated with aspects of pond community value in UK pond surveys.

Impact type	Impact	Source of information
Pollutants	Nutrients/eutrophication	PA (1994a)
	Acidification	Friday (1987), Fryer (1993), Flower and Beebee (1982)
	Heavy metals	Kett and Langley (unpublished results)
Physical degradation	Disturbed land uses (urban, intensive agriculture)	Swan and Oldham (1989, 1993), PA (1994a)
Semi-natural influences	Area	Swan and Oldham (1989, 1993), Helliwell (1983), Easton (1990), Gee and Smith (1995), PA (1994a), Fryer (1985), Brian *et al.* (1987)
	Water depth and permanance	PA (1994a), Swan and Oldham (1989, 1993)
	Water chemistry	Walker (1994), Gee and Smith (1995), PA (1994a)
	Proximity to other waterbodies	Swan and Oldham (1993), PA (1994a)
	Vegetation	Brian *et al.* (1987), PA (1994a), Swan and Oldham (1989, 1993), Gee and Smith (1995), Barnes (1983), Palmer (1981)
	Shade	Brian *et al.* (1987), Swan and Oldham (1989, 1993), PA (1994a), Easton (1990), Gee and Smith (1995)
	Grazing	Walker (1994), PA (1994a)
	Water source	PA (1994a)
	Age	Gee and Smith (1995)
	Fish	Swan and Oldham (1989, 1993)
	Turbidity	Walker (1994), PA (1994a)
	Inflows	PA (1994a)
	Semi-natural land uses	Easton (1990), PA (1994a), Swan and Oldham (1989, 1993)
	Geology	PA (1994a)

The NPS uses surveys in three seasons to ensure that comprehensive species lists are obtained for the sites. Three minute hand-net surveys (in one or more seasons) have also formed the basis of the Institute of Freshwater Ecology's RIVPACS database, NRA/Environment Agency river invertebrate monitoring and of the freshwater studies in CS1990.

Surveys using a shorter sampling period (e.g. 1 minute) have been undertaken but these produce very short species lists (e.g. Gee and Smith 1995), and the results are not compatible with those of other surveys.

Single season surveys can be undertaken and the ideal time for these is early in the spring (March/April). Alternatively sites can be surveyed in the summer but temporary sites may be dry.

Two groups of freshwater invertebrates, water beetles and dragonflies, are regularly recorded using alternative methods. Dragonflies are typically noted as adults by direct observation or by the collection of the cast larval skins (exuviae), left behind when the adults emerge (Moore and Corbet 1990; Brooks 1993). Recording of dragonflies using either of these methods is unlikely to be practicable for the Pond Survey 1996 since several visits to a site are required, and observations of adults are highly dependent on weather conditions. To ensure consistency and quality of data, it is essential that surveys of invertebrates are undertaken by experienced professional staff. Even family level identification (often used for river assessments) requires considerable skill. NRA trainees, for example, undergo a training period of three to four months before they are fully reliable at collecting, sorting and identifying macroinvertebrate samples to family level (J. Steel NRA Thames Region, personal communication)

4.12.4 Physical and biotic variables

The description of many aspects of the physical environment of ponds is relatively straightforward. Variables currently monitored for the NPS include:

- Geology (from maps)
- Pond area and maximum dimensions (from a field map drawn on site using tape and compass)
- Overhanging trees and shrubs - a surrogate for shade (% pond and pond margin overhung assessed from a site map)
- Plant abundance / structure (% cover of aquatics and marginal plants (from a field map)
- Sediment and water depth (average and maximum values from five measurements across two transects of the pond)
- Seasonal water fluctuation (height between current and maximum winter water levels)
- Nature of the pond base (butyl, rock, etc.)

- Sediment (% composition of organics and other sediment types)
- Water source (groundwater, surfacewater, etc.)
- Presence and volume of inflows/outflows
- Existence of other adjacent wetlands and waterbodies (e.g. ditches, lakes, etc. within 3 distance zones from the pond), and whether these are physically connected to the pond
- Surrounding land use (% cover of 14 categories assessed within three distance zones from the pond)

A copy of the NPS recording sheet is shown in Appendix 5.

Many of the variables listed above could be applied to Pond Survey 1996. However, some such as surrounding land use, are likely to require modification to ensure that they are compatible with Countryside Survey parameters.

4.12.5 Chemical variables

Description of water quality is more difficult than the measurement of other environmental variables and usually requires a considerable allocation of resources, particularly for measurement of heavy metals and biocides.

The most important practical problem associated with water quality assessment is the variability of the measured parameters and the consequent need either to (i) collect multiple samples throughout the year, or (ii) to ensure that samples are taken at the same time of year. If only one sample from each site is being taken this should be collected in *winter/early spring* when biological activity is at a minimum. Surveys undertaken in summer often give misleading nitrate and phosphate levels for example, since these nutrients are locked up in growing plant tissue.

A minimal option would be the use of field test kits and meters, with which it would be possible to assess pH, conductivity, calcium and alkalinity with moderate reliability.

It is also possible that surrounding land use and inflow could be used as a surrogate for water quality, but this would require further investigation to assess its feasibility. Countryside Survey data could be used to quantify surrounding land use and assess the likely inputs of nutrients and biocides.

4.13 Summary of ecological survey options for Pond Survey 1996

4.13.1 Assessing existing value

There is some evidence to suggest that wetland plants (aquatics and marginals) alone can give an adequate indication of the *existing* ecological value of ponds.

A plant survey could be undertaken in summer (July-September), by botanists of the quality used in previous Countryside Surveys.

More detailed surveys, including amphibians and particularly aquatic macroinvertebrate species, would give a much more representative baseline but would require considerably more resources and input from skilled professional freshwater biologists.

4.13.2 Grading ponds in terms of their quality

Ecological quality should be assessed using a number of criteria. Ideally these would include species richness, species rarity and community type.

The ecological quality of ponds could be ranked using only the information collected during Pond Survey 1996. However, it would be preferable to grade the ponds within the context of a national classification of ponds, and for the value of sites to be judged against the baseline provided by a sample of ponds relatively free from damaging anthropogenic impacts, and of similar community types. This comparison would require access to the National Pond Survey data base.

4.13.3 Reasons for changes in the pond communities

In order to detect and explain future changes in the ecological quality of ponds, it is currently necessary to:

1. monitor water quality using sensitive groups, preferably invertebrates, but possibly diatoms; and,

2. monitor a wide range of environmental condition variables (depth, nutrient levels, etc.) and correlate these with community quality variables including plants and macroinvertebrates.

Table 4.2 summarises the survey options currently available for Pond Survey 1996 and their relative advantages.

Unfortunately 'rapid' methods for assessing ecological quality *and* reasons for changes in quality are not yet fully developed, and although they are currently the subject of projects being undertaken by Pond Action and the Environment Agency, full methods are unlikely to be available until at least 1998.

There may, however, be opportunities for collaboration with these or other survey projects. Field work for the ROPA project, for example, will comprise ecological surveys of 100 ponds in 1996 and 1997, at sites located predominantly in the lowlands of Britain. Some sites for the NERC ROPA project could, in theory, be located in PS1996 squares, perhaps providing additional species-level invertebrate or water chemistry data, which might not otherwise be collected in Pond Survey 1996.

Table 4.3 Options for ecological component of Pond Survey 1996

Survey option	Advantages	Disadvantages
Physical environment		
CS 1990 environmental data	• Quick; compatible with CS1984 and CS1990.	• Does not adequately describe pond physical environment.
CS 1990 + NPS environmental factors	• Compatible with CS1984, CS1990 and NPS.	• Takes longer to collect field data.
Water chemistry		
None	• Reduces cost.	• Omits major environmental factor.
1-2 samples	• Provides basic information about water quality.	• Timing critical.
Regular (e.g. organised by Environment Agency)	• Provides excellent data on pond water quality.	• Cost.
Wetland macrophytes		
Wetland and aquatic plant species list (using NPS methods)	• Important component of biodiversity. • Relatively easy to survey. • Compatible with NPS and allows comparison with 'undamaged' reference sites. • Correlated with invertebrate biodiversity.	• Plants can only be surveyed in summer. • Marginal species not very sensitive to environmental pollution; aquatic species (which are generally more sensitive to pollution) may be naturally absent from seasonal, shaded and silty ponds.
Wetland and aquatic plant abundance (NPS methods)	• May be a correlate of other aspects of biodiversity.	• Difficult to measure accurately and survey work is time consuming.
Diatoms		
Standard plankton sampling to create site species list	• Good indicators of water quality.	• Sample collection and processing requires specialist staff.
Sediment cores	• Allows reconstruction of pond history.	• Cost (requires highly trained staff; each core may take 6 weeks to analyse). • Many ponds unsuitable (due to dredging).
Macroinvertebrates		
3-minute NPS compatible samples	• Compatible with NPS and allows comparison with NPS reference 'undamaged' sites. • Most diverse group which is relatively well-known biologically. • Compatible with CS1990 running water surveys.	• Time consuming (especially if surveyed in three seasons). • Requires experienced staff.
Field search (e.g. water beetles)	• Relatively quick. • Can generate species lists for 'internal' assessments (Section 4.8).	• Requires skilled staff and not compatible with NPS or other surveys. • Variability between surveyors considerable.

Table 4.3 Options for ecological component of Pond Survey 1996 (continued)

Survey option	Advantages	Disadvantages
Other macroinvertebrates (e.g. chironomids, other Diptera, semi-terrestrial beetles)		
Listing of species occurring	• Important component of biodiversity. • Many species of conservation importance • Neglected groups	• Surveys are moderately time consuming • Requires specialist staff and therefore costly.
Microinvertebrates (rotifers, micro-crustaceans etc.)		
Listing of species/taxa occurring	• Important component of biodiversity. • Currently neglected area about which little is known.	• Less well-known than macroinvertebrates; taxonomic problems and limited distribution data (e.g. no Red Data Books at present). • Considerable taxonomic expertise required.
Counts of abundance or biomass	• Standard freshwater ecological technique; important component of biodiversity.	• Too little research in this area to be of practical use at the moment. • Requires specialist staff and therefore costly.
Amphibians		
Simple species list	• Popular and well-studied group. • Relatively quick (with experience, may be done during other survey work). • Compatible with National Amphibian Survey (NAS) data.	• Few species, little information available about amphibians as biodiversity indicators. • Several site visits needed to be sure of recording reliably.
Species lists and population counts	• Allows sites to be ranked in terms of amphibian status. • Compatible with the more detailed/reliable survey work in the NAS.	• Several survey visits needed. • Some survey methods are very time consuming.
Fish		
Note whether fish occur (e.g. by seeking evidence of fish during brief site inspection).	• Popular group, with considerable public interest • Important influence on permanent and semi-permanent pond ecosystems	• Not generally regarded as a 'conservation' issue.
Recording of species and/or biomasses (e.g. by netting or electro-fishing)	• Provides reliable data about important group of organisms. • Many ponds lack fish so poor indicators of biodiversity.	• Survey work is very time consuming (needing at least two or more people in the field); limited range of species poor for environmental classification.
Birds, mammals		
Species list only	• Popular groups with considerable public interest	• Too little known; too time consuming • Several visits to sites needed to compile species lists.

5. ASSESSMENT OF LANDSCAPE FEATURES

5.1 Aims

The aim of the Scoping Study with respect to landscape assessment for Pond Survey 1996 is to:

1. propose a survey method which will enable the *landscape value* of ponds to be assessed;

2. review information and data which are relevant to assessment of pond landscapes; and,

3. develop and agree a system for the assessment of pond landscapes.

It is an essential requirement of the survey that the landscape information collected is capable of being stored as simple quantitative or semi-quantitative data which can be statistically analysed to provide a quantitative indication of site value and of long term changes.

5.2 Background

Ponds and other water features can be significant landscape features (Shuttleworth 1984) and it is widely acknowledged that they add diversity, beauty and interest to many types of landscape.

Assessment of this landscape quality requires that different *areas* of the landscape associated with ponds are recognised and the *value* of these areas assessed (see below).

5.2.1 Landscape areas

Areas of landscape associated with ponds fall into two categories:

1. The *micro landscape* of the pond: the small scale landscape created by the character of the pond and its banks.

2. The *macro landscape*: the larger scale landscape of the pond surrounds, including, the views that may be seen from its banks.

5.2.2 The value of pond landscapes

The value of pond landscapes can be assessed from three main perspectives.

1. ***The value of the pond as a landscape feature:*** the contribution that the pond makes to its surroundings, and the significance that pond loss would have on the quality of the landscape. A good village pond, may for example, contribute highly to the general landscape, by adding an element of 'naturalness' to built environments. A small pond, amongst many others in a wetland may, in itself, make relatively little contribution to a landscape, so that, in landscape terms, its loss would be little noticed.

2. *The value of the landscape around the pond:* the landscape value of the area surrounding the pond, or seen as a visual envelope from the pond (note that this approach is the obverse of 1 above i.e. the contribution that the landscape makes to the pond). Change in value would, in this case, be evaluated in terms of changes to the surrounds, e.g. a change from pasture to urban land use in the surrounds.

3. *The micro landscape value of the pond itself:* the inherent attractiveness of the pond and its banks. This may be viewed in a number of different ways. For example (a) how near does the pond approach the 'perfect pond'? or (b) how good is the pond as an example of its type: i.e. how does a village pond compare with other village ponds?

5.3 Review and appraisal of existing methods

5.3.1 Scope of the review

Very little research has been undertaken to assess the landscape value of ponds in any of the areas outlined above. In the absence of well developed criteria to assess pond landscape value, the methods reviewed for this study have been extended to provide a general review of landscape assessment methods.

An appraisal of methods which could potentially be applied to Pond Survey 1996 is given in Appendix 6. The following section gives a very brief summary of the findings.

5.3.2 General approaches to landscape assessment

Overall, landscape assessment can be divided into three approaches:

1. *landscape classification:* division of the landscape into areas of distinct and recognisable character;

2. *landscape description:* factual and systematic documentation of landscape character and the elements which contribute to this; and,

3. *landscape evaluation:* a subjective judgement of the relative value of landscapes or landscape features.

The ideal requirement for Pond Survey 1996, as interpreted from Section 5.1, would be a process of landscape evaluation. However, landscape classification and description may both provide valuable information and may be a precursor to the landscape evaluation process.

5.3.3 Summary points from the literature review

A number of summary points can be drawn from the results of the appraisal of landscape assessment techniques (see Appendix 6).

1. There are well developed methods of landscape *description*, elements of which might be partially applied to pond macro and micro landscapes. These include the Warwickshire Landscape Project approach (Countryside Commission 1991, 1993) and the NRA river landscape assessment method (NRA 1993a).

   However these methods are essentially large-scale strategic methods and are not ideal for Pond Survey 1996 because:

   (i) they do not translate well to either the small scale assessments required for micro assessment of a pond and its bank, or to the still relatively small field-scale assessment of the pond surrounds; and,

   (ii) they are not likely to fulfil the landscape *evaluation* requirements of Pond Survey 1996.

   In particular, these methods are concerned primarily with broad, area-wide landscape assessments rather than with detailed site specific assessments (Countryside Commission 1993). In practice this means that:

   (i) the detailed methodologies are not appropriate for assessing *micro* pond landscapes;

   (ii) they are not ideal for assessing the significance of local landscape *changes* (e.g. the impact of a hedge being removed from around a pond); and,

   (iii) the often descriptive results are not easily translatable to the numerical values desirable for Pond Survey 1996.

   In addition, in the Warwickshire and NRA methods, *evaluation* is a relatively limited part of the assessment, largely restricted to landscape sensitivity.

2. Landscape *evaluation* techniques are, in general, much more poorly developed than description and classification methods, and there is no one method of evaluation which is ideal for Pond Survey 1996.

3. Credible landscape evaluation will also inevitably require greater resources than landscape description, since it requires, at some point, an input of professional judgement or public consensus.

4. Evaluation methods which are most suitable for *micro* landscape assessment may differ from those most appropriate for *macro* landscape assessment. This is discussed further below.

5. *Macro* pond landscape methods (both description and evaluation) may require assessment within a classification system, which would require considerably greater resource inputs than *micro* landscape assessment.

6. Pond Survey 1996 will inevitably use field surveyors relatively untrained in landscape assessment (see below). This suggests that methods of landscape evaluation should *avoid* protocols which require professional judgement in the field.

Where possible, field survey assessment should be restricted to relatively objective measurement of simple variables e.g. pond visibility, vegetation cover, shade, land use, etc.

5.4 The applicability of existing methods to Pond Survey 1996

The development of a practicable method of landscape assessment for Pond Survey 1996 needs to take into account a number of factors:

Constraints

- there is likely to be minimal set-up time (perhaps 1 month) prior to the start of the survey in which to develop materials and detailed protocols for the landscape assessment,

- the survey is likely to be undertaken by ca. 30 personnel, most of whom are likely to be inexperienced in landscape assessment and it principles. Future surveys are also likely to be undertaken by different personnel.

Opportunities

- there is potential to use the ITE database for Pond Survey 1996, including pre-digitised and updated map and Land Class data,

- there is a limited opportunity to undertake training of field personnel.

5.5 Recommendations

This section outlines a number of options for both the description *and* evaluation of pond micro and macro landscapes.

5.5.1 Assessing the micro landscape value of a pond

Very few sources are available to guide the development of methods for micro landscape assessment. Only Gee's brief amenity/landscape criteria (Gee *et al.*, 1994) and the NRA's River Landscape Assessment Method (NRA 1993a), provide directly relevant techniques (see Appendix 6).

In the absence of an existing method, suggestions for the development of a method are made below. This takes elements from both Gee *et al.* (1994) and the NRA work. The method is specifically multi-functional in that it may be used purely for landscape *description*, or can be adapted (post-, or ideally, pre-survey) to provide a means of micro landscape *evaluation*.

Both the methods of Gee *et al.* (1994) and NRA (1993a) are as required in the brief, 'based on a limited range of parameters that can be quickly and consistently observed in the field by trained surveyors'.

5.5.2 Micro pond landscape description

The pond *description* method is a modification of the NRA micro landscape technique. The method assesses each pond on the basis of a series of questions on a structures survey form (see Table 5.1). A tick is placed in appropriate boxes where specific characters are significant, marking the approximate relevant position between the two extremes.

Information derived from the assessment can be logged digitally and analysed as required i.e. to describe predominant pond micro landscape characteristics or to undertake relatively crude correlations with other pond attributes, such as conservation or historical value.

5.5.3 Micro pond landscape evaluation

The landscape evaluation process builds upon the landscape description method. Its use is based on a number of facts and premises.

- **The 'ideal' pond**

The evaluation of ponds may be relatively simple compared to other landscape features, in that their value, should, like other waterbodies, be strongly related to a single major axis of variation - the amount of water that is visible (Shuttleworth 1984, Shafer and Brush 1977).

Water visibility is, in turn, partly related to the pond size and partly to the successional stage of a pond. Our experience advising many individuals and groups on pond management suggests that there is a consensus that early-mid succession ponds are the most attractive, and that landscape value declines as ponds fill with vegetation, and views of open water are lost.

The implication from this is that, using the attributes listed in Table 5.1, it should be possible to grade the landscape quality of a pond in terms of *its proximity to an 'ideal' state*.

- **Prior use of professional judgement**

As noted above, the use of field surveyors untrained in landscape assessment suggests that field measurements should be restricted to measurement of simple variables.

This focuses attention on evaluation methods which use professional judgement and/or public consensus to grade ponds *prior* to (or after) the field survey. This leaves field staff to make more objective measurements.

Because of the time and likely resource constraints for Pond Survey 1996, grading ponds by use of professional judgement is a more feasible option than gathering a public consensus.

- **Assessment using pond features**

Ponds are likely to be most effectively assessed in terms of a number of different component features (plant cover, tree shade etc.) rather than their landscape value as a whole. This is because: (a) the parameters used for assessing ponds as a whole are likely to be too subjective for use by untrained field surveyors and, (b) there are too many types of pond for them to be easily assessed together.

5.5.4 A method for assessing the micro-landscape value of ponds

The points outlined above have been used to create a method for assessing the micro landscape value of a pond, based on estimating how close each pond is to its 'optimal' landscape state.

It is proposed that the decision as to what is 'optimal' (and the range either side) is judged, from photographs, by a group of specialists experienced in landscape assessment. A methodology is outlined below.

1. A series of 5 photographs are collected for each feature likely to contribute significantly to the landscape value. These features may be positive or neutral attributes (e.g. tree shade, clarity of water) or detractors (e.g. presence of nuisance species or evidence of pollution). See Table 5.1.
   The series of photographs shows the likely field range of each component (e.g. 0% tree shade to 100% tree shade).

2. A group of specialists experienced in landscape assessment (ca. 5 - 10) are asked to place the photographs for each component in order of landscape value.

3. The specialists' values are combined to obtain an average response.

4. The average responses are used to give each component a series of scores (e.g. 10 - 30% emergent plant cover scores five, 100% plant cover scores zero). Detractors are given negative scores.

5. Field workers simply measure the physical parameters (e.g. the percentage of vegetation cover).

6. Landscape quality is calculated during later analysis using the weighted scores established by the group of specialists.

- **Analysis of results**

Individual ponds can be given a simple Micro Landscape Score by adding the weighted values. All ponds can be ranked on the basis of their Micro Landscape Scores and divided up into High, Moderate and Low value categories. Change in micro landscape value can be assessed by comparing the results of repeat visits.

- **Testing and validating the scores**

The approach to landscape assessment described above is a fragmented approach (i.e. individual pond attributes are scored independently). Some additional testing is therefore required in order to ensure that the method is appropriate for ponds *as a whole*.

The results of testing may indicate that some additional weighting is required. The presence of rubbish may, for example, completely dominate the landscape value of a pond, regardless of the presence of other attributes, such as ideal vegetation cover and views over open water.

Particular importance needs to be given to the significance of pond size at this stage. Larger waterbodies almost inevitably have greater landscape importance than smaller pools (Shafer and Brush 1977), so size may require heavy weighting.

Ideally, a testing phase, is also required with additional consultation from landscape professionals.

5.5.5 Assessing macro landscape value

Essentially, two approaches to the macro landscape assessment of ponds are possible:

1. simple description/appraisal,
2. full evaluation.

Whichever approach is adopted, it is recommended that ITE's existing digitised data are capitalised upon, since many macro landscapes elements (e.g. land cover and landscape features) are already recorded there.

- **Simple descriptions**

At its simplest it is already possible to describe the macro-landscape of areas around a pond in terms of their ITE Land Class and adjacent Countryside Survey land type code.

With further analysis it is possible to use existing digitised information from the Countryside Surveys to quantify the main landscape features within a specified distance from any pond. These may be summarised in terms of simple factors such as land use, length of boundaries, area of water or built features. They may also be analysed in more detail (e.g. types of boundary: hedges, wall, ditch, etc.).

Change can be measured by comparison of data between years, and this change can be relatively simply quantified.

The resources required to undertake this analysis are:

- field checks of landuse, etc. on existing maps, within a specified distance from the pond; and,
- inputting and analysis of the data.

The main technical drawbacks with such an approach are likely *to be* (i) decisions relating to the area around each pond which should be analysed and, (ii) gathering data for ponds located near to the edges of a square.

5.5.6 Evaluating the macro landscape

In contrast to the landscape description approach outlined above, the methods chosen to *evaluate* pond landscapes are likely to be both more time consuming and more contentious. Many methods could potentially be applied (see Appendix 6), and no one method or approach stands out clearly as preferable.

Statistical methods (see Appendix 6) could potentially be applied. These codify individual landscape attributes (hedges, etc.) based on correlations with their scenic landscape appeal. Their major advantage to Pond Survey 1996, is that, in theory, existing digitised Countryside Survey information could be utilised, and scored to give a numerical total landscape value. In addition:

1. analysis could be undertaken after data collection, making it unnecessary to score features before the fieldwork period,
2. once set-up, landscape changes can be quickly determined,
3. landscape values could be theoretically calculated both with and without the pond included, making it possible to assess both the value of the pond as a landscape feature and the value of the landscape around the pond.

The main disadvantages of such methods are:

1. following much criticism of early uses of statistical methods (particularly the Manchester method) these methods are not favoured - being seen as soulless computer print-out solutions (Countryside Commission 1988, David Brooke *personal communication*); and,
2. the 'set-up time' required to ascribe and test the landscape value of all components.

To some extent, the time required is likely to be a difficulty for any macro-scale evaluation method. Because the range of Pond Survey landscapes is likely to be so extensive, simple 'look-see' approaches are unlikely to be adequate for evaluation purposes, whilst more detailed methods, perhaps operating within a classification scheme, will inevitably demand considerable resources.

Table 5.1 Pond micro landscape assessment criteria

General						
Pond size (data already available from data base)						
Pond full of water						Pond dry
Views of open water can be seen considerable distances from the pond (i.e. >200m)						Open water cannot be seen even from the pond banks
Appearance of water						
Clear water/bed visible						Discoloured/polluted water
Water free of debris or pollution						Frequent debris, rubbish or evidence of pollution
Evidence of fish or other wildlife						No evidence of life
Pond vegetation and banks						
Semi-natural, diverse banks/edge						Artificial banks
No marginal or emergent vegetation cover						Pond full of emergent or marginal vegetation
No floating or aquatic vegetation cover (e.g. water lilies, *not* nuisance species such as algae and duckweed)						Complete cover of floating or aquatic vegetation
No nuisance plant species present						Complete cover of nuisance species
Pond not shaded by overhanging trees						Pond and bank completely overhung trees

5.6 Final comments and options

The section above outlines methods which could be used for pond landscape description and evaluation at micro and macro landscape scales.

The ultimate choice of method(s) will, however, depend on the resources available and the strategic priorities for Pond Survey 1996 set by Environment Agency/DOE.

At this level it will be necessary to decide between a number of major options, in particular :

1. Whether undertaking *both* macro and micro landscape assessment is appropriate for Pond Survey 1996.

It might, for example, be argued that *macro* pond landscape description and evaluation are merely a small aspect of general landscape assessment issues already addressed as part of the Countryside Surveys and through initiatives such as the Countryside Character Programme.
In this respect a 'pond-centred' view of the wider landscape may not provide sufficiently important, or different, information to warrant the resources required.

2. Similarly, a choice will need to be made whether to limit landscape assessment to description, or to include evaluation.

The brief for Pond Survey 1996 calls for an assessment of landscape *value*. Pond evaluation clearly comes closer to this aim than simple site description. However, evaluation methods are relatively poorly developed areas of landscape assessment and, whereas a description requires relatively simple field assessment, credible evaluation requires considerably greater resources.

6. ASSESSMENT OF THE HISTORICAL FEATURES OF PONDS

6.1 Aims and requirements of the survey

Many ponds have an acknowledged historical importance and many historic sites include ponds as part of their archaeological/historical interest.

The aim of this section of the Scoping Study is to recommend methods which will enable Pond Survey 1996 to:

1. Create a baseline which describes the historical value of ponds and allows an assessment to be made of their value.

2. Enable a quantitative evaluation of change in historical value to be made, so that future surveys can assess the importance and causes of losses in ponds with historical associations.

Ideally the results of the Survey should be expressable in a quantitative or semi-quantitative form, enabling storage and manipulation of information on a database.

6.2 Background

Ponds may be considered to be of historical significance from two different viewpoints:

1. They may be important *features* in their own right, e.g. moats, fish ponds, duck decoys, places with literary or community associations.

2. Both their structure and their sediments may *contain* important historical information relevant to the history of the waterbody, its surrounds and the wider environment (pollen record, historical artefacts etc.). In some cases, particularly in more remote areas, these sediment records may span thousands of years.

In a recent pilot survey undertaken by the Pond Conservation Group (PCG) at the beginning of 1996, ca. 10% of ponds were estimated to be of historic interest by conservation organisations (PCG, unpublished results). These included 32 different types of pond identified as having '*...some social history associated with them*' (Table 6.1).

Although ponds may have a wide range of historical associations, most are relatively poorly documented. Analysis of the 2500 records including the term 'pond' on the National Monument Record (NMR), for example, indicates that the majority (89%) fall into two classes: 'fishponds' and unspecified 'ponds'. The remaining 11% of records are largely made up by pond bays, dew ponds, ornamental ponds, decoy ponds, ducking ponds and mast ponds.

It is certain that many more ponds (perhaps the majority) will have at least some archaeological or historical interest, but for the vast majority of ponds this is, as yet, unrecorded and unresearched.

Table 6.1 Ponds with historical or heritage associations

Pond types identified in Pond Conservation Group pilot survey

Mill ponds	Duck ponds
Old farm ponds	Subsidence ponds
Ornamental ponds	Cattle ponds
Extraction ponds	Peat ponds
Reclamation ponds	Stew ponds
Drinking water tarns	Droving ponds
Artesian ponds	Ice ponds
Decoy ponds	Pond bays
Hammer ponds	Forge/Furnace ponds
Curling ponds	Watercress beds
Dye pond	Flax retting ponds
Fish ponds	Swannery ponds
Moats	Silt ponds (on peat)
Marl pits	Heathland ponds
Dew ponds	Retting ponds
Traction engine ponds	Distillery ponds

Pond types listed on National Monuments Record database

Fishponds	Mill ponds
'Ponds'	Decoy ponds
Dew ponds	Pond bay
Ornamental ponds	Mast ponds
Ducking ponds	

6.3 Review and appraisal of existing methods of assessment

To date, no specific method has been developed for assessing the historical/ archaeological value of ponds. The following section therefore briefly reviews the range of methods commonly used for historical assessment.

6.3.1 Assessing the value of sites

Methods for assessing the historical value of sites can essentially be divided into two approaches:

- Investigation of existing databases and discussion with local experts to identify ponds of known interest.

- Field investigation of often previously undocumented, or poorly known, sites.

1. Existing databases and sources of information

Historical and archaeological sites are archived in a number of databases of which the most important are:

- National Monuments Record (held by the Royal Commission on the Historical Monuments of England).

- National Monuments Record for Wales (the Royal Commission on the Historical Monuments of Wales).

- National Monuments Record for Scotland (held by the Royal Commission on the Historical Monuments of Scotland).

- Sites and Monuments Record (SMR), (in each county or district in England, Wales and Scotland).

- The database of Listed Buildings.

The NMR is a fully computerised database which can be searched using standard database techniques. It currently contains 2573 items which include the term 'pond'. An example page from the NMR is shown in Appendix 7.

County and district SMRs contain some 600,000 total records. It is not known what proportion of these sites include pond related features, but an estimate is ca. 5% (30,000 sites). Computerisation is in progress.

The criteria which are used to grade sites for designation and inclusion on national and regional data bases include:

- period
- documentation
- survival/condition
- diversity and potential.
- rarity
- group value
- fragility/vulnerability

2. Detailed investigations of individual sites

Overall, very few ponds (<1%) are likely to be designated on national or regional databases. To obtain information about most ponds, therefore, other techniques need to be applied.

The list below covers the principal methods that can be used to collect data, in roughly increasing order of detail and time required:

- documentary research (maps, literature)
- assessment of aerial photographs
- fieldwalking
- geophysical surveys
- test pits
- trial excavations
- detailed site investigation (survey, excavation, coring sediments).

These methods are described further in Appendix 8.

6.4 Options for the survey methodology for Pond Survey 1996

Combining the database, research and field methods outlined above, the main options available for the assessment of historical value of ponds (again arranged in order of increasing effort) are:

1. Inspection of contemporary maps
2. Quick field assessment of archaeological/historical interest
3. Searches of national and regional databases
4. Landowner questionnaire surveys
5. Full desk study of sites
6. Full research survey of sites.

The advantages and disadvantages of these methods are discussed briefly in the following section.

- **Contemporary maps**

Contemporary maps (i.e. 1:10,000 scale), will be used as the basis for Pond Survey 1996.

Advantages

Contemporary maps can sometimes provide an indication of historical interest. Moats and fish ponds are, for example, often noted.

Disadvantages

There will be little or no information about the historical interest of the vast majority of ponds on contemporary maps.

- **Brief field surveys**

Surveyors will make a field visit to each pond during the Survey.

Advantages
It may be possible for field surveyors to make limited observations about the origins of ponds such as quarry pools, dew ponds or farm ponds. Additional information may be obtainable, on a casual basis, by discussions with local residents.

Disadvantages
Field surveyors are likely to be untrained in archaeological assessment. In a brief field visit only a limited amount of information could be obtained.

- **Search of national and regional data bases**

Advantages
This option provides reliable historical and archaeological data. It also offers an effective use of resources, in that, once informed of survey squares, county archaeologists will undertake the search.

Disadvantages
A relatively small proportion of sites are likely to be documented in county and national archives. For example, in Oxfordshire, inspection of the Countryside Survey squares surveyed in 1990 in the NMR and the Oxfordshire SMR showed no records of existing ponds even though one square contains six ponds which appear to have the characteristics of a series of fish ponds.

- **Landowner questionnaire survey**

It is possible that some information about pond history could be obtained from landowners using questionnaires. Gee *et al.* (1994), for example, had a moderate response to a question about the archaeological interest of ponds on farmland in Wales, with landowners at 8 out of 51 sites having some comments on the site history.

Advantages
Landowners often have a good knowledge of the history of their land, and if long-established on a site, their knowledge may date back over a considerable time. Some may have copies of documents of value for historical research.

Disadvantages
Many farmers/landowners will have little information about the history of their ponds.

Information given by landowners may not be accurate. For example, landowner and pond managers frequently describe their ponds as 'dew ponds' in circumstances where this is implausible

The design and implementation of questionnaire surveys has (moderate) resource implications.

- **Desk study**

A desk study of sites could be undertaken based on assessment of maps, aerial photography and documentary research.

Advantages
A desk study could provide at least some information about most sites. Archive maps, for example, would allow the identification of more recent sites, and the minimum age of many others.

Disadvantages
A desk study covering all sites surveyed would be time consuming and could be beyond the resources of the 1996 survey.

- **Full survey**

At most sites it seems likely that only with detailed investigation would it be possible to assess the historical significance of sites.

This would require site inspection by a trained archaeologist with the option for limited investigation by trial trenches or coring.

Advantages
Clearly, undertaking a detailed survey of the sites is, in many cases, the only way of determining the historical significance of the sites. This approach would therefore enable sites to be properly assessed and ranked at a national, and perhaps regional level.

Disadvantages
This approach is the most time consuming and, in the context of the Pond Survey 1996, prohibitively expensive.

Although the amount of effort needed on individual sites would obviously vary, it is unlikely that less than 1 month per site would be needed.

A full historical survey of ponds is an area which should certainly be encouraged, but it is likely to be well outside the scope of the resources provided by Pond Survey 1996 alone..

- **Combination of approaches**

It is possible that a combination of approaches could be taken, or perhaps a limited survey of all sites and a more detailed study of a subset of ponds.

6.5 Compatibility and integration with previous surveys

Previous ITE Countryside Surveys in 1984 and 1990 did not include areas of curtilage (i.e. ponds within the grounds of buildings, school ponds, garden ponds). It also did not include areas which were more than 75% built-up.

Ideally it would be highly beneficial to include these in the 1996 baseline survey since:

- ponds, recognised as important features by historians and archaeologists, often form a component of larger sites which include a variety of buildings and remains. Many of these areas are likely to be within curtilage.
- many ponds of local historical importance will lie within relatively urban areas.

In practice, however, including areas of curtilage will considerably increase the burden of gaining permission to visit sites. The additional resources needed to do so, may be prohibitive.

6.6 Developing criteria to assess the value of ponds

Ponds may have historic associations at local, regional and national levels. There are, however, no specific criteria to define the importance of ponds at these three levels.

In the absence of an already well-developed set of evaluation criteria, a pragmatic selection of indicators for defining pond value at national, regional and local level are suggested below and summarised in Table 6.2.

National criteria
Ponds of national importance are outstanding examples of their type in terms of the period, rarity, documentation, group value, survival/condition, fragility/vulnerability, diversity and potential.

They are likely to include ponds on the site of, or adjacent to a:

- Scheduled Ancient Monument
- Listed building

By definition, any pond site scheduled as an Ancient Monument will be of national importance.

Pond sites are also likely to be of national significance if they are within or adjacent to a:

- Historic Park or Garden
- World Heritage Site
- Conservation Area.

Theoretically ponds in Areas of Archaeological Importance might also be listed, but there are likely to be very few ponds in the centres of the five cities which fulfil this criterion.

In total, a relatively small proportion of ITE pond sites are currently likely to fall within these categories although the Monuments Protection Programme may increase this number.

Regional criteria
Generally, the criteria used to identify sites of importance for scheduling at a national level are also used (usually informally in the light of professional judgement) to identify sites of regional importance. These sites, are however, not those that would normally be regarded as outstanding examples.

The best criterion for a site of regional importance is therefore likely to be the presence of a pond on a regional, but not national, database.

Local criteria
It is suggested that a pond of local importance is one which is not present on national or regional databases, but which has a clear local importance. This might include:

- ponds typical of the local area or region e.g. Cheshire marl pits, downland dew ponds;
- large, deep ponds with considerable sediment accumulations; and/or,
- any pond associated with urban areas (e.g. old village ponds), and which are therefore likely to have strong local historical associations.

Table 6.2. Criteria for identifying ponds of historic importance

Ponds of national significance	Criteria: outstanding examples in terms of the period, rarity, documentation, group value, survival/condition, fragility/vulnerability, diversity and potential. Sites of national importance are likely to be on the site of, adjacent to , or within a: • Scheduled Ancient Monument • Listed building • Historic Park or Garden • World Heritage Site • Conservation Area.
Ponds of regional significance	Criteria: sites which would not normally be regarded as outstanding examples which are still documented historical sites. Present on a regional database.
Ponds of local significance	Criteria: ponds typical of the local area or likely to have strong local associations e.g. Cheshire marl pits. Ponds that are little managed and likely to contain a valuable sediment record.

6.7 Numerically grading sites

For the purpose of Pond Survey 1996, it may be possible to apply a numerical score to the national/regional/local categorisation outlined above.

An example of a simple scoring system is shown in Appendix 9.1 and the calculation of an Historical Importance Score in Appendix 9.2, based on three ponds in Berkshire and Oxfordshire.

However, it should be noted that numerical scoring, although common in ecological, amenity and landscape assessment work, is not widely applied in historical and archaeological site assessment.

6.8 Evaluating change

Future Pond Surveys will undertake research aimed at determining change in the historical value of sites.

For ponds which are *well studied* and researched, the historic value of the pond is likely to remain relatively fixed - with change largely caused by damage to, or destruction of, the pond. The causes of such loss or damage will be assessed in other parts of the Survey dealing with the cause of pond loss or change in physical state.

For other sites where historical knowledge is currently poor, the most likely *change* is an increase in value resulting from increasing knowledge.

Change in this case will be evident, at national or regional level, by periodic trawls through relevant data bases to see if new sites have been discovered or upgraded (or occasionally downgraded) in importance.

6.9 Conclusions and recommendations

The main difficulties in assessing the historical value of ponds are: (i) the lack of standard assessment criteria, (ii) the lack of general information about the history of individual sites and, (iii) the considerable resources required to gather adequate information about sites not currently listed on national or regional databases.

It is not possible to quickly evaluate the historic importance of a pond from contemporary field and map evidence alone. At all sites of known historical importance (whether for environmental archaeology or cultural history) field and documentary evidence forms the basis for assessment of the site.

The potential importance of a pond's sediment record is, in particular, very difficult to establish without specific and detailed surveys, because the management (particularly dredging history) of waterbodies is rarely, if ever, fully recorded.

Bearing these points in mind the following recommendations are made for assessing historical value in the 1996 Pond Survey:

1. All 1 km survey squares are checked against the NMR and checked against the relevant SMRs. This should be undertaken by the relevant local expert (usually the County Archaeologists), who will have contact with other local and national experts.

2. The opportunity to provide field surveyors with some basic knowledge of historical assessment skills should be investigated. This could consist of interpretation of contemporary maps and field observation of site structure, morphology etc.

3. Assessment of historical value should use a tripartite division using database information to place sites in regional or national categories, and other information to note ponds likely to be of local importance.

4. Investigation of pond sites by archaeologists and historians, in conjunction with the 1996 Pond Survey (and subsequent surveys) should be encouraged. The 1996 (and subsequent) surveys represent a major opportunity to stimulate research in a neglected area of cultural and environmental history.

7. ASSESSMENT OF AMENITY VALUE

7.1 Aims and requirements of the survey

The aim of this section of the Scoping Study is to recommend methods which will enable Pond Survey 1996 to:

1. assess the amenity value of sites;

2. provide information which will allow significant changes in amenity quality to be assessed; and,

3. where possible, provide methods which can be used to evaluate the reasons for any changes in quality.

7.2 Background

The most important *formal amenity* use of ponds is undoubtedly for fishing, but ponds are also recognised as having a considerable *passive amenity value* simply as scenic features which add interest and focus to the landscape.

In addition, ponds are used for a variety of leisure activities (see Table 7.1), including the use of larger ponds for water sports and shooting and more urban sites for hobbies such as model boating. Ponds with semi-natural surrounds may be used for birdwatching and other natural history studies. Those in private grounds are often used to keep ornamental fish or wildfowl.

Table 7.1 Amenity uses of ponds

- Fishing
- Shooting (wildfowl)
- Ornamental fish
- Ornamental and other pinioned wildfowl
- Pond dipping and other wildlife and conservation interests
- Boating and other water sports
- Swimming
- Model boating

7.3 Review and appraisal of existing methods of assessment

7.3.1 Approaches to assessing amenity value

There are essentially two broad approaches to the assessment of amenity value.

1. **general assessments** of the amenity value of sites: determining, for example, how often sites are used and for what purposes. These assessments may be either quantitative or qualitative.

2. **economic valuation** which quantifies amenity value in monetary terms.

7.3.2 Data searches

An initial data search provided little information about the amenity value of ponds The review was therefore widened to include methods used to assess the value of other waterbodies including lakes, rivers and canals.

The findings from this broader review indicated that there is a relatively limited literature describing the amenity value of rivers and lakes. The amenity value of canals, however, has been widely researched.

The reviewed below combines information on methodologies used to assess amenity value in all four waterbody types (ponds, lakes, canals and rivers).

7.3.3 General assessments of the amenity value of sites

Assessments of waterbody amenity value have generally used one of the handful of methods described below.

1. Owner questionnaires and rapid assessment surveys

Most of the very limited data relating to the amenity value of ponds comes from regional pond surveys and takes the form of one or two simple on-site observations usually relating to whether ponds were fished or used for wildfowling (e.g. HCC 1987).

The only *specific* survey of pond amenity value is a survey of the landscape/amenity value of Welsh farm ponds undertaken by Gee and co-workers (Gee *et al.* 1994).

The Welsh pond field-survey included estimates of:

- visibility of the pond from a public highway scored on a five point scale (1 = obscured; 5 = clearly visible),

- the distance between the pond and the nearest point of access and the type of highway (e.g. footpath, bridle path, A or B-road),

- obvious pollution (0 = absent; 1= present),
- presence of fishing platforms (0= none; 1= some),
- commercial exploitation (0 = none; 1= some), indicating whether the pond was managed for commercial exploitation.

An 'amenity visibility rating' was calculated by multiplying the score for the nearest point of public access by the visibility rating.

A parallel farmer-landowner questionnaire included questions on use of the pond for amenity and commercial purposes, such as fishing and shooting.

2. General visitor surveys at specific locations

On-site interview-based questionnaires of visitors and passers-by have been used on canals, lakes and rivers to obtain information about visitor types and their levels of enjoyment (British Waterways 1992,1993a, 1994). Most surveys have been undertaken at 'honeypot sites' to maximise the numbers of responses obtained (Glen Miller *personal communication*).

In order to make accurate estimates of the *numbers* of people using the waterways generally, both British Waterways (BW) and, more recently the NRA/Environment Agency, have used laser operated 'pedestrian counters'.

3. Specific user group studies

Studies of user groups (e.g. pedestrians, anglers) have included on-site interviews, group discussions and postal questionnaires. British Waterways, for example, distributed questionnaires to canal anglers through their respective angling clubs (British Waterways 1993).

4. Surveys of local residents

Surveys of local residents in areas adjacent to waterbodies have recently been undertaken by the River Restoration Project. The aim was to establish attitudes to adjacent river reaches and the proposals for their restoration. Survey methods included group meetings and structured interview questionnaires of householders in streets adjacent to the restoration sites.

5. National Household Interview Surveys

National Household Interview Surveys are omnibus questionnaire surveys undertaken by professional polling organisations. They have large sample sizes (often ca. 10,000 respondents) and aim to be statistically representative of the population as a whole in terms of age, sex, location and social class.

This method has been used by British Waterways to assess the public image of the waterways system as a leisure and amenity resource (NOP 1986; Adamowicz *et al.* 1994). Overall, they have provided BW's best source of data for measuring national attitudes towards the waterways (Glen Miller *personal communication*).

Such methods are, however, likely to be beyond the resources available to Pond Survey 1996.

7.3.4 Economic evaluation

Assessing the economic value of public amenities is a rapidly developing area. The application of these methods to river and canal systems is well established, but they have yet to be applied to ponds. A wide variety of economic methods have been developed, but most fall under the following headings.

- **Hedonic pricing**

Hedonic pricing is based on the observation that goods are valued on the basis of a number of attributes, and by statistical analysis it is possible to estimate that part of the value contributed by each attribute. British Waterways, for example, used observations that houses adjacent to canals commanded higher market prices than those in neighbouring streets, to develop estimates for the value of the waterways.

- **Travel-cost method**

Travel-cost methods evaluate a resource (such as a pond) in terms of how much people are prepared to pay to gain access to that resource. Valuation is made in terms of the cost of travel (mileage rate x distance per head). Travel-cost methods have been applied to canals and have been used to compare the value of rivers with other open spaces, such as parks.

- **Contingent valuation**

Contingent valuation (CV) is a generic term for methods in which individuals are provided with information about a situation and a proposed change and asked their willingness to pay for that change. British Waterways have used CV methods to gain information about how much the public would be willing to pay for (or to be compensated for) that change. British Waterways have used CV methods to gain information about the public's willingness to pay for the upkeep of the canal system.

CV methods require careful structuring of information and rigorous survey research procedures if the results are to be reliable (Adamowicz *et al.*. 1994, Bateman *et al.*. 1994).

7.3.5 The costs of economic assessment

The main drawback with most economic methods is the cost of implementing them. Surveys need to be designed and undertaken by competent professional staff. Large sample sizes are required in order to ensure results are statistically valid - usually a minimum of 250+ respondents.

7.4 Relevant results from amenity surveys

Over the last decade British Waterways, in particular, have undertaken a wide range of amenity survey of different types, at different scales and using different methods. Results of these studies provide some useful guidance for methodological development of the 1996 Pond Survey. Three aspects of these studies are of particular interest *(see over)*:

1. There was consistent evidence that the most significant use of canals was by frequent casual visitors, such as dog walkers or people using canals *en route* to their place of work.

2. A relatively large number of visits to canals were concentrated at 'honey-pot' sites.

3. All the evidence suggests that most people who use the waterways live close by (e.g. Adamowicz *et al.*. 1994).

The implications of these findings for Pond Survey 1996 are that:

(i) the passive landscape amenity value of ponds may sometimes be considerable and an effort should be made to estimate this; and,

(ii) passive amenity value is likely to be strongly related to the proximity of the pond to residential areas or areas with a lot of visitors, such as National Parks.

7.5 Constraints from previous surveys

The development of a practicable method of amenity assessment for Pond Survey 1996 needs to consider previous Countryside Survey protocols. The most significant constraint is likely to be that areas with >75% urban cover were specifically excluded from the 1984 ITE survey and the 1990 Countryside Survey.

In effect this excluded ca. 5% of the 1 km squares in Great Britain from Countryside Survey 1990. These were largely squares in cities and large towns. Villages (and therefore village ponds) are likely to remain relatively well represented.

7.6 Discussion of the applicability of existing methods to Pond Survey 1996

In summary, the methods available for assessing amenity value for Pond Survey 1996 include (in order of increasing resource implications):

1. analysis of existing data
2. rapid field survey
3. questionnaire surveys of landowners/farmers
4. questionnaire surveys of users/visitors
5. questionnaire surveys of local inhabitants
6. questionnaire surveys of the general public.

For all of these, except the rapid field survey, it is possible to use a choice of survey methodologies, including interviews or postal surveys. It is also possible to use a general appraisal method and/or economic evaluation to assess amenity value.

Ultimately, the choice of method will depend on the degree of precision and accuracy required from the results and the resources available.

The advantages and disadvantages of each option are described briefly below.

7.6.1 Analysis of existing data

It would be possible to use OS maps and existing Countryside Survey maps to look at the relationship between aspects of informal amenity value.

Advantages

- This method would be relatively quick
- It is possible to relatively quickly and accurately estimate parameters such as the proximity of ponds to footpaths, roads and areas of settlement which could be time-consuming in the field.

Disadvantages

- It is not easy to assess 'visibility' from maps (whether a pond can be seen from a footpath, for example).
- Formal amenity uses cannot be identified from maps.

7.6.2 Rapid field survey

Advantages

- Field workers will already be on site.
- It is possible to design a field survey that can be undertaken quickly.
- It is possible to directly estimate some of the most important factors likely to influence informal amenity value, e.g. visibility from footpaths.
- There is an excellent survey return rate (ca. 100%!)
- Some additional evidence of formal amenity use may be present (e.g. boathouse, fishing platform).

Disadvantages

- Rapid field assessments can give only a 'guesstimate' of amenity value based on gross assumptions about the relationship between factors such as visibility and amenity value.
- Assessments of formal amenity use, such as fishing or shooting, can be difficult to make.

7.6.3 Questionnaires to farmer/landowner

Advantages

- A relatively cost-effective option for gathering information to extend and corroborate field data.
- The most effective means of assessing formal amenity values (e.g. shooting, fishing).

This option is likely to be most cost effective if questionnaire surveys are considered for other aspects of Pond Survey 1996.

Disadvantages

- Questionnaires may be 'politically' untenable if there is a risk that they will alienate farmers/landowners who have given permission for Countryside Survey work on their land
- Further questionnaires would be required in future years
- There may be a low survey response rate (typically ca. 20-70% depending on method and persistence)
- Survey replies may represent a biased sample and answers may not always be truthful.

Further information on the drawbacks of individual methods is given below.

7.6.4 Interview vs. telephone vs. postal questionnaires

There is no ideal method of contacting farmers and landowners. ITE's experience from previous surveys is that preferences vary; some farmers prefer personal contact, others, particularly larger farmers/landowners, dislike interruptions to their working day and prefer postal questionnaires.

Overall, telephone questionnaires are unlikely to be an appropriate option; it can be impossible to identify and discuss individual ponds with landowners, who may have several ponds on their land.

Postal questionnaires are likely to be undertaken more quickly than telephone or site visits. However return rates may be poor (typically only 30 - 35%), individual discussion and clarification is not possible, and questions must be very carefully phrased so as to avoid misunderstandings.

On-site interviews are likely to be disruptive to the field surveyor if combined with the general field survey of ponds ("He's not available now - could you come back at 2.00 o'clock?"), and very inefficient if an independent return trip is required.

Since any questionnaires would be part of a Government sponsored survey, this will require approval from the Survey Control Unit (SCU).

7.6.5 Recommendations for a farmer landowner questionnaire

Questionnaire surveys to farmers and landowners should have the following characteristics:

1. Questions should be quick to answer - especially since a farmer may have more than one pond on his/her land.

2. Interviews/questionnaires should be designed to give fixed and/or numerical answers (not discursive).

3. A map clearly showing the location of the pond(s) should be enclosed.

Questions may be simply aimed at gathering information about the type of amenity use (see example in Appendix 11).

Alternatively they may be directed towards identifying the value that the landowner places on the pond. This may, in turn, be assessed in either qualitative terms, or through questions which may be given economic value (see examples given in Appendix 11).

Ideally any questionnaire used should be drawn up by a professional pollster.

7.6.6 Other surveys

Other types of survey could be undertaken if more detailed information is required. There are two main options:

1. A more detailed questionnaire survey of a subset of ponds across a range of amenity values from semi-urban to rural. This would be best undertaken as a 'nearest neighbourhood' survey, since on-site questions to users could have very few respondents from rural sites.

2. If it proves impossible to include urban areas and areas of curtilage as part of the survey, a small sub-survey of these areas could be undertaken. This could use either the field and owner methods outlined above and/or site and neighbourhood interviews.

More detailed and quantitative surveys, such as national or regional omnibus or census studies are likely to be well outside the scope and budget of Pond Survey 1996.

7.7 Assessing changes in amenity value

Few aspects of pond amenity value are likely to change significantly with time. Most changes will reflect changes in the condition of the pond (i.e. the ability to see open water) or changes in use (i.e. addition of coarse fish for angling). These changes can be simply assessed through use of repeat field surveys and follow-up questionnaires where appropriate. The reasons for change will be evident from the answers to both.

7.8 Conclusions and recommendations

The main conclusions and recommendations from this assessment of amenity value are given below.

7.8.1 Main conclusions

- The amenity value of sites is primarily related to their use.
- The main use of ponds is likely to be their *informal* amenity value as a landscape feature. A broad approximation of *informal* amenity value can be made on site using criteria such as visibility from highways and proximity to areas of habitation or 'honeypot' areas.

  Obtaining more detailed information on informal amenity value is likely to be prohibitive in terms of resources.
- *Formal* amenity values will sometimes be evident from field evidence. However, effective assessment is likely to require farmer/landowner questionnaires.
- It may not be practicable to use questionnaires because of the risk of alienating landowners and farmers.
- On a cost-benefit basis, postal questionnaires are likely to be preferable to site visits. Telephone questionnaires are unlikely to be viable.

7.8.2 General recommendations

It is clear from the above that the most appropriate and viable means of assessing ponds is likely to be a rapid assessment made by fieldworkers on site.

The main disadvantage of field methods is that they are likely to underestimate the more formal amenity uses, such as shooting and fishing. A farmer/landowner questionnaire is likely to be the best means of assessing this. However, note that it is unlikely that more than 50% of questionnaires will be returned without a follow up of some kind.

Suggestions for rapid field assessment questions and examples of postal or interview questions are given in Appendices 10 and 11.

8. SAMPLING STRATEGY FOR POND SURVEY 1996

8.1 Introduction

An objective of this scoping study as given in the project brief is 'to recommend a survey design to provide information about national trends in the number and condition of ponds and to assess the reasons for the trends observed'.

Previous chapters have reviewed (i) methods for identifying and explaining pond loss (ii) methods for identifying new ponds and, (iii) means of assessing ponds on the basis of their ecological, landscape, historical and amenity value.

This chapter specifically summarises *aspects of the sampling strategy*, which relate to trends in number and condition. Stated requirements of the survey, which affect the choice of sampling strategy, are the need for it to be:

- based on a *representative* sample of ponds;
- designed to provide quantitative and qualitative information on pond habitats and landscapes for *GB, England and Wales;*
- capable of *repetition* at intervals of several years in order to measure change in the number, frequency, extent and quality of ponds; and,
- *fully compatible with ITE Countryside Surveys* undertaken in 1984 and 1990.

8.2 Issues

8.2.1 Addressing the brief

The requirements of the brief, as set out above, reduce the options for survey. The need to be fully compatible with the Countryside Surveys and to provide information relating to national trends in pond numbers suggests that methods for Pond Survey 1996 should follow those employed in earlier surveys. However, there are opportunities for enhancing the information obtained in this way by using additional methods and by increasing the information baseline for future monitoring.

8.2.2 Objectives

Implicit in the brief are a range of objectives, each of which has a different optimal sampling strategy:

- The sample should be *representative;* of GB for example. This objective means that no bias should be introduced into the selection of sample squares (e.g. to favour ITE Land Classes with more ponds) and that all ITE Land Classes should be sampled.

- The sample should allow estimates of the *number* of ponds to be made. The sample must be large enough to give (statistical) confidence in the estimates. To reduce the size of the statistical error terms associated with the estimates, more samples would need to be placed in heterogeneous Land Classes.

- The sample should allow estimates of the *quality* of ponds to be made. To assess quality, it would be necessary to obtain as wide a range of pond types as possible, in a wide range of environmental situations, in order to obtain the extremes of a quality gradient.

- Results should be expressed for *GB, England, Scotland and Wales*. To produce reliable estimates for areas as relatively small as Wales, then more samples will have to be placed in certain Land Classes (e.g. Land Class 17). Similarly, where estimates have higher statistical errors due to inherent heterogeneity (see below), then more samples will need to be placed in other classes.

No one sampling strategy will be optimal for each of these objectives; some compromise will have to be reached.

8.2.3 Estimates of statistical error

To gain an overall impression of the effect of increasing the sample number on the size of statistical errors associated with estimating numbers of ponds, Figure 8.1 shows the theoretical relationship between sample number and Coefficients of Variation (CV) for a range of geographical regions, based on the 508 squares used in CS1990. In this theoretical model, it can be seen that, for GB, a doubling of the sample size would decrease the CV from about 24% of the estimate to about 19% of the estimate. This, arguably, represents a poor return for the additional effort. On the other hand, halving the sample from ca. 500 squares to 250 would significantly increase the CV (to about 34%).

However, (from Figure 8.1) to give comparable CVs for Scotland and the upland landscape type generally (where sample squares are highly variable) then very large sample sizes would be necessary.

Table 8.1 Reduction of CV by choice of sampling strategy. (CV is expressed as a percentage.)

	Observed Sample		Weighting by Constancy		Weighting by Frequency	
	CV	No. of sites	CV	No. of sites	CV	No. of sites
GB squares	19.70	381	18.84	430	14.43	430
Lowland squares	15.24	232	12.02	332	10.31	325

8.2.4 Repeatability

The change in the mean value of a population of attributes (such as number of ponds) between two dates can be estimated by taking samples at each time. If the two sets of samples are independent of each other (two separate population samples) then to demonstrate change, the statistical error bars associated with each mean estimate must not overlap. Thus, if the samples are highly variable, it is likely that only large changes can be demonstrated

An alternative approach is to use the same sample at both dates; the change between the two samples is then known (from observation) and the statistical issue then becomes one of representativeness of the sample. The Countryside Survey approach uses the latter technique which is said to be more appropriate for most features recorded in this sort of general countryside survey (Barr *et al.* 1993).

8.2.5 Deployment of effort

In addressing the objectives in section 8.2.2 above, consideration needs to be given to preferential sampling of Land Classes which have a high percentage of squares with ponds present (constancy) as opposed to Land Classes which have a high number of ponds overall (frequency). Figure 8.2 shows this relationship for the 32 ITE Land Classes based on CS1990 data.

Figure 8.2 shows that while Land Class 32 has both high mean frequency of ponds per squares and high constancy, some Land Classes (e.g. 5, 30 and 31) are characterised by having a small number of squares which have ponds but with a relatively large number in each of those squares. Land Classes 1, 3 and 11 have a greater frequency of squares with ponds but with relatively few in each. To meet the objectives of the survey, as defined, it is likely that any weighting of Land Classes should take both these measures into account in order to meet the range of objectives as discussed in 8.2.2 above.

The effect of these measures is shown in Table 8.1. The observed CV for all 381 GB squares surveyed in 1984 and 1990 is 19.70%. Increasing the sample size to 430 weighted by constancy gives a CV of 18.84%, whilst a weighting by frequency gives a CV of 14.34%. To estimate CV in lowland landscapes, a subset of 232 lowland squares with an observed CV of 15.24% was increased to a sample size of 332, which gives a CV of 12.02% if the sample is weighted by constancy, and 10.31% if weighted by frequency.

8.2.6 New ponds in 'non-pond squares'

As discussed in Chapter 3, there is a temptation to only revisit squares in which ponds were present in 1990. The argument is that if there were no ponds at the time of the last survey, then there are less likely to be new ones now and it is inefficient to deploy much effort in establishing whether this is true. However, the counter-argument is that if new ponds are being created or restored, then this may be taking place in Land Classes which contained few ponds in earlier surveys and this does need to be validated.

There may be scope for compromise here, and as noted in Chapter 3, options include:

- survey in detail only the squares that contained ponds in *1990 and* carry out a rapid field check on a sub-sample of 'non-pond' squares
- as above, but carry out the check on all non-pond squares
- as above, but use other survey data (e.g. questionnaire or recent aerial photography to check for new ponds in previously non-pond squares)

8.3 Preliminary recommendation (to meet all objectives)

The following recommendation is for the minimum scientific programme that needs to be carried out to address all the stated objectives of the survey.

The core sample
To be fully compatible with the Countryside Survey, the basic sampling strategy should be to survey the 381 1 km squares that were surveyed in both 1984 and 1990 (some of these were also surveyed in 1993). By reference to this **core sample** of squares, time series data from three dates would (i) allow trends in pond numbers to be calculated and, (ii) be representative of GB.

The survey should make use of the same definitions as in previous surveys, even if these are sub-divided or aggregated to meet additional objectives in the current survey. Similarly, the same standard of surveyor expertise and the same times of year should be considered, even if these have to be incorporated into a more ambitious or broader research programme.

A targeted additional sample
The earlier Countryside Surveys were not designed to survey ponds specifically: the sampling frame was not optimal for this purpose. However, the data collected from a representative sample of sites across GB, suggested that although most types of land contained ponds, some areas (e.g. ITE Land Classes characteristic of mountain tops and much of northern England and southern Scotland) had few ponds while others (especially in south and south east England) had many. There are two measures of pond abundance that are important. First the number of 1 km squares in each Land Class that has one or more ponds, and second, the mean number of squares that do not have ponds present (see Figure 8.2).

If a more efficient sampling strategy is to be devised, which builds on the basic sample, then there needs to be recognition of the differing objectives outlined above, especially:

- the need to obtain better (more statistically robust) estimates of pond numbers in GB; and,
- the need to increase the range of pond types in the survey.

These twin objectives cannot be easily maximised in any one scheme - the first needs larger numbers of more homogeneous pond squares (and is best achieved by visiting a small number of Land Classes where pond numbers are similar in each square), whereas the latter needs greater heterogeneity (and a wider range of Land Classes and sample squares).

It is recommended that the 381 squares which form the core sample should be supplemented by a further sample of squares which are allocated optimally, according to the frequency and constancy of ponds occurring in a given Land Class (and the Scotland estimates). It is anticipated that the inclusion of this **targeted, additional sample** would reduce the CV of the estimate further than would visiting the 508 squares used in CS1990. Thus, better placement of samples is likely to be more important than increasing the sample size.

For example, Table 8.2 shows the distribution of ITE sample squares across four landscape types for all 508 sites used in CS1990 and for the 381 squares surveyed in both 1984 and 1990. The two 'lowland' landscape types (arable and pastural) contain 63% of the CS1990 squares and 67% of the 153 'pond' squares. A targetted additional sample of squares in these landscape types should improve the national estimate of pond numbers.

Table 8.2 ITE sample squares by landscape type

	CS 1990 sample squares	84-90 change squares	Pond squares in 84 and/or 90
Arable	162 (32%)	116 (30%)	46 (30%)
Pastural	158 (31%)	116 (30%)	57 (37%)
Marginal Upland	77 (15%)	56 (15%)	16 (11%)
Upland	111 (22%)	93 (25%)	34 (22%)
Total	**508** **(100%)**	**381** **(100%)**	**153** **(100%)**

In addition, if a sub-sample of the 'non-pond' squares is surveyed (say 20%), and new ponds are found, the results of such an exercise could be used to further refine the national (or regional) estimate of pond numbers. 'Non-pond' squares must be used in the calculation of the mean number of ponds per ITE Land Class.

8.4 Other options and their consequences

Some other options for the sampling strategy should also be considered. These are discussed briefly below.

Option 1
Reduce effort by only surveying core sample of 381 squares surveyed in 1984 and 1990.

This will reduce costs but will give no better statistical confidence than from earlier estimates, especially for Wales and Scotland.

Option 2
Survey only the ca. 40% of squares in the 1984 and 1990 sample that contained ponds (=153 squares) and undertake either (i) a rapid assessment of 'non-pond' squares or, (ii) a sub-sample of non-pond squares

A 'rapid assessment' is unlikely to save costs if the 'non-pond' squares are checked by field visits as a large proportion of the cost is associated with travel and access. A different source of information (such as a questionnaire survey) is an alternative. A sub sample of non-pond squares could be surveyed as a trial. This would produce an indication of pond creation rates, and could be followed up by further survey work in future years if necessary.

Option 3
Re-deploy additional samples in different ways.

The way the additional samples are placed will have effects on the overall costs. If, for example, additional information was required from only the lowlands, then survey costs are likely to be reduced as travel and access may be easier than in the uplands. However, the main source of the statistical variation in the sample lies in the uplands and any sacrifice of effort in the uplands will be at the expense of improved statistical confidence overall.

9. AN INFORMATION STRATEGY FOR POND SURVEY 1996

9.1 Introduction

This chapter summarises an information strategy for the collection, storage and presentation of data from Pond Survey 1996.

Amongst the most critical aspects of the strategy is that all information is fully compatible with previous Countryside Survey (CS) data, including, for example, digitised base maps, entry codes and software used.

9.2 Data collection, entry, storage and analysis

9.2.1 Data collection

The following data collection protocol is recommended:

1. Field data collection should, as far as possible, follow existing Countryside Survey methodologies. Where *comparable* data are collected (e.g. surrounding land use information) this should be fully compatible with CS information in terms of method of collection, form of data (e.g. entry codes) and quality.

2. *Additional* survey information should be entered on a *simple, well-structured* survey sheet.

3. Data could potentially be entered onto field sheets or straight into hand-held data loggers. However, it is unlikely that there is sufficient time to specifically customise data logger software for the approaching field season.

4. Quality assurance (QA) will be critical to ensure high, consistent quality of survey results. This is discussed further below.

9.2.2 Quality assurance

The quality assurance measures which have been undertaken in previous Countryside Surveys and related work should also be included in Pond Survey 1996. These include:

1. Pre-survey

- Use of qualified survey staff, field tested at interview to ensure ability.
- A field training course (ca. 5 days duration).
- Provision of a field hand book detailing survey methodologies.
- Use of an internal appraisal document.
- Development of training and survey methods would also be informed through assessment of surveyors' recommendations from earlier surveys and consultant's recommendations from previous QA exercises.

2. During survey

Quality assurance during the survey should consist of:

- Mixing survey teams to complement abilities
- Supervision/expertise available at each ITE site
- Field supervision and checking
- Desk-checks of recording sheets
- Newsletter

3. Post-survey

Quality assurance post-survey should consist of:

- Co-ordinator's feedback session
- Partial repeat survey by management team
- External checking of data recording forms

9.2.3 Data entry, storage and analysis

Data storage and analysis will require use of hardware and software compatible with existing ITE data bases i.e. a Geographical Information System compatible with ARC/INFO and access to ORACLE data bases (see Barr *et al.*, 1993).

Data processing is likely to involve:

- digitising of the mapped linework onto GIS
- computer entry of the codes to describe mapped features and database storage.

Data validation is essential and should entail at least; double punching of data, routine logical checks and on-screen visual checks.

Analysis of mapped information will require manipulation and analysis using the overlay facilities of ARC/INFO and its links with ORACLE databases.

Data analysis is likely to include investigations of reasons for existing quality or change using regression, correlation and multivariate techniques such as CANOCO.

Pond Survey 1996 analyses could potentially include the following:

- Data describing the number of ponds in Britain - counts (including extrapolation using Land Class data).
- Pond loss/gain trends - by comparing Pond Survey 1996 results with other Countryside Survey data.
- The existing ecological quality of ponds - by comparing Pond Survey 1996 data with the results of ponds in the National Pond Survey database.
- An indication of reasons for pond loss - by, for example, correlating environmental data with pond loss data between, or within, Land Classes.

- Reasons for existing ecological and landscape (and potentially amenity) value - by correlating environmental variables with biotic or landscape variables.

Other analyses, such as the reasons for change in ecological, landscape, historical or amenity value, require the gathering of survey data in future years.

9.3. Data presentation

The Countryside Survey Project is intended to provide datasets which are widely available to appropriate agencies with an interest in rural land-use.

Data from the survey therefore needs to be provided in at least the following forms:

- A written report describing survey results and summarised data.
- Raw data available on databases for other agencies[*1]
- Computer-based data, summarised within the format of the Countryside Information System.

9.3.1 Written report

A written report is the most appropriate vehicle in which to describe survey methods and results. Summarised data and analytical results can be presented in tables and appendices as appropriate.

Pond Survey 1996 report could potentially include the results of the analyses outlined in section 9.2.3 above.

User access to data collected during Pond Survey 1996 could be provided at two levels: direct access to the survey database[*1] or through the provision of interpreted summary results. Precise details would depend on user needs for information and their existing systems for data storage and retrieval.

9.3.2 Survey database

Database survey results could be relatively simply provided as a spreadsheet, or more likely given the complexity of the data, a relational database. Depending upon the likely interrogative and analytical skills of users it might be appropriate to provide an interface for users of the database, perhaps using a complete database package, such as Microsoft Access, or a query tool, such as Andyne GQL.

[*1] Note that the precise location of the survey squares used for Pond Survey 1996 and other Countryside Surveys is confidential, and this confidentiality needs to be maintained as far as it relates to the availability of raw data.

9.3.3 Interpreted Results (e.g. CIS)

Computer-based data, summarised within the format of the Countryside Information System (CIS), have the potential to provide a more accessible format for presenting the results of Pond Survey 1996.

CIS is a computer program designed to be used alongside other software in the standard Windows environment allowing interrogation and presentation of information about the British countryside. Information in CIS is summarised at 1 km square resolution and CIS data files may be based on:

- the Easting and Northing for a 1 km square - CIS region file
- the ITE Land Class mean and variance - CIS sample file
- the Easting and Northing and a data value - CIS census file.

CIS has the ability to integrate information collected during a sample survey with 'census' type data. Conversion of information not in CIS format is possible and a number of utilities are available to facilitate this.

CIS is the medium through which policy advisors in the Department of the Environment gain access to the results of the ITE Countryside Surveys. Support in the use of CIS and interpretation of data is currently being provided to the Department through a contract with ITE. NRA were involved in the evaluation of CIS prototypes and setting the specifications for the final system.

Using CIS, data from Pond Survey 1996 could be compared with ITE Countryside Surveys and other information about the British countryside such as National Farm Type or Urban Areas. Suitable output from Pond Survey 1996 might include the number and size of ponds or data on water quality and species abundance. In addition to data files, full definitions and descriptions of survey methodology and accuracy could be provided for the Environmental catalogue and CIS Supplementary Menu.

10. SURVEY OPTIONS AND RECOMMENDATIONS

This chapter summarises the main options and recommendations made in the report. Where appropriate, two levels of survey are described:

Level 1: the work to provide a screening level survey which should enable general trends in pond quality or number to be identified.

Level 2: a more detailed level of investigation which should achieve all the stated objectives of Pond Survey 1996.

The implications of choosing screening level options are discussed. A summary of Level 1 and 2 survey options is given in Table 10.1.

10.1 Pond definition

The recommended definition of a pond for Pond Survey 1996 is:

> *'a body of standing water 25m² - 2ha in area, which usually holds water for more than four months of the year'.*

To use this definition, however, requires a more detailed (i.e. Level 2) survey which includes two site visits (spring and summer) to count all ponds - temporary and permanent.

If only a Level 1 (summer) survey is possible, the definition needs to be modified to reflect this i.e. it should become:

> *'a body of standing water 25m² - 2ha in area'.*

The implication here is that the waterbody held water at the time of the survey only.

The difference between Level 1 and Level 2 surveys

If a spring survey is not possible, information which cannot be collected includes:

- counts of temporary ponds (a vulnerable and ecologically important habitat);
- counts of the *total* number of ponds (permanent, semi-permanent and temporary); and,
- greater understanding of the pond loss process, including the likely effects of potential impacts such as climate change.

An intermediate option would be to undertake a trial sub-sample of ponds in winter/spring to provide an indication of the status of temporary ponds and their abundance in comparison with permanent waterbodies.

10.2 Pond outer boundary

If *detailed* long term monitoring of ponds is envisaged (e.g. to investigate reasons for pond loss or changes in ecological status), it would be valuable to re-map the outer boundary of all ponds. A Level 2 assessment, would include the use of vegetation criteria to produce a consistent baseline from which to monitor future change.

A Level 1 survey which simply uses existing map-based outlines is likely to be a satisfactory solution however, if data are only required to assess changes in pond size between the existing ITE size categories.

10.3 New ponds

Pond Survey 1996 needs an accurate assessment of the number of new ponds created in order to estimate changes in total pond numbers between years.

A Level 2 survey would entail re-surveying all existing 1 km squares visited in 1984 and 1990, plus an additional stratified sample to reflect variations in pond density, or areas of interest (lowland farmland or ESAs, for example). This could be undertaken using field and/or questionnaire surveys. However a site visit will almost inevitably be necessary to gain accurate data about the size and precise location of new ponds.

A questionnaire survey is likely to be the best source of information for identifying the *reasons* for creating ponds.

60% of survey squares in 1990 did not support ponds and for a screening (Level 1) survey it would be possible to visit only a *subset* of these non-pond squares (surveyed either by a field visit or questionnaire). The effect of visiting fewer squares would, however, be to increase the variability of estimates of numbers of new ponds. This would, in turn, widen the confidence limits for estimates of net pond loss/gain. Overall, therefore, this is not a recommended option.

10.4 Pond Loss

Monitoring pond loss
The ideal approach to monitoring pond loss in Countryside Surveys is to make two visits (winter/spring and summer) and from this, describe the number of temporary, semi-permanent and permanent ponds *as a temporal trend over a number of years.*

The Level 1 alternative is to assess only permanent and semi-permanent ponds, using a single summer survey visit which records the number of 'ponds containing water'. Changes in the numbers of these ponds would, again, be described as a temporal trend over a number of years.

Reasons for pond loss
Pond loss is a complex process and may be influenced by a number of factors. A detailed Level 2 protocol to achieve all the stated project objectives requires:

1. Installation of gauge boards to monitor water levels and sediment depths in ponds.
2. Environmental measurements (e.g. surrounding land use, tree cover, sediment depths, presence of inflow) to provide evidence of factors which may be causing loss.

In the future years this data can therefore be used:

- to investigate the main causes of pond loss by analysing water level measurements and environmental data;
- to indicate ponds where follow-up information might be useful by analysing anomalies in water and sediment levels; and,
- to predict the future rate of infill of ponds by analysing information on sediment accumulation and pond depth.

Further analysis would be required to separate out the effects of impacts such as climate change, abstraction and drainage. The results could, for example, be used to look at the effect of changes in landuse or schemes such as ESAs.

A less detailed (Level 1) protocol, would entail an investigation of the (statistical) relationship between pond loss and surrounding land use. Such an analysis would only require standard environmental information gathered for previous Countryside Surveys (e.g. surrounding land use, tree cover, sediment depths, presence of inflow).

10.5 Ecological quality of ponds

A Level 2 survey which can be used to assess both the current ecological value of ponds *and* the future changes in value would ideally include surveys of a number of taxa, including aquatic plants (macrophytes and diatoms), aquatic macroinvertebrates and amphibians.

In addition a range of physical and chemical variables (depth, sediment type, surrounding land use, proximity of surrounding waterbodies) need to be monitored to provide information on environmental factors which may be responsible for changes in ecological value. Water chemistry would ideally be monitored in winter/spring (or throughout the year), to obtain reliable phosphate and nitrate data, and samples analysed in a NAMAS accredited laboratory.

Assessment of existing quality and future change would be made using a number of community parameters (species richness, species rarity and community type), with classification and assessment by comparison with undisturbed sites using the National Pond Survey dataset.

Level 1 option
Undertaking a good assessment of the ecological quality of ponds is time consuming and the identification of many taxa requires considerable experience and skill. The Level 1 option takes account of the likely skills of fieldworkers which could be employed to undertake the survey.

Plant surveys, and collection of physical data and chemical samples, could be relatively easily undertaken by trained Countryside Survey staff, who have good botanical ability. However, field collection, sorting and identification of invertebrates or diatoms, even to family level, requires considerable experience. In the 3 - 5 day period used to train Countryside Survey field staff it would not be possible for either of these groups to be surveyed reliably.

Collection of amphibian data (e.g. egg searches) would be possible during a spring survey (if undertaken) but due to latitude-related differences in amphibian egg-laying times it is unlikely that consistent results could be obtained across Britain.

A Level 1 survey, which provided a thorough plant survey, is likely to give adequate screening-level data for assessment of *pond quality*, especially where a number of community measures are made (e.g. species richness and rarity of marginal and aquatic plants analysed together or separately).

Investigations of the relationships between additional physical variables and chemical variables derived from field test kits could also provide an indication of the environmental *influences* on plant community quality. Wetland plants have, however a number of drawbacks for accurately assessing environmental *change* and, although they can be used for this purpose, are not an ideal group for monitoring long term trends in the ecological quality of ponds.

Additional options for ecological survey work include collaboration with other projects or postponement of ecological assessment until the results of these projects become available (see Section 10.12).

10.6 Landscape value

The Level 1 option for landscape assessment comprises a description of the micro landscape characteristics of the pond and its banks using a simple structured field survey form.

Further (Level 2) evaluation could be undertaken using professional judgement criteria either pre or post-field survey. Assessment of the wider landscape could also be relatively easily assessed - using ITE Countryside Survey codes to describe the surrounds within a specified (e.g. 100m) distance from the pond.

10.7 Historical value

A Level 1 historical assessment would aim to check each 1 km survey square for the occurrence of survey ponds on national, county and district databases.

More detailed Level 2 assessment would provide information which could indicate a pond likely to be of local historical value. This would require an assessment of contemporary maps using field survey staff who had been given basic skills in historical interpretation during the pre-survey training period.

A brief landowner questionnaire would be a valuable addition, especially if a questionnaire survey is considered for other aspects of the project.

A map and document desk study and/or field investigation of pond sites by professional archaeologists would undoubtedly provide considerable additional information, but may not be feasible within the budget of Pond Survey 1996.

10.8 Amenity value

A rapid field assessment using a structured field sheet would allow an estimate to be made of the likely informal amenity value of a pond. It would also give some indication of formal amenity uses, such as fishing.

For a more detailed (Level 2) survey, an additional questionnaire survey to landowners would increase the level of information detailing the use and value of the ponds.

10.9 Survey strategy within 1 km squares

For Pond Survey 1996 to fully assess pond numbers in the countryside, a Level 2 survey should include areas of curtilage together with full surveys of woodland areas. A full survey of urban areas is likely to be impractical for the survey as a whole, but a sub survey of urban squares might be feasible.

It is recommended that Level 1 assessment should at least include full surveys of golf courses and woodlands.

10.10 General survey strategy

A Level 2 survey strategy to fulfil all requirements of Pond Survey 1996 would entail a re-survey of the 508 1 km survey squares visited in CS1990 plus an additional targeted sample placed to improve confidence limits for analyses which are of specific interest e.g.:

- A small number of additional squares in areas such as Cheshire and East Anglia to adequately reflect areas which other surveys have indicated are of unusually high pond density.

- Additional squares in the 'upland' Land Classes to reduce standard errors in areas which previous Countryside Surveys have indicated are more heterogeneous (which would, in turn, increase confidence limits for the data set as a whole).

- Additional squares to allow greater analytical resolution for particular administrative areas (for example further squares on Land Class 17 to improve analyses for, and within, Wales).

- Additional squares placed in lowland Land Classes to facilitate analyses of the impacts of specific agricultural practices, or enhancement schemes such as ESA.

The Level 1 option would be to re-survey the 384 squares visited in both 1984 and 1990, or alternatively, the 153 squares with inland waterbodies present in 1984 and 1990, with a sub-sample of the additional non-pond squares.

10.11 Maximising the efficiency of Pond Survey 1996

It is evident from the summary above that there may be opportunities to combine areas of survey work and to maximise survey efficiency. For example:

Land-use data and amenity value questionnaires
Assessments of surrounding land use could potentially be used for assessment of landscape value and as environmental correlates for assessments of ecological value and reasons for pond loss. Similarly if a questionnaire survey is to be undertaken to assess the formal amenity value of ponds, then a limited number of additional survey questions might also be possible to investigate the historic importance of ponds, or reasons for pond creation.

Efficient utilisation of the time of the survey teams
A large proportion of the resources for field survey are spent simply getting a survey team to a site. Once there, it is unlikely that each survey pair will be able to survey more than one square in a day (unless there are no ponds present). Previous experience from the Countryside Survey has shown that it is very inefficient to 'finish early' and start another square. In effect, the best use of time is to spend a whole day (or multiples of whole days) in each 1 km square.

This suggests that, once the survey teams are on site they should gather as much detailed information about the square as is possible in the day. On average, about 4 hours pond survey work would be possible, with the remainder of the time left to gain access and undertake transects across the square to search for new ponds.

With training and some experience it is likely that up to two medium-sized field ponds in one survey square might be surveyed per day including:

- a plant list for each pond compiled by undertaking a marginal survey and throwing a grapnel into deeper water.
- completion of a field survey sheet giving information relating to the pond and its surrounds (depth, sediment type, basic kit chemistry etc.).
- compilation of extra field survey information relating to amenity, history etc. (as appropriate).
- updating of existing data on the Countryside Survey base sheet (e.g. land use codes).

Extra time would be required for larger ponds where a boat will be necessary.

In the 'non-pond' squares survey teams should be able to complete the survey of squares more quickly. It seems likely that each field team should be able to complete search transects for two 'non-pond' squares per day, especially in the lowlands.

10.12 Integration with other projects

There may be opportunities for collaboration with other survey projects which could provide additional data to the Pond Survey 1996 which might not otherwise be collected.

Opportunities for collaboration with two projects could be explored further: the Environment Agency project "Biological techniques of still water quality assessment" and the NERC ROPA project which is extending the National Pond Survey database.

1. Environment Agency project "Biological techniques of still water quality assessment"

This Environment Agency project is likely to include field validation and testing of biological survey methods. Field work is likely to be undertaken between 1996 and 1998.

Further discussions with the Project Steering Group about potential interactions with Pond Survey 1996 may be appropriate.

2. NERC ROPA extension to NPS

The NERC ROPA project work will involve standard NPS level surveys of ponds at 200 sites in the 'wider countryside' (i.e. sites of all qualities) to complement the high quality sites of the NPS. Approximately 100 sites will be surveyed in 1996 and 100 in 1997, mainly in lowland agricultural areas.

Some sites for the NERC ROPA project could, in theory, be located in PS1996 squares, perhaps helping to increase the sample sizes or to collect data which is costly and which can only be collected by experienced staff.

Table 10.1 Summary of survey options

Aspect of survey	Level 1: General trends survey	Level 2: Detailed survey
Pond definition	• 'a body of standing water 25m² - 2ha in area' • Survey ponds in mid summer only (dates compatible with Countryside Surveys)	• 'a body of standing water 25m² - 2ha in area, which usually holds water for more than four months of the year' • Survey ponds in early spring and mid summer
Pond outer boundary	• Use existing map-based outlines as the basis for identifying change	• Re-map the outer pond boundary using vegetation criteria
New ponds	• Survey all squares which supported ponds in either 1984 or 1990 plus a sub sample of the previously pondless squares	• Field survey of all existing 1 km squares surveyed in 1984, and 1990, plus all the previously pondless squares • Questionnaire survey to identify the reasons for creating new ponds
Pond loss	• Record only ponds that are wet in summer. Analyse as temporal trend	• Analysis of pond loss in both temporary and permanent categories as a temporal trend
Reasons for pond loss	• Correlate all pond loss data (1984 to 1996) with existing data available e.g. surrounding landuse	• Set up a monitoring project including gauge boards etc. • Monitor water level and sediment change and correlate with environmental variables
Ecological value	• Survey wetland plants and a wide range of physical environmental variables as part of the main field survey • Assess quality in terms of species richness and rarity • Assess site quality by internal ranking	• Survey wetland plants and a wide range of physical environmental variables as part of the main field survey • Survey invertebrates and amphibians using professional staff • Survey water chemistry in winter/spring with NAMAS accredited lab. analysis • Assess quality in terms of species richness, species rarity and community type • Analyse and assess quality within the National Pond Survey classification
Landscape value	• Assess micro landscape using general assessment sheets	• Assess micro landscape using general assessment sheets • Evaluate micro landscape using professional judgement criteria • Assess macro pond landscape using simple land use descriptions e.g. ITE Countryside Survey codes
Historical value	• Check 1 km squares on national, county and district databases	• Check 1 km squares on national, county and district databases • Assess contemporary map evidence • Quick assessment of site evidence by field surveyor • Landowner questionnaire • Map and document desk study
Amenity value	• Field assessment using a structured field sheet	• Field assessment using a structured field sheet • Landowner questionnaire
Within-square sampling strategy	• Survey golf courses and fully survey woodlands	• Survey areas of curtilage. Fully survey areas of woodland. Sub-sample urban areas
Broad sampling strategy	• Re-survey 1 km squares visited in both 1984 and 1990	• Re-survey all 1 km survey squares visited in 1984 and 1990 plus additional targeted squares placed to increase confidence limits in areas of specific interest

11. REFERENCES

Aberg, F.A. (ed.) (1978). *Medieval moated sites.* CBA research report, 17, Council for British Archaeology, London.

Adamowicz, V., Garrod, G. and Willis, K. (1994). *Public perceptions and valuation of waterways.* CRE (Centre for Rural Economy) Dept. of Agricultural Economics and Food Marketing, University of Newcastle upon Tyne.

Allen, R.E. (ed.) (1990). *Concise Oxford dictionary of current English.* Clarendon Press, Oxford.

Ashworth, W, (1991). *The encyclopaedia of environmental studies.* Facts on File, New York.

Barnes, L.E. (1983). The colonization of ball-clay ponds by macroinvertebrates and macrophytes. *Freshwater Biology*, **13**, 561-578.

Barr, C.J., Ball, D.F., Bunce, R.G.H. and Whittaker, H.A. (1985). *Rural land use and landscape change.* Annual report of the Institute of Terrestrial Ecology 1984,133-135.

Barr, C.J., Bunce, R.G.H., Clarke, R.T., Fuller, R.M., Furse, M.T., Gillespie, M.K., Groom, G.B., Hallam, C.J., Hornung, M., Howard, D.C. and Ness, M.J. (1993). *Countryside Survey 1990 main report.* Countryside 1990 Series Volume 2. Department of the Environment, London.

Barr, C.J., Howard, D.C. and Benefield, C.B. (1994a). *Countryside Survey 1990. Inland water bodies.* Countryside 1990 Series Volume 6. Department of the Environment, London.

Barr. C.J., Gillespie, M.K. and Howard, D.C. (1994b). *Hedgerow Survey 1993: stock and change estimates of hedgerow length in England and Wales 1990-1993.* Institute of Terrestrial Ecology, Grange-over-Sands

Bateman, I., Willis, K., and Garrod, G. (1994). Consistency between contingent valuation estimates: a comparison of two studies of UK National Parks. *Regional Studies* **28**, 457-474.

Beebee, T.J.C. (1991). *Pondlife.* Whittet Books, London.

Bevercombe, A.M., Cox, N., Thomas, M.P. and Young, J.O. (1973). Studies of the invertebrate fauna of a wet slack in a sand dune system. *Archiv fur Hydrobiologie*, **71**, 487-516.

Biggs, J., Corfield, A., Walker, D., Whitfield, M. and Williams, P. (1995). The importance of ponds for wildlife. In *Protecting Britain's ponds* (ed. Biggs, J. and Aistrop, C.), Pond Action, Oxford and the Wildfowl & Wetland Trust, Slimbridge.

Biggs, J., Corfield, A., Walker, D., Whitfield, M. and Williams, P. (1994). New approaches to the management of ponds. *British Wildlife,* **5**, 273-287.

Bishop, I.D. and Hulse, D.W. (1994). Prediction of scenic beauty using mapped data and geographic information systems. *Landscape and Urban Planning*, 59-70.

Blankson, E.J. and Green, B.H. (1991). Use of landscape classification as an essential prerequisite to landscape evaluation. *Landscape and Urban Planning*, 149-162.

Bratton, J.H. (1990). *A review of the scarcer Ephemeroptera and Plecoptera of Great Britain.* Research and survey in nature conservation No. 29. Nature Conservancy Council.

Brian, A.D., Price, P.S., Redwood, B.C. and Wheeler, E. (1987). The flora of the marl-pits (ponds) in one Cheshire parish. *Watsonia*, **16**, 417-426.

Briggs, D. J. and France , J. (1981). Assessing landscape attractiveness: a South Yorkshire Study. *Landscape Research*, **6**, 2-5.

British Waterways (1992). *Rudyard Lake Visitor Survey.* Research Paper No 72.

British Waterways (1993). *Informal visitors to waterway towing paths.*

British Waterways (1993a). *Angling club survey (draft and top copy).*

British Waterways (1994). *Bingley Locks Visitor Survey.* Research Paper No 75.

Brooke, D. (1994). A Countryside Character programme. *Landscape Research* **19**, 128-132.

Brooks, S.J. (1993). Review of methods used to monitor adult dragonfly populations. *Journal of the British Dragonfly Society*, **9**, 1-4.

Brown, A.L. (1971). *Ecology of fresh water.* Heinemann Educational Books.

Bunce, R.G.H., Barr, C.J. and Whittaker, H.A. (1983). A stratification system for ecological sampling. In: *Ecological mapping from ground, air and space*, (ed. Fuller, R.M.), pp. 39-46 (ITE symposium no 10.) Cambridge: Institute of Terrestrial Ecology.

Burgis, M.J. and Morris, P. (1987). *The natural history of lakes.* Cambridge University Press, Cambridge.

Charles, D.F. and Smol, J.P. (1994). Long-term chemical changes in lakes - quantitative inferences from biotic remains in the sediment record. *Advances in Chemistry Series*, **237**, 3-31.

Clegg, J. (1974). *Freshwater Life.* F. Warne, London.

Coker, R.E. (1968). *Streams, lakes, ponds.* Harper and Row, New York.

Collinson, N.H., Biggs, J., Corfield, A., Hodson, M.J., Walker, D., Whitfield, M. and Williams, P.J. (1995).Temporary and permanent ponds: an assessment of the effects of drying out on the conservation value of aquatic macroinvertebrate communities. *Biological Conservation*, **74**, 125-134.

Countryside Commission (1988). *A review of recent practice and research in landscape assessment.* CCD 25, Countryside Commission, Cheltenham.

Countryside Commission (1991). *Assessment of conservation and landscape character. The Warwickshire Landscape Project Approach.* CCP 332, Countryside Commission, Cheltenham.

Countryside Commission (1993). *Landscape Assessment Guide.* CCP 423, Countryside Commission, Northampton.

Countryside Commission (1994). *Quality of countryside: quality of life.* CCP 470, Countryside Commission, Northampton.

Cowardin, L.M. and Golet, F.C. (1995). US Fish and Wildlife Service 1979 wetland classification: a review. In *Classification and inventory of the worlds wetlands* (Finlayson, C.M. and van der Valk, A.G.). Kluwer Academic Publishers, Dordrecht.

Currie C. K. (1990). Fishponds as garden features, c. 1550-1750. *Garden History*, **19**, 22-46.

Day, P. (1981). *Ponds (marl pits) in the Lower Dee Valley of Clwyd - a preliminary appraisal.* Nature Conservancy Council.

Easton, J.R. (1990). *An assessment of the conservation potential of forest fire ponds.* Department of Biological Sciences, The University of Durham.

Elton, C.S. and Miller, R.S. (1954). The ecological survey of animal communities: with a practical system of classifying habitats by structural characters. *Journal of Ecology*, **42**, 460-496.

Fines, K. D. (1968). Landscape Evaluation: a research project in East Sussex. *Regional Studies*, **2**, 42-55.

Finlayson, M. and Moser, M. (eds.) (1991). *Wetlands.* International Waterfowl and Wetland Research Bureau. Facts on File Ltd, Oxford.

Fitter, R. and Manuel, R. (1986). *A guide to the freshwater life of Britain and north-west Europe.* Collins, London.

Flower R. J. and Beebee, T. J. C. (1982). *The recent palaeolimnology of Woolmer Pond, Hampshire, with special reference to the documentary history and distribution of the Natterjack toad, Bufo calamita L.* Report to the Nature Conservancy Council (NCC) by ENSIS Ltd.

Fojt, W. (1994). The conservation of British fens. *British Wildlife*, **5 (6)** 355-366.

Foster, G.N. and Eyre, M.D. (1992). *Classification and ranking of water beetles communities.* UK Nature Conservation, 1. Joint Nature Conservation Committee, Peterborough.

Foster, G.N., Nelson, H.H., Bilton, D.T., Lott, D.A., Merritt, R., Weyl, R.S. and Eyre, M.D. (1992). A classification and evaluation of Irish water beetle assemblages. *Aquatic conservation-marine and freshwater ecosystems*, **2**,185-208.

Friday, L.E. (1987). The diversity of macroinvertebrate and macrophyte communities in ponds. *Freshwater Biology* **18**, 87-104.

Fryer, G. (1985). Crustacean diversity in relation to the size of waterbodies: some facts and problems. *Freshwater Biology* **15**, 347-361.

Fryer, G. (1993). *The freshwater Crustacea of Yorkshire.* Titus Wilson and son, Kendal.

Gee, J.H.R. and Smith, B.D. (1995). *The conservation value of farm ponds: macroinvertebrates.* Contract Science Report, 127. Countryside Council for Wales

Gee, J.H.R., Lee, K. and Wyn Griffiths, S. (1994). *The conservation and amenity value of Farm Ponds*. Contract Science Report, 44. Countryside Council for Wales.

Gray, J. (1988). Evolution of the freshwater ecosystem: the fossil record. Palaeogeography, Palaeoclimatology, *Palaeoecology*, **62**, 1-214

Haworth, E.Y., Atkinson, K.M. and Carrick, T.R. (1988). *The preliminary assessment of diatom distribution in the waterbodies of Cumbria, North-West England.* 10th Diatom-Symposium 1988.

HCC (1987). *Report of the Hertfordshire Pond Survey 1986, 1987.* Hertfordshire County Council.

Helliwell, D.R. (1983). The conservation value of areas of different size: Worcestershire ponds. *Journal of Environmental Management* **17**, 179-184.

Horne, A.J. and Goldman, C.R. (1994).

Jeffries, M. and Mills, D. (1990). *Freshwater ecology, principles and applications.* Belhaven, London.

Johnes, P., Moss, B. and Phillips, G. (1994). *Lakes - classification and monitoring, a strategy for the classification of lakes.* R&D Project Record 286/6/A. NRA, Bristol.

Kabisch, K. and Hemmerling, J. (1984). *Ponds and pools: oases in the landscape.* Croom Helm, London.

Kirby, P. (1992). *Habitat management for invertebrates: a practical handbook.* RSPB/JNCC/National Power, Sandy.

Lassiere, O. (1993). *Central region lochs and ponds - The Operation Brightwater survey of their status; past, present and future.* Department of Biological and Molecular Sciences, University of Stirling.

LCC (1995). *Biological Heritage Sites, Draft Guidelines for Site Selection.* Lancashire County Council, Lancashire Wildlife Trust, English Nature.

Lowenthal, D. (1978). Finding valued landscapes. *Progress in Human Geography,* **2**, 373-418.

Macan, T.T. (1973). *Ponds and lakes.* George Allen & Unwin Ltd, London.

Macan, T.T. and. Worthington, E.B (1974). *Life in lakes and rivers.* Collins, London.

MAFF (1985). *Survey of environmental topics on farms, England and Wales: 1985.* Prepared by the Government Statistical Service.

McCartney, P. (1990). *Ponds in Cornwall.* A report to the National Rivers Authority.

Mitsch, W. J. and Gosselink, J.G. (1993). *Wetlands.* Van Nostrand Reinhold, New York.

Moore, N.W. and Corbet, P.S. (1990). Guidelines for monitoring dragonfly populations. *Journal of the British Dragonfly Society,* **6**, 21-23.

Morgan, A.H. (1930). *Field book of ponds and streams, an introduction to the life of fresh water.* Putnam, London.

Moss, B. (1988). *Ecology of fresh waters. Man and medium.* Blackwell Scientific Publications, Oxford.

NOP Market Research Ltd (1986). *The British Waterways System - Leisure and tourism usage and perception.* A report prepared for British Waterways Board, Leisure Division.

NRA (1993a). *River landscape assessment.* Conservation Technical Handbook No 2. National Rivers Authority, Bristol.

NRA (1993b). *Ponds and conservation. A rough guide to pond restoraion and creation.* National Rivers Authority, Bristol.

PA (1994a). *The Oxfordshire Pond Survey.* Pond Action, Oxford.

PA (1994b). *The National Pond Survey: 1989-1993.* Interim report to the World Wide Fund for Nature. Pond Action, Oxford.

Palmer, M. (1981). Relationship between species richness of macrophytes and insects in some water bodies in the Norfolk Breckland. *Entomologist's Monthly Magazine.* **117**, 35-46.

Palmer, M. (1989). *A botanical classification of standing waters in Great Britain.* Research and survey in nature conservation No. 19, Joint Nature Conservation Committee, Peterborough.

Palmer, M.A., Bell, S.L., and Butterfield, I. (1992). A botanical classification of standing waters in Britain. Applications for conservation and monitoring. *Aquatic Conservation-Marine And Freshwater Ecosystems*, **2**,125-143.

PCG (1993). *A future for Britain's ponds. An agenda for action.* Pond Conservation Group, Oxford.

Penning-Rowsell, E. C. (1982). A public preference evaluation of landscape Quality. *Regional Studies.* **16**, 97-112.

Penning-Rowsell, E.C. (1981). Assessing the validity of landscape evaluations. *Landscape Research*, **6**, 22-24.

Pfannkuch, H.O. (1969). *Elsevier's dictionary of hydrogeology in three languages: English, French, German, compiled and arranged on an English alphabetical basis by Hans Olaf Pfannkuch.* Elsevier, Amsterdam.

Pontin, R.M. and Langley, J.M. (1993). The use of rotifer communities to provide a preliminary national classification of small water bodies in England. *Hydrobiologia* **255/256**, 411-419.

Porter, V. (1988). *The pond book.* Christopher Helm, London.

Preece, R. A. (1980). *An evaluation by the general public of scenic quality in the Cotswold AONB. A basis for monitoring future change.* Working Paper 48, Oxford Polytechnic.

Probert, C. D. (1989). *Pearls in the landscape: the conservation and management of ponds.* Farming Press, Ipswich.

Rackham, O. (1986). *The history of the countryside.* Dent, London.

Shafer, E. L. and Brush, R. (1977). How to measure preferences for photographs of natural landscapes. *Landscape Planning* **4**, 237-256.

Shuttleworth, S. (1984). Consensus and perception of Landscape Quality. *Landscape Research* **9**, 17-22.

Simpson, J.A and Weiner, E.S.C. (1989). *The Oxford English dictionary.* Clarendon Press, Oxford, 1989

Sterry, P. (1992). *Rivers and ponds.* Hamlyn, London, 1992

Swan, M.J.S. and Oldham, R.S. (1989) *Amphibian communities.* Final Report. Nature Conservancy Council, Peterborough.

Swan, M.J.S. and Oldham, R.S. (1993). *Herptile sites. Volume 1: National Amphibian Survey Final Report*. English Nature Research Reports, 38. English Nature, Peterborough.

Sweeting, R.A., Lowson, D. and Wright, J.F. (1992). 1990 biological assessment of rivers in the UK. In *River water quality ecological assessment and control* (ed. Newman, P.J., Piavaux, M.A. and Sweeting, R.A.). Commission of the European Communities, Brussels.

Walker, D. (1994) *Differences in community structure between fenced and unfenced dewponds.* School of Biological Sciences, University of Sussex.

Ward, J.V. (1992). *Aquatic insect ecology. 1. Biology and habitat.* John Wiley and Sons, Inc., New York.

Waring, R.D. (1991) *The use of aquatic Coleoptera (water beetles) as indicators of pond macroinvertebrate communities.* Division of Environmental and Earth Sciences, Hatfield Polytechnic.

Welch, P.S. (1952). *Limnology*. McGraw-Hill, New York.

Williams, D.D. and Feltmate, B.W. (1992). *Aquatic insects.* CAB International, Wallingford.

Williams, W.D. (1983). *Life in inland waters.* Blackwell Scientific Publications, Melbourne.

Wright, J.F., Moss, D. and Furse, M.T. (1996). *Macroinvertebrate richness at running water sites in Great Britain: a comparison of species and family richness.* Verh. int. Ver. Limnol. in press.

APPENDICES

Appendix 1 Attributes from the 1984 and 1990 Countryside Surveys which were used in analysis of waterbody data

Waterbody features distinguished during field surveys in 1984 and 1990

1984	1990
Lake natural	Lake/pond natural
Lake artificial	Lake/pond artificial
Pond (<1ha) natural	-
Pond Artificial	-
Aquatic macrophytes	Aquatic macrophytes
Aquatic marginal vegetation	Aquatic marginal vegetation

Waterbody size categories used in analysis

A	<400m^2	(0.04ha)
B	401m^2 - 2,000m^2	(0.04-0.2ha)
C	2,001m^2 - 10,000m^2	(0.2-1.0ha)
D	10,001m^2 - 50,000m^2	(1.0-5.0ha)
E	50,001m^2 - 1,000,000m^2	(5.0-100.0ha)

Land use (context in which each waterbody was described)

Enclosed land
- Arable
- Pasture
- Mixed

Forestry/woodland
Other

Where change had taken place between 1984 and 1990, individual waterbodies were analysed in terms of the type of change that had taken place as follows:

- Water body created
- Water body enlarged
- Water body filled in or removed completely
- Water body reduced by growth of marginal vegetation
- Water body dried out
- Water body decreased in size - including seasonal drying out
- Water body no longer present

Appendix 2 Definitions of ponds and other waterbodies

A2.1 Ponds

It is difficult (if not impossible) to define a pond.	
"....in general, no scientific distinction can be made [between ponds and lakes]."	Macan and Worthington, 1972.
"There is no satisfactory definition of a pond for the term covers such a wide variety of freshwater habitats."	Clegg, 1974
"No firm boundaries exist between the various sorts of standing water...."	Williams, 1983.
"There is no point at which a definitive line can be drawn between a pond and a lake or even between a puddle and a pond."	Fitter and Manuel, 1986.
"....it is impossible to provide a precise, technical difference."	Jeffries and Mills, 1990.
"....it is probably better to think of ponds as a special class of lakes than as something separate."	Ashworth, 1991.

Ponds are small and shallow	
"....lakes of slight depth."	Forel, 1892 (in Horne and Goldman, 1994)
"A body of standing water that is smaller than a lake." "....bodies of water small enough that a rainstorm will significantly change the water chemistry...."	Ashworth, 1991.
"A small body of still water of artificial formation, its bed being either hollowed out of the soil or formed by embanking and damming up a natural hollow.	Simpson and Weiner, 1989.
"A fairly small body of still water formed naturally or by hollowing or embanking."	Allen, 1990.
A smaller version of lakes.	Moss, 1988.
"A pond is a small freshwater lake". "....ponds are shallow enough to allow light to penetrate to most of their depths."	Porter, 1988.

Ponds are shallow enough for rooted plants to grow throughout	
"....a body of water which is so shallow that rooted plants can grow all the way across it."	Morgan, 1930.
"....very small, shallow bodies of standing water in which the relatively quiet water and extensive plant occupancy are common characteristics."	Welch, 1952
"A pond can be described as a body of still water which is sufficiently shallow to enable attached water plants to grow all over it. This cannot hold true for all ponds...."	Brown, 1971.
"....they are small bodies of shallow, stagnant water, usually well supplied with aquatic plants."	Clegg,, 1974.

Continued.

"....small bodies of freshwater, shallow enough for vegetation to grow across the whole surface area."	Sterry, 1982.
"Ponds are of many kinds but typically are small bodies of shallow, stagnant water in which rooted plants can grow even in the deepest parts."	Clegg, 1974.
"A pond, then, is likely to be a small body of water, shallow enough for plants rooted on the bottom to grow all over it (though this also depends on the clarity of the water) and to ensure a fairly even temperature throughout."	Fitter and Manuel, 1986.
"....shallow, but often thermally stratified waters, with abundant growths of rooted and floating macrophytes."	Horne and Goldman, 1994.

A miscellany of other physical characteristics	
"....a typical pond is virtually a self-contained system, a closed biotope, a world within itself...."	Coker, 1954.
"Ponds are much less stable than lakes. Heavy rain may change completely the water in a pond. In dry weather it may disappear."	Macan, 1973.
Small pond: between the size of a tree-hole and 20 sq. yards (17 sq. m.); Pond: <1 acre (0.4 hectares)	Elton and Miller,
Waterbodies up to a size of about 2000m².	MAFF, 1985.
"....stillwaters no deeper than 3 metres and ranging in size from a few square metres to 0.405 hectares."	Probert, 1989.
"....a pond [is] anything less than 50m (165 feet) or so across...."	Beebee, 1991.
'Ponds' includes water bodies up to 0.5 hectares. Water bodies of 1.5 hectares are called 'large' by Fryer. No upper or lower size limits defined.	Fryer, 1993.
NRA *lake* classification and monitoring refers to water bodies "....greater than about 1ha...." (p2) and "....lakes greater than 2ha." (p13).	Johnes, Moss and Phillips, 1994
"Standing water bodies less than 2 hectares...."	LCC, 1995.

A2.2 Lakes

"A large body of water surrounded by land."	Allen, 1990.
"Lakes are but larger editions of ponds."	Morgan, 1930.
"A body of water [which] must have a barren wave-swept shore."	Welch, 1952.
"A lake is a fairly large body of water".	Macan, 1973.
"A lake is a bulge in a drainage system, where the flow is so slow that certain processes that would not otherwise be possible can take place."	Macan, 1973
"....a sheet of still water lying in a depression of the ground, without direct communication with the sea."	Kabish and Hemmerling 1984
"A lake is a water-filled hollow in the earth's surface, inland from the ocean".	Burgis and Morris 1987
A lake is a large body of still water, often too deep for emergent plants to grow in the middle, and with a marked difference between the temperature of the surface and bottom".	Fitter and Manuel, 1986.
"....lakes are large and deep enough to provide a stable habitat...."	Porter, 1988.
"Any body of standing water on the land. Usually, a lake is larger than a pond, although the distinction between them is by no means hard and fast...."	Ashworth, 1991.
"...large bodies of water surrounded entirely by land...." with "....inflows and outflows connecting them to each other or to rivers."	Williams and Feltmate, 1992.

"....lakes are typically deep enough to have regular wave action, [and] a deep area that never warms up, even in summer...."	Beebee, 1991.
Lake: >100 acres (40 hectares)	Elton and Miller, 1954
The lake classification and monitoring scheme developed for NRA by Johnes, Moss and Phillips refers in some sections to water bodies "....greater than about 1ha...." and in other sections to "....lakes greater than 2ha."	Johnes, Moss and Phillips, 1994

A2.3 Springs

"A place where water....wells up from the earth."	Allen, 1990.
"....share the characteristics of a pond, but as they have an outflow cannot be wholly stagnant."	Fitter and Manuel, 1986
"....a location where water flows out of the earth."	Ashworth, 1991.
"....the smallest of flowing waters."	Kirby, 1992.
"Springs are the sites of emergence of groundwater flowing along an impervious rock stratum...."	Ward, 1992.

A2.4 Flushes

"....share the characteristics of a pond, but as they have an outflow cannot be wholly stagnant."	Fitter and Manuel, 1986

A2.5 Rills

"A very small stream, usually less than 15cm across (6").	Ashworth, 1991.

A2.6 Streams

"A flowing body of water, especially a small river."	Allen, 1990.

A2.7 Rivers

"A copious natural stream of water flowing in a channel to the sea or a lake etc.	Allen, 1990.
"....natural watercourse through which runoff reaches the sea".	Pfannkuch, 1969.
"Rivers and streams....have no scientific definition, except that rivers are usually larger than streams...."	Fitter and Manuel, 1986.
"....larger, faster moving and often warmer [than streams]."	Home and Goldman, 1994.

A2.8 Wetlands

"....lands transitional between terrestrial and aquatic systems, where the water table is usually at or near the surface and the land is covered by shallow water....Wetlands must have one or more of the following attributes: (1) at least periodically the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water during the growing season of each year."	Cowardin and Golet, 1995
".....areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including area of marine water the depth of which at low tide does not exceed six metres."	Finlayson and Moser, 1991.

A2.9 Mires

"A stretch of swampy or boggy ground."	Allen, 1990.
[Europe]. "....any peat accumulating wetland"	Mitsch and Gosselink, 1993.

A2.10 Fens

"A low marshy or flooded area of land."	Allen, 1990.
Mires which receive water and nutrients from the soil, rock and groundwater, as well as from rainfall. Eight types have been identified.	Fojt, 1994.
"....have some characteristics of both bogs and marshes. They are distinguished by a mineral-rich groundwater source and a more alkaline (higher) pH than bogs.	Goldman and Horne, 1994.

A2.11 Bogs

"Wet spongy ground; a stretch of such ground.	Allen, 1990.
Mires which receive water and nutrients mainly from the rainfall. Eight types have been identified.	Fojt, 1994.
"A peat-accumulating wetland that has no significant inflows or outflows and supports acidophilous mosses, particularly *Sphagnum*.	Mitsch and Gosselink, 1993.
"....accumulate peat and are dominated by acidophilous mosses and sedges. They have few or no trees or aquatic macrophytes."	Horne and Goldman, 1994.

A2.12 Marshes

"Low land flooded in wet weather and usually watery at all times."	Allen, 1990.
"A frequently or continually inundated wetland characterised by emergent herbaceous vegetation adapted to saturated soil conditions. In European terminology a marsh has a mineral soil substrate and does not accumulate peat."	Mitsch and Gosselink, 1993.
"....are dominated by emergent aquatic macrophytes, such as reeds and sedges, and have submerged or floating macrophytes, such as pondweeds and waterlilies. A major distinguishing feature of marshes is the absence of trees and shrubs."	Home and Goldman, 1994.

A2.13 Swamps

"A piece of waterlogged ground; a bog or marsh."	Allen, 1990.
Areas of water shallow enough for emergent hydrophytes (including forbs and grasses) and woody plants adapted to grow in water saturated soils (such as Cypress trees) to grow across the entire area	Ward, 1992.
[North America]. "Wetland dominated by trees or shrubs. In Europe a forested fen or reedgrass-dominated wetland is often called a swamp."	Mitsch and Gosselink, 1993.
Type of fen characterised by water levels at or above the surface for most of the year, with species-poor vegetation often dominated by tall bulky monocotyledons.	Fojt, 1994.
"....contain large trees and shrubs, but a variety of aquatic macrophytes grow in the more open, sunlit areas."	Home and Goldman, 1994.

Appendix 3. Pond ecology: major research areas

A3.1 The National Pond Survey

The National Pond Survey (NPS) was initiated by Pond Action in 1989 and core funded by WWF-UK. The first phase of field work was completed in 1993, and analysis of survey data is currently in progress.

The aim of the NPS has been to describe the physical, chemical and biological characteristics of small water bodies in Britain, and to use this information to both classify ponds and improve understanding of pond conservation techniques.

The survey has initially been based on a sample of approximately 200 sites throughout England, Wales and Scotland, in areas of semi-natural habitat. In 1996-97 a further 200 sites will be added, from the wider countryside.

The main aim of the NPS has been to provide the baseline scientific data needed to support pond conservation work. In particular the NPS provides:

(i) a baseline for monitoring long-term trends in the quality of small water bodies in Great Britain
(ii) information about the location of high quality ponds
(iii) information on the distribution of individual species
(iv) a wide variety of data about pond management
(v) a suite of techniques for prioritising ponds for protection

A particularly important objective of the NPS is to establish which environmental factors are correlated with pond conservation status and to develop techniques for assessing the conservation value of ponds. Predictions of pond conservation status (as measured in terms of species rarity and diversity) will be made from easily measurable factors (e.g. landuse, water chemistry, vegetation structure).

A3.2 National Amphibian Survey

The National Amphibian Survey was undertaken as part of the 1989-92 Herptile Sites project, funded by English Nature. (Swan and Oldham 1993). This project was the third of a series of projects undertaken by De Montford University (formerly Leicester Polytechnic) for the Nature Conservancy Council.

Survey work was undertaken by a national network of voluntary amphibian recorders, co-ordinated by the project team at De Montford University.

The survey collected two types of information: 'simple' data (site location, species of amphibian present and year of survey) and 'pond questionnaires' which provided habitat details in addition to the 'simple' information. An example of the pond questionnaire is given below. (APP 5)

Between 1983 and 1992 874 recorders contributed data to the survey. Data were received on 11,059 sites, about half of which were detailed pond questionnaires.

Information was obtained on:

- the type of pond (field, garden, quarry, etc.)
- size and depth
- shading
- percentage cover of emergent, floating leaved and submerged plants
- the occurrence of fish
- frequency of drying out
- uses (e.g. anglers, cattle, horses, ducks)
- harmful activities within 200m (e.g. drainage, dumping)
- surrounding landuse (in zones up to 1000m from pond)
- habitat features (in zones up to 1000m from pond).

The survey provides information on:

1. the numbers and densities of ponds, the successional stage of ponds, the proportion of sites which dry out and the perceived uses of, and threats to, ponds.

2. national distribution patterns of native amphibian species and the terrestrial and aquatic habitat features which were associated with the presence of each species.

A3.3 National Aquatic Coleoptera (Water Beetles) Recording Scheme

The aquatic Coleoptera recording scheme was formally initiated in 1979 and has been undertaken by volunteer surveyors working throughout Great Britain and Ireland (Foster and Eyre 1992). Aquatic Coleoptera are good indicators of high quality wetland habitats (especially long-established semi-natural habitats). Therefore, in addition to being of importance in their own right, they have considerable value as habitat quality indicators. This usefulness has been recognised in the support given to water beetle recording by Nature Conservancy Council and Joint Nature Conservancy Council..

In the course of the national recording scheme water beetles were collected from a large number of sites, data being recorded on the standard Biological Records Centre recording cards. Sampling was undertaken mainly by hand netting, but also a range of other methods such as pitfall trapping (Foster and Eyre 1992), the objective being to collect as full a species list from each site surveyed as possible. Season of visit was not standardised and sites could have been visited once or more than once. Identification of rare and taxonomically difficult specimens was quality controlled by the Recording Scheme organiser (or equally experienced coleopterists). About 5000 species lists have been collected throughout Great Britain, of which about 2100 have been suitable for analysis (Foster and Eyre, 1992). However, Foster *et al* (1992) noted in another paper that "much of the data base comprised incomplete lists mainly produced by Coleoptera enthusiasts ignoring the commoner species."

A limited amount of environmental data is collected at each site (grid reference, altitude, surrounding habitat etc.). Consequently, descriptions of the environmental factors which distinguish community types are generally based on 'feel', rather than objective analysis of data.

Despite technical shortcomings, the water beetle recording scheme has identified a large number of sites of biological importance throughout England, Wales and Scotland, including some pond sites. The methods used are especially useful for experienced invertebrate biologists and have the benefit of being relatively quick and, therefore, inexpensive.

A3.4 Botanical survey of Scottish freshwater lochs

The Scottish Loch Survey, organised by Scottish Natural Heritage and currently in progress, is describing the wetland plant communities of about 3000 water bodies of 0.1ha or more. Survey work began in 1983 and is expected to be completed in 2000.

The objectives of the survey are :

- to determine the range and quality of loch vegetation.
- to provide a baseline against which to monitor change.
- to identify sites vulnerable to change (e.g. acidification, eutrophication) and sites already damaged.
- to identify sites of high conservation value for aquatic flora
- to improve knowledge of the distribution of aquatic plants.

Sites are selected for survey within SNH administrative boundaries. In some areas, particularly vulnerable or interesting sites are identified and survey is limited to these. In other areas, a synoptic survey approach is employed. All standing water bodies appearing on Ordnance Survey 1:50,000 scale maps are identified and fitted into a three-way matrix based on surface area, altitude and underlying solid geology. Priority sites for survey are selected from this matrix in liaison with regional SNH staff and include:

- lochs lying within designated areas (e.g. SSSIs, National Nature Reserves)
- lochs with records of rare plants or *Potamogeton* (pondweed) species, or other previous survey information.
- sites of interest for other groups (e.g. birds)
- a random selection to ensure full coverage of all field in the matrix
- sites to ensure a full coverage of 10 x 10 km squares in the Area of Search
- sites for which SNH regional staff require further information.

Sites are surveyed in "the summer months (June to September)" . Lochs are circumnavigated and plants growing at the shoreline and in shallow water recorded. A double headed rake is used for deeper water and, where possible, a grapnel survey from a boat is undertaken. All plants are recorded on the DAFOR (dominant, abundant, frequent, occasional, rare) scale; stands of emergent vegetation are mapped and the distribution of dominant and otherwise notable species recorded in all three vegetation zones.

Sites are evaluated within the classification developed by Palmer *et al* (1992) using some or all of the following criteria:

- number of plant species or number of NVC communities
- rarity of plant species
- physical diversity
- lake community type (rare types score more highly)
- anthropogenic disturbance
- paleolimnological and geological features
- catchment naturalness.

Appendix 4. Wetland plant and aquatic invertebrate biodiversity relationships: Oxfordshire Pond Survey and National Pond Survey

A4.1 Introduction

The results of analyses showing biodiversity relationships in the Oxfordshire Pond Survey and the National Pond Survey are shown below.

Correlations are Spearman's Rank Correlations. Significance levels are shown at the bottom of each page.

A4.2 Oxfordshire Pond Survey

	Species Richness				Species Rarity Index			
Species richness	All wetland plants	Aquatic plants	Emergent plants	Inverts.	All wetland plants	Aquatic plants	Emergent plants	Inverts
All wetland plants		++++++	++++++	+++++	+++	+++	++++	++
Aquatic plants	++++++		+	+++++	++	+	+	ns
Emergent plants	++++++	+		+++	+	++	++	+++
No. of invertebrate families	+	++	ns	++++++	ns	ns	ns	ns
No. of invertebrate species	+++++	+++++	+++		+	ns	ns	+
Species Rarity Index								
SRI - All wetland plants	+++	++	+	+		+++++	++++F+	+
SRI - Aquatic plants	+++	+	++	ns	+++++		++++	+
SRI - Emergent plants	++++	+	++	ns	++++++	++++		ns
SRI - Invertebrate species	++	ns	+++	+	+	+	ns	

4.3 National Pond Survey

	Species Richness				Species Rarity Index			
Species richness	All wetland plants	Aquatic plants	Emergent plants	Inverts.	SRI All wetland plants	SRI Aquatic plants	SRI Emergent plants	SRI Inverts
All wetland plants		++++++	++++++	++++++	++++++	•	•	ns
Aquatic plants	++++++		++++++	ns	++++++	•	•	++
Emergent plants	++++++	++++++		+++++	++++++	•	•	ns
No. of invertebrate families	++++++	++++++	++++++	++++++	++++	•	•	---
No. of invertebrate species	++++++	ns	++++		++++++	•	•	ns
Species Rarity Index								
SRI - All wetland plants	++++++	++++++	++++++	++++++		•	•	ns
SRI - Aquatic plants	•	•	•	•	•		•	•
SRI - Emergent plants	•	•	•	•	•	•		•
SRI - Invertebrate species	ns	•	•	ns	ns	•	•	

+ = positive correlation; - = negative correlation; ns = not significant; • = not analysed
Levels of significance + <0.05, ++ <0.01, +++<0.005; ++++<0.001; +++++<0.0005; ++++++<0.0001

Appendix 5 National Pond Survey Field Recording Sheet

NATIONAL POND SURVEY Field Recording Sheet (1)

Site name ______________________ Grid ref. __________

Nearest town or village ______________________ County __________

Access/contact ______________________ Altitude __________

SURVEY SEASON	SPRING (Mar-May)	SUMMER (Jun-Aug)	AUTUMN (Sept-Nov)
Surveyor(s)			
Date			

Geology

Geology underlying pond		Rock type	
Geology of catchment		Rock types	

Pond size: calculated from summer survey map

Pond circumference		Pond area		Maximum dimension	
Water circumference		Water area			

Plant abundance: (within the whole area)

List the wetland plants which occupy more than 5% of the pond (calculated from vegetation map). Note under the headings 'Other emergents' or 'Other aquatics' the total cover of stands with species in lower abundance.

Aquatic plants	%	Emergent/marginal plants	%
Other aquatics		Other emergents/marginals	
Total aquatics		Total emergents/marginals	
		Total species	

Plant habitats for invertebrates

Estimate the % plant cover within the WATER area of the pond

	Spring	Summer	Autumn
Above water level: % cover of all emergent plants			
Below water level: % of plants with rigid narrow-leaves e.g. bulrush, bur-reed			
Below water level: % plants with flexible leaves e.g. water mint, grasses			
Below water level: % 'true aquatic' plants e.g. water starwort, pondweeds			
Water surface: % cover of all floating leaved e.g. floating grasses, duckweed			

Overhanging trees & shrubs

Calculate from the map:

% pond overhung

% water overhung

% total pond margin overhung

% water margin overhung

NATIONAL POND SURVEY Field Recording Sheet (2)

Seasonal water fluctuation

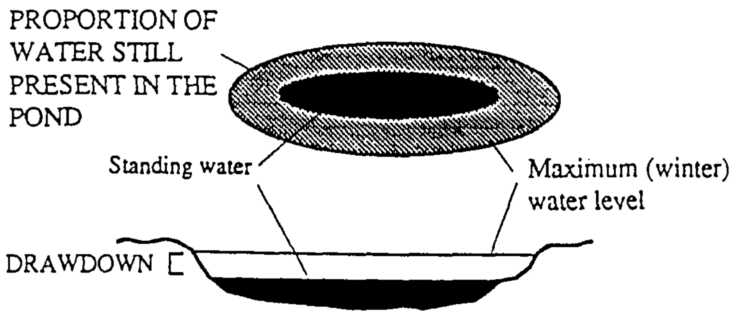
Proportion of water present in the pond

Spring	Summer	Autumn
%	%	%

Drawdown

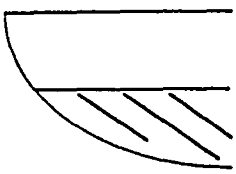
The height difference between maximum water levels and current water levels

Spring	Summer	Autumn
cm	cm	cm



Sediment and water depths

Season measured? Spr/Sum/Aut



	Transect A (longest dimension) 1/4	Transect A 1/2	Transect A 3/4	Transect B (right angles to A) 1/4	Transect B 3/4	Max. depths	Average depths
Water depths (cm)							
Silt depths (cm)							
Total depth (silt and water) (cm)							

Nature of pond base

Tick any of the following:

Clay/silt ________
Butyl/synthetic ________
Concrete ________
Gravel/sand ________
Bed rock (specify) ________
Others (specify) ________

Sediment

Rank the following where possible:

Decomposing leaves and twigs ________
Organic and inorganic debris < 1mm ________
Organic and inorganic ooze ________
Stream-bome gravel/sand/silt ________
Peat ________
Others (specify) ________

Water quality

	Spr.	Sum.	Aut.
pH			
Time			

	Spr.	Sum.	Aut.
Conductivity (us cm^{-1})			

	Spr.	Sum.	Aut.
Temperature			

	Spr.	Sum.	Aut.
Alkalinity (m mol^{-1})			

	Spr.	Sum.	Aut.
Calcium (mg l^{-1})			

	Spr.	Sum.	Aut.
Clear			
Moderately clear			
Moderately turbid			
Turbid			

Water colour Spring ________ Summer ________ Autumn ________

Probable source of colour ________ ________ ________

Note any obvious pollution (e.g. oil, dumped rubbish) ________________

NATIONAL POND SURVEY Field Recording Sheet (3)

Water source

Rank the importance of the following water sources (? where unsure):

Water source	Rank	Water source	Rank	Water source	Rank
Groundwater/water table	______	Runoff & near surface water	______	Direct precipitation	______
Spring	______	Stream	______	Other (state)	______
Flood water	______	Ditch	______		

Inflows and outflows

Does the pond have any inflows or outflows? [ ] If so, estimate their average width, depth & flow category. Flow category: 1 - imperceptible; 2 - slow; 3 - moderate; 4 - fast. Measure flow rate in metres/sec if possible.

	INFLOWS				OUTFLOWS			
	Width(cm)	Depth(cm)	Flow category	Flow rate	Width(cm)	Depth(cm)	Flow category	Flow rate
SPRING								
SUMMER								
AUTUMN								

Other adjacent wetlands & water bodies

Are there any OTHER wetlands within 500m of the pond? [ ] If so, record whether the pond is connected to adjacent wetlands (P - permanent connection; T - temporary connection (including flooding); N - not connected.

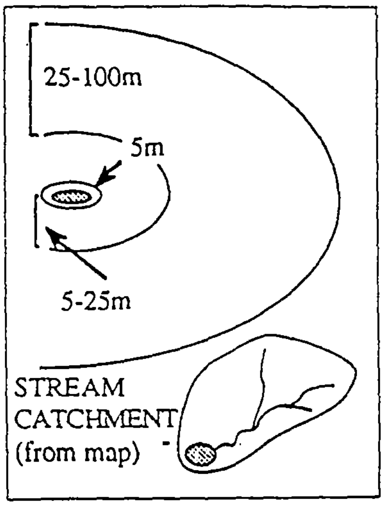
	Wetlands/waterbodies adjacent to the pond		
Waterbody/ wetland	<10m (connections)	10-250m (connections)	250-500m (connections)
Pond/lake			
Ditch			
Stream/river			
Fen/bog/marsh			
Other (specify)			

Surrounding land-use

Estimate the percentage of surrounding land-use within the three land-use zones and the catchment

LAND-USE	<5m	5-25m	25-100m	Catchment
Deciduous woodland				
Coniferous woodland				
Scrub/hedge				
Moor/lowland heath				
Bog				
Fen/marsh				
Rank vegetation				
Unimproved grassland				
Improved grassland				
Arable				
Parks and gardens				
Buildings and concrete				
Roads				
Rock, stone, gravel				
Other (please state)				

Land-use zones



NATIONAL POND SURVEY Field Recording Sheet (4)

History and use of the pond

What is the origin of the pond? ______________________________

How old is the pond? ("at least *x* years if exact dates unknown") ______________________________

Does the pond ever dry out? [ ] If so, how often does it dry out? ______________________________

When did it last dry out, and for how long? ______________________________

Is the pond used by man/animals (e.g. grazing animals, fishing)? [ ] If so, how? ______________________________

Has the pond been managed (e.g. cleared of vegetation)? [ ] If so, when, and how extensively?

____

Amphibians and fish

Are fish present in the pond? (? if only probable) Yes [ ] No [ ] Don't know [ ]

Are amphibians present in the pond? (? if only probable) Yes [ ] No [ ] Don't know [ ]

Record the species and abundance of fish and amphibians where known.

Also note the source of this information. ______________________________

____

____

____

Micro-habitats

SPRING

____

SUMMER

____

AUTUMN

____

Additional information

e.g. easily identifiable macro-invertebrate species returned to the pond from the 3 minute sample or seen on the wing (state which)

SPRING

SUMMER

AUTUMN

Brief description of the pond

____

List of wetland plants recorded at the pond

____

NATIONAL POND SURVEY FIELD RECORDING SHEET (5)

Tick or underline all wetland plants within the outer boundary of the pond (i.e. limit of maximum - winter - water level)

SUBMERGED & FLOATING PLANTS

Apium inundatum
Aponogeton distachyos
Azolla filiculoides
Callitriche brutia
Callitriche hamulata
Callitriche hermaphroditica
Callitriche obtusangula
Callitriche platycarpa
Callitriche stagnalis
Callitriche truncata
Callitriche sp. (undetermined)
Ceratophyllum demersum
Ceratophyllum submersum
Crassula aquatica
Crassula helmsii
Egeria densa
Elatine hexandra
Elatine hydropiper
Eleogeton fluitans
Elodea canadensis
Elodea ernstiae
Elodea nuttallii
Eriocaulon aquaticum
Glyceria fluitans
Groenlandia densa
Hippuris vulgaris
Hottonia palustris
Hydrocharis morsus-ranae
Isoetes echinospora
Isoetes lacustris
Juncus bulbosus
Lagarosiphon major
Lemna gibba
Lemna minor
Lemna minuscula
Lemna polyhriza
Lemna trisulca
Littorella uniflora
Lobelia dortmann
Ludwigia palustris
Luronium natans
Menyanthes trifoliata
Myriophyllum alterniflorum
Myriophyllum aquaticum
Myriophyllum spicatum
Myriophyllum verticillatum
Najas flexilis
Najas marina
Nuphar advena
Nuphar lutea
Nuphar pumila
Nymphaea alba
Nymphoides peltata
Oenanthe aquatica
Oenanthe fluviatilis
Polygonum amphibium
Potamogeton acutifolius
Potamogeton alpinus
Potamogeton berchtoldii
Potamogeton coloratus
Potamogeton compressus
Potamogeton crispus
Potamogeton epihydrus
Potamogeton filiformis
Potamogeton friesii
Potamogeton gramineus
Potamogeton lucens
Potamogeton natans
Potamogeton nodosus
Potamogeton obtusifolius
Potamogeton perfoliatus
Potamogeton pectinatus
Potamogeton polygonifolius
Potamogeton praelongus
Potamogeton pusillus
Potamogeton rutilus
Potamogeton trichoides
Potamogeton hybrid(s)
Ranunculus aquatilis
Ranunculus baudotii
Ranunculus circinatus
Ranunculus fluitans
Ranunculus hederaceus
Ranunculus omiophyllus
Ranunculus peltatus
Ranunculus penicillatus
Ranunculus trichophyllus
Ranunculus tripartitus
Sagittaria latifolia
Sagittaria rigida
Sagittaria sagittifolia
Sagittaria subulata
Sparganium angustifolium
Sparganium emersum
Sparganium minimum
Stratiotes aloides

Subularia aquatica
Utricularia australis
Utricularia intermedia
Utricularia minor
Utricularia vulgaris
Vallisneria spiralis
Wolffia arriza
Zannichellia palustris

Bryophytes:
Fontinalis antipyretica
Riccia fluitans
Ricciocarpus natans
Sphagnum sp.

Algae:
Chara sp.
Nitalla sp.
Tolypella sp.
Enteromorpha sp.
Filamentous
Planktonic

EMERGENT & OTHER WETLAND PLANTS

Achillea ptarmica
Acorus calamus
Agrostis stolonifera
Alisma gramineum
Alisma lanceolatum
Alisma plantago-aquatica
Alopecurus aequalis
Alopecurus geniculatus
Anagallis tenella
Andromeda polifolia
Angelica archangelica
Angelica sylvestris
Apium graveolens
Apium nodiflorum
Apium repens
Baldellia ranunculoides
Barbarea intermedia
Barbarea vulgaris
Berula erecta
Bidens cernua
Bidens tripartita
Blysmus compressus
Butomus umbellatus
Calamagrostis canescens
Calamagrostis epigejos
Caltha palustris
Cardamine amara
Cardamine pratensis
Carex acuta
Carex acutiformis
Carex appropinquata
Carex aquatilis
Carex curta
Carex demiss
Carex diandra
Carex disticha
Carex elata
Carex elongata
Carex flacca
Carex hostinana
Carex laevigata
Carex lasiocarpa
Carex lepidocarpa
Carex limosa
Carex nigra
Carex otrubae
Carex panicea
Carex paniculata
Carex pendula
Carex pseudocyperus
Carex pulicaris
Carex riparia
Carex rostrata
Carex spicata
Carex vesicaria
Catabrosa aquatica
Cicuta virosa
Cirsium dissectum
Cirsium palustre
Cladium mariscus
Conium maculatum
Corrigiola litoralis
Crepis paludosa
Cyperus longulus
Cyperus fuscus
Dactylorhiza fuchsii
Dactylorhiza incarnata
Dactylorhiza praetermissa
Damasonium alisma
Deschampsia caespitosa
Drosera rotundifolia
Dryopteris cristata
Eleocharis acicularis
Eleocharis multicaulis
Eleocharis palustris
Eleocharis quinqueflora
Eleocharis uniglumis
Equisetum fluviatile
Equisetum palustre
Epilobium ciliatum
Epilobium hirsutum
Epilobium nerteroides
Epilobium obscurum
Epilobium palustre
Epilobium parviflorum
Epilobium tetragonum
Epipactis palustris
Erica tetralix
Eriophorum angustifolium
Eriophorum gracile
Eriophorum latifolium
Eriophorum vaginatum
Eupatorium cannabinum
Filipendula ulmaria
Galium boreale
Galium palustre
Galium uliginosum
Geum rivale
Glyceria declinata
Glyceria fluitans
Glyceria maxima
Glyceria plicata
Gnaphalium uliginosum
Hesperis matronalis
Hydrocotyle vulgaris
Hypericum elodes
Hypericum tetrapterum
Impatiens capensis
Impatiens glandulifera
Impatiens noli-tangere
Iris pseudacorus
Isolepis cernua
Isolepis setacea
Juncus acutiflorus
Juncus articulatus
Juncus bufonis agg.
Juncus compressus
Juncus conglomeratus
Juncus inflexus
Juncus subnodulosus
Juncus effusus
Lathyrus palustris
Liparis loeselii
Lotus uliginosus
Lychnis flos-cuculi
Lycopus europaeus
Lysimachia nemorum
Lysimachia nummularia
Lysimachia thyrsiflora
Lysimachia vulgaris
Lythrum hyssopifolia
Lythrum portula
Lythrum salicaria
Mentha aquatica
Mentha pulegium
Mimulus guttatus
Mimulus luteus
Minuartia stricta
Molinia caerulea
Montia fontans
Myosotis laxa
Myosotis scorpioides
Myosotis secunda
Myosoton aquaticum
Myrica gale
Narthecium ossifragum
Nasturtium microphyllum
Nasturtium officinale
Oenanthe aquatica
Oenanthe crocata
Oenanthe fistulosa
Oenanthe lachenalii
Osmunda regalis
Parnassia palustris
Pedicularis palustris
Peucedanum palustre
Petasites hybridus
Phalaris arundinacea
Phragmites australis
Pilularia globulifera
Pinguicula vulgaris
Polygonum amphibium
Polygonum hydropiper
Polygonum lapathifolium
Polygonum minus
Polygonum mite
Polygonum persicaria
Potentilla erecta
Potentilla palustris
Pulicaria dysenterica
Pulicaria vulgaris
Ranunculus ficaria
Ranunculus flammula
Ranunculus lingua
Ranunculus ophioglossifolius
Ranunculus sceleratus
Rhinanthus minor
Rhynchospora alba
Rorippa amphibia
Rorippa palustris
Rorippa sylvestris
Rumex aquaticus
Rumex hydrolapathum
Rumex maritimus
Rumex palustris
Sagina procumbens
Saggitaria sagittifolia
Samolus valerandi
Schoenoplectus lacustris
ssp. lacustris
ssp. tabernaemontani
Schoenoplectus triqueter
Schoenus nigricans
Scorzonera humilis
Scrophularia auriculatas
Scutellaria galericulata
Senecio aquaticus
Senecio fluviatilis
Senecio paludosus
Sium latifolium
Solanum dulcamara
Sparganium erectum
Stachys palustris
Stellaria alsine
Stellaria palustris
Symphytum officinale
Teucrium scordium
Thalictrum flavum
Thelypteris palustris
Tofieldia pusilla
Tricophorum cespitosum
Triglochin palustris
Typha angustifolia
Typha latifolia
Valeriana dioica
Vallisneria spiralis
Veronica anagallis-aquatica
Veronica beccabunga
Veronica catenata
Veronica scutellata
Viola palustris

Trees and shrubs:
Alnus glutinosa
Frangula alnus
Populus sp.l
Salix repens
Salix sp.

NATIONAL POND SURVEY FIELD RECORDING SHEET (6)

Name of pond: Date: North arrow

Scale

Appendix 6. Landscape Assessment: an appraisal of methods

A.6.1 General approaches to landscape assessment

Overall landscape assessment can be divided into three approaches:

1. *landscape classification*: division of the landscape into areas of distinct and recognisable character,
2. *landscape description*: factual and systematic documentation of landscape character and the elements which contribute to this,
3. *landscape evaluation*: a subjective judgement of the relative value of landscapes or landscape features.

The requirement for Pond Survey 1996 is, as interpreted from Section 5.1, essentially a process of landscape evaluation. However, landscape classification and description may both provide valuable information and they may be an essential precursor to the landscape evaluation process.

A.6.2 Current Guidelines

The Countryside Commission's *Landscape Assessment Guidance* (1993) lays out guidelines for landscape assessment in all three areas of assessment (description, classification, evaluation). The guidelines build upon the Warwickshire Landscapes Project approach developed in the late 1980s (Countryside Commission, 1991), and have subsequently been used as the basis for many local, regional and thematic assessments (e.g. NRA 1993a).

The Countryside Commission method essentially comprises:

- **a planning phase** to evaluate aims and resources,
- **desk study of maps, photographs and documents** relating both to landscape and other criteria (including ecological and historical information),
- **Overlay analysis and/or computer-aided landscape classification** to define landscape areas and types,
- **Field survey** using a structured survey form, drawings and photographs to give written and pictorial landscape descriptions,
- **Analysis and presentation of results.**

Landscape *evaluation*, if undertaken, is part of the final stage of the assessment, and uses all the evidence gathered during earlier phases. The aim of evaluation is largely to aid strategic decision making at a regional scale. In published examples using this method (Warwickshire Landscapes Project, NRA River Landscape Assessment Method), evaluation involved placing landscapes into a simple tripartite division of landscape sensitivity and vulnerability (i.e. the need for conservation, restoration or enhancement).

A.6.3 Suitability of the Warwickshire method for assessment of pond value

The Warwickshire Landscapes Project method and Countryside Commission recommendations provide a standardised and widely adopted methodology which should be applied wherever appropriate.

Many aspects of the methodology are relevant to pond assessment, particularly the requirement for planning and structured field surveys.

There are, however, a number of difficulties in applying Warwickshire-type methods as a means of assessing pond value in Pond Survey 1996. In particular, these methods are concerned primarily with broad, area-wide landscape assessments rather than with detailed site specific assessments (Countryside Commission 1993). In practice this means that:

1. the detailed methodologies are not appropriate for assessing *micro* pond landscapes,
2. they are not ideal for assessing the significance of local landscape *changes* (e.g. the impact of a hedge being removed from around a pond),
3. the often descriptive results are not easily translatable to the numerical values desirable for Pond Survey 1996.

In addition, in the Warwickshire and NRA methods, *evaluation* is a relatively limited part of the assessment, largely restricted to landscape sensitivity.

A.6.4 Other methods of landscape assessment

Since standard methods of landscape assessment are not completely applicable to the requirements of Pond Survey 1996, the section below, draws out the relevant aspects of the Warwickshire Landscape project approach and discusses other approaches to landscape evaluation

A.6.5 Landscape classification

Landscape classification is, as stated above, often a necessary prerequisite to evaluation (Blankson and Green 1991). Its value is that, it can be used to rationalise landscape complexity, allowing comparisons to be made *within* landscape types of 'like with like'.

Two national landscape classifications have been, or are in the process of being, developed: (i) the ITE Land Classes and (ii) the Countryside Commission's 'Countryside Character Programme'.

ITE Land Classes: ITE's Land classification, developed in the 1980s, was the first major computer aided landscape classification system to be developed. Classification was undertaken using climatic, geological and topographic attributes giving 32 Land Classes. Field survey data was used to provide additional vegetation and landscape component information for each Class. Data is resolvable at 1 km grid squares level across Britain.

The Countryside Character Programme: The ITE Land Class approach is currently being extended by the Countryside Commission in their 'Countryside Character Programme' (Brooke, 1994). This aims to ensure that the classification end-groups based on map and other evidence also reflect 'visual' landscape types in the sense conventionally understood by landscape professionals. It seeks particularly to provide more detailed county and district landscape information. In a pilot study of Southwest England, for example, 38 regional character areas were identified (Countryside Commission 1994).

A.6.6 Use of landscape classification for landscape assessment in Pond Survey 1996

Any landscape (or landscape feature) which is characterised by a number of major environmental gradients will require classification or other forms of multivariate analysis as a prerequisite to evaluation.

Pond Survey 1996, may cover the whole range of Britain's landscape types. Assessment and evaluation of the *macro* landscapes associated with ponds is, therefore, likely to benefit from analysis within the framework of a classification. In the absence of the fully developed Countryside Character Programme, the ITE Land Classes currently provide the only national classification within which macro pond landscape evaluation could be undertaken

At a *micro* assessment level, however, national landscape classifications are likely to provide little benefit. There is, for example, no reason to expect that the micro landscape characteristics of the pond itself (extent of vegetation, permanence, degree of shade, bank slopes etc.) will inevitably reflect more general landscape types.

There is currently no specific classification of micro pond landscapes and to create one would require extensive desk and field survey work. It is also debatable as to whether the inherent variation in this single landscape attribute is sufficient to necessitate classification prior to evaluation.

A.6.7 Landscape evaluation

Landscape evaluation is the most difficult and controversial of all landscape study areas. Part of the difficulty is that the aesthetic appeal of a landscape is highly subjective and strongly influenced by individual preference.

To facilitate 'objectivity' in landscape evaluation, extensive work has been undertaken to develop 'statistical' evaluation methods.

A.6.8 Statistical methods of assessing landscape elements

Methods of statistical evaluation aim to quantify information on physical landscape elements and use statistical analysis to find their relationship with the intuitive judgements of professionals working in the field.

Initial work developing statistical methods in the 1970's was subsequently extended by the Countryside Commission's Landscape Evaluation Research project carried out by Manchester University. This project correlated landscape value judgements (made in the field by landscape professionals) with map attributes (for example hedgerows, woodland, moorland). Regression analysis was used to develop quantitative scores for the map -based attributes allowing landscape value to be predicted from map or other similar, evidence alone.

Following development of the Manchester method many adaptations were devised and applied. Of particular relevance to this project are: (i) Shafer and Brush's work which used regression analysis to link public preference for photographs of landscape, including components such as perimeter vegetation and area of water visible (Shafer and Brush 1977), (ii) much more recent work by Bishop and Hulse (1994) which suggests combining use of computational capabilities of GIS with prediction equations based on video panoramas.

A.6.9 The appropriateness of statistical methods

Statistical methods could, in principle, provide methods for *macro* landscape evaluation, especially if used in association with a classification scheme. Although considerable resources may be required to assign numerical values to individual landscape attributes, the method could capitalise on landscape information already digitised for the Countryside Survey. Once set up, the method would enable rapid calculation of existing landscape value and of potential or actual landscape change. By calculating and comparing landscape scores with and without a pond present, the method could also be used to quantify the importance of any pond as a landscape feature.

Statistical analysis methods appear not to have been applied to *micro* scale landscape evaluation, but in theory, the method is equally applicable.

Both in principle and practice, however, the Manchester method and its variants have a number of drawbacks. There have, for example, been many criticisms of the reductionist approach of attaching single numerical values to landscapes, and in ignoring factors such as 'landscape beauty' in the quest for a 'computer print-out' solution (Countryside Commission 1988).

Similarly, the relatively complex statistical analysis used can have an effect of distancing the result from the real landscape, creating difficulties of understanding and interpretation.

Perhaps more fundamentally for Pond Survey 1996, there are considerable time and resource implications for use of such methods. Once up and running the method is quick to use. The *initial* total labour input required for these methods can however, be very high. The set-up phase of evaluating landscape elements in the field, correlating and scoring landscapes using the Manchester method is acknowledged to take many person months. The rationale for Pond Survey 1996 is to cover the whole of Britain including the widest range of landscapes and land class types. The numerical characterisation of all the landscape elements that this would entail would therefore be extensive. Calculation of timings for the elements required suggest that it could take at least 0.5-1 person year to complete all preliminary steps and analyses.

A.6.10 Assessing landscape using professional judgement

A range of landscape evaluations have been developed which use as their base, the professional judgement of one or more 'experts' trained in landscape assessment and working in the field.

In theory the advantage of these methods is that the trained opinion of professional workers, provides a less variable and more objective assessment method than canvassing the opinions of a wider public.
Many 'professional-based' methods have been devised, and they have been used both to assess landscapes as a whole, and the component landscape parts.

The following examples are used simply to exemplify the type and range of methods which have been applied.

Tandy used 1 km grid squares as survey units and for each range of landscape elements scored the 1km square according to the quantity of each element and the impact of that element (positive and negative) on the landscape. A score for each element in that square is then calculated, and the scores for each element summed to give a score for the square (Countryside Commission 1988).

Whilst not strictly a professional judgement method, Gee *et al* (1994) used a similar method of intuitive scoring of individual features/attributes in one of the few micro landscape assessments of ponds. This method essentially involved noting or ranking a mixture of amenity and landscape criteria such as:

- visibility of the pond from a public highway - scored on a five point scale (1 = obscured; 5 = clearly visible),
- the extent of vegetation and the presence/absence of pollution.

An amenity visibility rating was calculated by multiplying a score for the nearest point of public access by the visibility rating.

Durham County Council devised a hybrid method of evaluation which is a cross between an analytical scoring system and an intuitive approach. The method uses a team of three or more observers to undertake a visual analysis of the landscape, based on factors including: overall visual effect, relief, land use, vegetational effect and the influence of buildings and other man-made artefacts. These factors are scored and added to give 'landscape quality' for each view, and for four sectors of the view. Scores range from 0 (very poor) to 20 (very good/excellent). Evaluation of these scores aims to identify which particular views and features add or detract from the quality of visual envelopes, and which features are most vulnerable to change or require reinforcement.

Land Use Consultants recommended that a similar method should be used to evaluate the landscape of Scotland but only to compare landscapes of the same type, as defined by their proposed system of classification. Evaluation was based on a long checklist of features from which the surveyor could select those which were considered relevant (Countryside Commission, 1988).

Significantly, however, the Countryside Commission for Scotland opted not to use LUC's recommended scoring system to select highly valued landscapes. It was felt that the scoring system's attempt to combine objective analysis and subjective judgement did not in the event produce results which were more valid than a simpler descriptive/analytical approach (Countryside Commission, 1988).

A drawback of many professional, and other, scoring systems which evaluate landscape using its component parts is that there is no proven basis for combining these scores to give a total score for landscape value. To quote Lowenthal (1978) "Adding together land form and land use, panoramic extent and historic features, is like summing apples, oranges, bacon and peppercorns."

To combat the difficulties of using landscape *elements* to define landscapes, some workers have developed methods which rely on professional evaluation of the impression of the landscape as a *whole*.

Fines (1968) for example, asked 45 trained professional observers to grade 20 colour photographs of landscapes according to their beauty and in relation to a 'control' view. The resulting rankings were used to devise a scoring system which ranged from 0 - 1 = unsightly to 16 - 24 = spectacular. The ten observers whose scores were closest to the calculated mean were selected to carry out a field evaluation in E. Sussex.

A major problem identified with this approach, however, is that differences of opinion between observers are often not just a matter of degree, but involve a strong element of preferences for different types of landscapes.

Another *difficulty* shared with other methods, is that evaluation is only likely to be appropriated either (i) within the confines of a fine scale classification which will allow comparisons of similar landscapes (ii) in landscape areas with relatively little inherent variation, or (iii) for landscapes dominated by a single highly influential gradient (degradation for example). In this respect, whole landscape approaches may be appropriate for micro pond assessments since the aesthetic appreciation of these waterbodies is likely to be determined by a relatively limited set of parameters, such as successional stage.

A.6.11 The appropriateness of 'expert-based' methods

To their adherents, the advantages of 'expert' assessment methods are that they provide a successful compromise between the highly reductionist outputs of statistical methods and the highly variable preferences of public appreciation.

These methods have well recognised advantages in terms of cost, and in practice they may be as effective and realistic in their results as seemingly more objective statistical methods (Countryside Commission 1988).

Briggs and France (1981), for example, tested four classification methods: use-value analysis; statistical classification, intuitive classification and evaluation from inspection of maps. They concluded that the professional-based intuitive classification and evaluation method was perhaps the best method for evaluating landscape for speed, simplicity and cheapness.

For Pond Survey 1996 the main practical difficulty with use of 'professional judgement methods, is their frequent requirement for:

1. a professional judgement made *in the field*,
2. surveys carried out by the *same expert*, or a small team, across the whole of the area surveyed, and frequently also,
3. a *consensus* of opinion on any landscape to give a mean value of opinion.

None of these conditions are likely to be met for Pond Survey 1996 where:

1. fieldwork for the survey is likely to be undertaken by a considerable number of field personnel (perhaps 30 across Britain),

2. most, if not all surveyors will be untrained in landscape assessment,
3. it is unlikely that future surveys will be undertaken by the same personnel.

A.6.12 Use of 'public' versus 'expert' evaluation

Some researches have argued strongly that public tastes, although varied and much coloured by personal preferences, should be the ultimate arbiter of landscape value. Thus landscape appreciation, including all aspects of personal associations and experience, cannot be reduced to dispassionate appraisal of scenic quality applied by 'experts' according to professional rules of judgement (Penning-Rowsell 1981, Lowenthal 1988)

Most public preference evaluation methods elicit opinion using photographs as a substitute for the real landscape. Few use public assessments of the real study area (though see Preece 1980 for an exception).

A major concern is establishment of who's preference should be measured. Attitudes and preferences are, for example, known to vary widely according to factors such as age, social class, resident or visitor status.

Census or stratified omnibus surveys can be difficult and costly to use. The selection of methods (e.g. visitor surveys, house-to-house interviews, ranking of photographs) all demand high professional input and cost (Penning-Rowsell 1982).

Where they are used well, public preference methods may provide some of the most valuable information on perception of landscape and landscape values. However, in the context of Pond Survey 1996, such methods need to be considered with caution, because of the inevitably high resource requirements.

Appendix 7 The National Monuments Record - pond records, a page taken at random

Identifier	Name/ description	District	Paris or non-parish	Grid reference	Dates	Term
SJ 60 SW 12	Bildwas Abbey	Shrewsbury and Atcha	Bildwas	SJ 6434 0432	Medieval	Fishpond, Cistercian Monastery
SJ 60 SW 20	C18th forge (site) Pond bay	Shrewsbury and Atcha	Sheinton	SJ 6071 0393	Post Medieval	Forge Pond
SJ 60 SW 26	N/A	Bridgnorth	Much Wenlock	SJ 6260 0003	Post Medieval	Fishpond, Formal Garden, Trackway
SJ 60 SW 34	N/A	Bridgnorth	Much Wenlock	SJ 6273 0001	Early med. or late	Pond Bay
SJ 60 SW 4	Willey New Ironworks	Bridgnorth	Barrow	SJ 6723 0083	Post Medieval	Ironworks, Pond Bay
SJ 60 SW 5	N/A	Bridgnorth	Barrow	SJ 650 007	Medieval Post Medieval	Deserted Village, Pond
SJ 60 SW 34	N/A	Bridgnorth	Barrow	SJ 66 00	Early med. or late	Pond Bay, Deer Park
SJ 60 SW 6	Stoke Manor	North Shropshire	Stoke upon Trent	SJ 6460 2771	Post Medieval	Moat, Fishpond, Castle, Fishpond, Moat
SJ 60 SW 3	N/A	Crewe and Nantwich	Newhall	SJ 6137 4563	Early med. or late	Moat, Ornamental Pond

Appendix 8. Methods that can be used for detailed investigation of the historical value of sites

A8.1 Documentary research

At the individual site level, detailed analysis of documents and maps can assist in interpreting identified archaeological remains. Examples of data sources which may be relevant include:

- Early maps e.g. Estate Maps (generally from 17th century onwards), Tithe and Enclosure Maps;
- Ordnance Survey maps (from 1800 onwards);
- 1930s Land Utilisation Survey;
- Aerial photographs (generally from 1940s onwards);
- Estate Records;
- Research literature relating to history and environmental archaeology (including literary references).

Other documentary sources may also be relevant (e.g. Aberg, 1978 for moats).

However, it should be noted that techniques of documentary research for ponds are relatively poorly developed (e.g. for the wide variety of ponds due to mineral excavation), so that documentary research techniques require further investigation.

A8.2 Assessment of aerial photographs

Aerial photography has been extensively used in the identification of archaeological features.

A8.3 Fieldwalking

Methodical walking, usually of ploughed fields, collecting and plotting artefacts. Analysis of the material found and its distribution can indicate areas of settlements, burials or industrial activities.

A8.4 Geophysical surveys

Sensitive electrical surveys used to locate buried features and designed to suit the scale of the project and the type of features suspected.

A8.5 Test pits

Excavation of small holes down to bedrock usually done at regular intervals in areas of grassland, not available for fieldwalking. This process, with total or sample sieving of all soil, is designed to find artefacts and environmental information.

A8.6 Trial excavations

Excavations of trenches to test the depth of stratification, and extent and survival of features on known archaeological sites (see for example, excavation of fish ponds at Southwick Park, Hampshire in Currie, 1990).

A8.7 Sediment coring

Extensively used for environmental reconstruction, coring to collect biological and anthropogenic remains has been undertaken successfully on a variety of small shallow water bodies (e.g. Woolmer Pond). This technique is also used to assess the likely impact of desilting ponds (e.g. English Heritage Sedimentology Research Laboratory).

Appendix 9.1 Example of a simple scoring system: for historical sites of national, regional and local importance

National historic importance	Regional historic importance	Local historic importance
High value=10	High value=7	High value=4
Moderate value=7	Moderate value=4	Moderate value=1
Low value=0	Low value=0	Low value=0

Appendix 9.2 An example of calculation of a simple scoring system for three ponds in Oxfordshire and Berkshire

Sites described

Friars Court Moat lies adjacent to a 17th Century manor house, which is a Grade 2 Listed Building. The moat itself is listed on the SMR but is not a Scheduled Ancient Monument.

Ruscombe Village Pond is a small 19th century village pond, with documented 193O's photographs and strong community associations.

Ardley Quarry ponds are seasonal pools in a former limestone quarry, now a County Wildlife Trust nature reserve. They are undocumented historically and are away from the village centre.

Example of historical evaluation of the three ponds

Pond	National significance	Regional significance	Local significance
Friar's Court moat	Moderate	High	High
Ruscombe village pond	Low	Low	High
Ardley Quarry pond	Unknown	Unknown	Moderate

Historical Significance Score

Pond	Historical Significance Score
Friar's Court moat	18
Ruscombe Village pond	4
Ardley Quarry pond	1

Appendix 10 Field assessment questions for assessing amenity value

Is there a clear view of the pond from the following? • footpath • bridle path • A road • B-road • Other e.g. car parks (please state)	....	Score each on a five point scale (1 = obscured; 5 = clearly visible)
Are any residential areas located within 1km of the pond?	....	Score each on a five point scale (0 = no residential areas; 5 = large urban area)
Is the pond located in areas of open public access e.g. national parks, nature reserves?	....	0=no; 1=yes
Evidence of formal amenity use : • Fishing (e.g. fishing platforms, pegs, swims, embayments) • Shooting (e.g. hides, blinds) • Ornamental fish • Ornamental and other pinioned wildfowl (e.g. nesting/roosting boxes, feeders, platforms) • Pond dipping and other wildlife interests (e.g. dipping platforms, bird hides) • Boating and other water sports (e.g. boat, boat) • Model boating • Swimming	....	Score for each recorded (0= none; 2= present)

Appendix 11 Examples of survey questions for and amenity value postal questionnaire

Example 1. Simple question

What amenity benefit do you receive from the pond?

Please tick: any of the following that are appropriate

- Fishing
- Shooting
- Ornamental fish
- Ornamental and other pinioned wildfowl
- Pond dipping and other wildlife interests
- Boating
- Other water sports
- Model boating
- Swimming
- Landscape feature
- Other

Example 2. Question to determine qualitative value

How valuable is the pond to you as an amenity? (please tick)

A place to visit and enjoy	High value ☐	Moderate value ☐	Low value ☐
A fishery	High value ☐	Moderate value ☐	Low value ☐
etc.			

Example 3. Question to determine economic value

How much total time have you, or others, spent managing the pond in the last 10 years? (please tick)

No time	1 day or less	2-6 days	1 -2 weeks	2 -6 weeks
☐	☐	☐	☐	☐

Other (please state........................
