LOWLAND POND SURVEY 1996

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Lowland Pond Survey 1996 was undertaken for the Department of the Environment, Transport and the Regions (DETR) under contract number (CR0192) by Pond Action and the Institute of Terrestrial Ecology (ITE)

Pond Action

Pond Action is an independent non-profit making organisation, established with the support of the World Wide Fund for Nature to promote freshwater conservation. Pond Action is a national centre for applied research on pond ecology and conservation and is responsible for the National Pond Survey, the first phase of which was undertaken from 1989-1994.

The Institute of Terrestrial Ecology (ITE)

ITE is a component Institute of the Natural Environment Research Council's Centre for Ecology and Hydrology. ITE undertakes a wide range of specialist ecological research in Britain and overseas and has more than 20 years' experience of collecting, analysing and interpreting countryside data. ITE has undertaken surveys for DOE and the conservation agencies and includes the Biological Records Centre.

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ABSTRACT

This report describes the results of the Lowland Pond Survey 1996 (LPS96), a study commissioned by the Department of the Environment, Transport and the Regions.

The survey, which was based on a stratified random sample of 150 one-kilometre squares, aimed to estimate the number of ponds in lowland Britain and to provide the first national estimates of pond ecological quality and amenity value. The survey's main findings were:

Pond Numbers

1. The number of ponds in lowland Britain was estimated to be 228,900, with densities of 1.7, 0.4, and 1.4 ponds per km^2 in England, Scotland and Wales, respectively.

2. Between 1990 and 1996 there was a high turnover of ponds, with an estimated 17,000 (±3,900) ponds lost and an estimated 15,000 (±6,400) new ponds created in lowland Britain.

3. More than one third of the ponds identified in the survey were seasonal and were dry in summer 1996. Of the remaining 'permanent' ponds, more than 40% were very shallow, having average water depths of less than 25 cm.

Wildlife Value

4. The survey indicated that ponds are an important biodiversity resource. Over half of all Britain's wetland plant species were recorded in the survey ponds, including uncommon species of national conservation importance.

5. Although the collective conservation value of ponds was very high, there was also evidence that many lowland ponds were degraded. For example, the countryside ponds supported less than half the expected number of wetland plant species when compared to similar, but minimally impaired, reference ponds from semi-natural areas.

6. A range of evidence suggested that factors associated with intensive land-use were linked to pond degradation. For example, as the extent of arable land-use within 100 m of the pond increased, so the number of wetland plant species decreased. Biological evidence also indicated that many lowland ponds were significantly over-enriched with nutrients.

7. The survey showed that new ponds often had a high conservation value. New ponds were typically rich in wetland plant species and often supported uncommon plants. They were also less likely to be over-enriched by nutrients than older ponds.

8. The survey revealed how extensively non-native (exotic) wetland plant species have invaded countryside ponds. Exotics occurred in 14% of ponds and one in six of all submerged plant records was of a non-native species.

9. Seasonal ponds, a little-studied pond type, had fewer wetland plant species than permanent ponds. However, over 40% of the rarest plants recorded in the survey were found only in seasonal ponds.

Amenity Value

10. At least one in seven ponds was used for leisure activities, with fishing and shooting the most popular amenity uses.

11. Over one third of ponds could be viewed from a public right of way or area of open access and were therefore likely to provide some scenic value in the landscape.

Recommendations

To ensure that ponds are maintained as a resource for wildlife and amenity it is recommended that:

1. There is active promotion of buffer zone schemes to protect the quality of new and existing ponds.
2. Grant funding policies are re-focused to give greater emphasis to high quality pond creation schemes.
3. Current pond management and creation grant schemes are modified to include stipulations for 'good practice'.
4. Monitoring programmes are initiated to evaluate long-term pond quality trends with respect to pollution and climate change.
5. Statutory protection measures are considered to provide greater protection for high-quality ponds, including those supporting nationally-uncommon species.

EXECUTIVE SUMMARY

1. Objectives of the study

This report describes the findings of the 1996 Lowland Pond Survey (LPS96), a study carried out for the Department of the Environment, Transport and the Regions (DETR) by Pond Action and the Institute of Terrestrial Ecology (ITE).

The main survey objectives were:

(i) To describe the number, condition and quality of Britain's lowland countryside ponds.

(ii) To review current policies which directly affect the maintenance and protection of ponds.

(iii) To make policy recommendations based on the results of the study.

The definition of a pond used for LPS96 was: "a body of standing water 25m^2 - 2 ha in area which usually holds water for at least four months of the year". "Lowland Britain" was defined as areas of ITE pastural or arable landscape types. This area covers about 64% of the land surface of Britain.

2. Survey methodology

LPS96 results are based on surveys of a stratified random sample of 150 one-kilometre squares located so as to represent the lowland land classes of England, Scotland and Wales. All 150 survey squares had been previously surveyed for water bodies during Countryside Survey 1990 and a proportion were surveyed during Countryside Survey 1984. Both 1984 and 1990 Countryside Surveys focused on recording the number and size of ponds. LPS96 was, therefore, the first Countryside Survey to investigate the condition, ecological quality and amenity value of ponds in the wider countryside.

Within the 150 one kilometre survey squares a total of 460 pond sites (or ex-pond sites) were visited during LPS96. A pond was recorded at these sites in 403 cases. Access to gather detailed ecological data was obtained for 377 of the waterbodies seen.

3. The number of lowland ponds

The numbers of ponds recorded from the LPS96 field survey squares were extrapolated to give national estimates for lowland Britain.

The 1996 stock of lowland countryside ponds was estimated to be 228,900 (±25,900)[1]. Table I gives a breakdown of the number and density of ponds for England, Scotland and Wales.

Table I. Number and density of lowland ponds in 1996

	Number of ponds	Standard error	Pond density (ponds km^{-2})
Britain	228,900	±25,900	1.5
England	203,100	±23,000	1.7
Scotland	10,100	±2,700	0.4
Wales	15,700	±3,500	1.4

4. Change in pond number

Comparisons of compatible CS1990 and LPS96 survey data were used to provide an estimate of loss, gain and net change in the number of lowland ponds between 1990 and 1996 (Table II).

An estimated 17,000 (±3,900) ponds were lost in the period 1990-96. This represents approximately 7.4% of the estimated stock of lowland ponds in 1990. The main causes of loss were the deliberate in-filling (34%) and drainage (35%) of ponds in agricultural settings. Twelve percent of the lost ponds had been built over during urban development or road construction. The reasons for loss of the remaining 19% could not be determined. The lost ponds were typically smaller-than-average water bodies. They were also significantly more likely to be located in arable than in pastural landscape types and to have adjacent agricultural or woodland landuse.

Table II. Estimates of change in lowland pond numbers between 1990 and 1996

	Number of ponds lost	Number of new ponds	Net change 1990-1996
England	14,500	12,800	-1,700
SE	(±3,400)	(±5,000)	(±6,000)
Scotland	1,200	0*	-1,200
SE	(±900)	0*	(±900)
Wales	1,300	2,100	+800
SE	(±500)	(±1,600)	(±1,600)
Britain	17,000	15,000	-2,100
SE	(±3,900)	(±6,400)	(±7,500)

SE = Standard error, * Survey found no new ponds

[1] Standard errors are given in parentheses

During the same period (1990-96), pond loss was offset by the creation of an estimated 15,000 (±6,400) man-made ponds. The new ponds were generally larger water bodies, located in pastural landscape types and in areas surrounded by a variety of other land uses.

The figure for estimated net loss is less than 1% of the estimated stock of over 200,000 ponds and its associated standard error is proportionally high. Appropriate conclusions from the data are:

(i) There was a high rate of turnover in lowland ponds between 1990 and 1996, with over 7% of 1990 pond stock lost and gained. The creation of new ponds was therefore critical in maintaining the overall number of ponds during this time.

(ii) The net change in pond numbers between 1990 and 1996 of less than one percent lies within the range of uncertainty associated with sampling, so it is not possible to confidently state whether a net loss or small gain in pond numbers occurred during the six year period.

5. Pond attributes

Physico-chemical features

The survey showed that a high proportion of lowland ponds were shallow or seasonal. Forty-one percent (±7%) of ponds were dry or nearly dry (<1 cm water depth) at the time of survey, in summer 1996. A further 22% (±4%) had average water depths of less than 25 cm. Therefore, almost two thirds (63%) of all lowland ponds surveyed were either very shallow or seasonally dry in 1996.

Many ponds were relatively unshaded by trees, about half (47% ±6%) had less than 25% cover. However 20% (±4%) were heavily overhung (more than 75% tree cover).

Most ponds were circum-neutral in terms of their pH, although pH values for the data set as a whole ranged from 5.6 (moderately acid) to 10.7 (alkaline). Conductivity values for the data set ranged from 44 $\mu S\ cm^{-1}$ to 7100 $\mu S\ cm^{-1}$, with a moderately high average of 808 $\mu S\ cm^{-1}$. Conductivity was significantly higher in areas of arable landscape and land-use.

Small amounts of rubbish were common in the ponds, and in 5% (±1%) of sites there was sufficient rubbish or rubble to at least partly fill the pond.

There was evidence that some form of pond management had been undertaken on at least 14% (±3%) of lowland ponds. More than half of the managed ponds had been partly or fully dredged in the previous 6 years, an annual average of 1% of all ponds. Pond management was typically associated with larger ponds and was more likely to have occurred where ponds were located near to urban areas. Management was less frequently undertaken where ponds were more heavily shaded or located in woodland.

Survey data describing rates of sediment accumulation and dredging were used to speculate on the extent to which natural succession might reduce the number of permanent ponds and increase the number of seasonal ponds in future. The results suggest that, despite management efforts, there may be a progressive loss of permanent ponds from the lowland countryside. Smaller, more isolated, shaded and woodland ponds are those most likely to become increasingly seasonal.

Wildlife value

Wetland plant biodiversity

Recent research indicates that ponds are an important biodiversity resource with a wildlife value at least equal to that of other freshwater habitats such as rivers.

In LPS96, wetland plants were recorded in order to investigate the floristic value of ponds. The results confirm the importance of lowland ponds in protecting freshwater biodiversity.

Altogether, 177 vascular wetland plant and five charophyte species were recorded from LPS96 ponds (n=377). This represents approximately 55% of all vascular wetland plant species occurring in Britain.

The number of wetland species recorded from individual ponds ranged from zero to 35. The average number of species per pond was approximately 10.

Seven rare RDB (Red Data Book) or nationally uncommon plant species were recorded during the survey. The most uncommon was Fox Sedge (*Carex vulpina*) which has RDB2 (vulnerable) status.

Extrapolation of the survey data to give national estimates suggests that, in lowland Britain as a whole, approximately 3,500 ponds (c. 2%±1%) are likely to support RDB or nationally uncommon plant species.

The survey showed the extent to which non-native (exotic) wetland plant species have invaded countryside ponds. Exotics occurred in 14% of water bodies. Most were species commonly stocked by aquarists and garden centres. The extensive occurrence of exotic plant species within the *submerged* plant community was of particular note: one in six of all submerged plant records was of a non-native species.

New ponds

New ponds (≤12 years old) were often rich in plant species and supported a relatively high proportion of uncommon plants. New ponds were also typically less enriched by nutrients than older ponds.

Seasonal ponds

Seasonal ponds are an ecologically important, but largely unrecognised, pond type in Britain. LPS96 data showed that these summer-dry ponds typically contained fewer plant species than permanent ponds and supported fewer locally-uncommon species. However, more than 40% of the rarest plants recorded in the survey were found only in seasonal ponds. This included the RDB2 species the Fox Sedge (*Carex vulpina*).

Evidence of degradation

Although the collective biological value of the survey ponds was very high, there was consistent evidence that the quality of the plant community in many lowland ponds had been at least partly diminished by human activities.

Ponds supported significantly fewer species where they were surrounded by arable land or were located in ITE arable landscape types. In contrast, ponds in non-wooded, semi-natural habitats, or located in pastural landscape types supported above-average numbers of wetland plant species.

Analyses also indicated a significant tendency for the highest-quality ponds to be situated in, or adjacent to, long-established wetlands, such as river valley flood plains and in semi-natural areas with traditional management (e.g. SSSIs).

A comparison between LPS96 ponds and a set of reference ponds located in areas of semi-natural land-use (National Pond Survey, NPS) showed that:

- LPS96 ponds supported significantly fewer uncommon plant species, and fewer plant species overall. Thus, most LPS96 ponds (c.80%) supported plant communities of Low or Moderate conservation value, whereas most NPS ponds (c.70%) supported plant communities of High or Very High conservation value.
- LPS96 ponds also had significantly higher Trophic Ranking Scores than NPS ponds, suggesting that they were chemically enriched and, by implication, floristically degraded by excess nutrients.

Amenity value

The amenity value of ponds was assessed in terms of 'amenity use' (e.g. fishing, shooting) and 'visual amenity' (e.g. visibility). LPS96 only provides a minimum estimate of the amenity value of ponds, since evaluations were based mainly on on-site evidence.

Amenity uses

More than 27,000 ponds (15%±3% of the total) were estimated to have an amenity use. The predominant uses were fishing (13%±3% of all ponds) and shooting (7%±3%). Ponds which had an amenity use were much more likely to be managed than those which did not. New ponds were more likely to have an obvious amenity use than older ponds.

Visual amenity

Just over one third of all ponds could be viewed from a public right of way (37%±6%), although only about 13% (±3%) of ponds were judged to provide a good visual amenity.

Overall amenity value

Combining use and good visibility, it was estimated that 50,000 ponds (22% ±4 of the national total) had an important amenity value.

6. Policy review and summary of recommendations

The results of the Lowland Pond Survey 1996 were evaluated in relation to current UK policies for countryside and wildlife. Suggestions for future policy development derived from this evaluation include recommendations for:

- Active promotion and enhancement of schemes to establish buffer zones or areas of low-intensity land-use around ponds.
- Promotion of schemes for pond creation together with improved guidance on design and location of ponds.
- Inclusion of simple stipulations for good management practice as part of grant conditions, to improve the conservation benefits derived from grants.
- Establishment of a national quinquennial programme of biological water quality monitoring in a representative range of ponds.
- Investigation into methods for ensuring greater statutory protection for high-quality ponds, e.g. those supporting nationally-uncommon species.
- Increased public awareness of major pond issues including the ecological importance of ponds, the value of seasonal ponds and the damaging spread of exotic species.
- Investigation into the relative effect of sediment accumulation, changing water tables and climate change on the number and value of ponds.

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1. INTRODUCTION

1.1 About this report

This report describes the findings of the Lowland Pond Survey 1996 (LPS96) undertaken for the Department of the Environment, Transport and the Regions (DETR) by Pond Action and the Institute of Terrestrial Ecology (ITE).

The overall aim of LPS96 was to describe the number and quality of ponds in countryside areas of lowland Britain in 1996. Specific project objectives were:

1. to undertake a national sample survey of ponds in 1996 following recommendations made in the project scoping study (Biggs *et al.* 1996),
2. to assess changes in the numbers of ponds in the lowland countryside between 1984, 1990 and 1996, and to assess the quality of ponds in lowland Britain,
3. to examine the reasons for the changes reported, and assess the implications of the survey's findings in relation to policies for countryside and wildlife,
4. to review the effects of current policies and make recommendations for policy development and for the practical conservation of lowland ponds,
5. to disseminate the results of the survey and make data available in digital formats compatible with the Countryside Information System (CIS).

Within the context of the survey, the term **pond** was defined as 'a body of standing water between $25 m^2$ and 2 ha in area that usually holds water for at least four months of the year' (see discussion of this definition in Biggs *et al.*, 1996).

The term **lowland** refers to the areas of Britain defined as arable or pastural landscapes within Countryside Survey 1990 (Barr *et al.* 1993). Thus the survey explicitly omitted ponds from upland and marginal upland landscapes (see also Section 2.1).

1.2 Background to the survey

1.2.1 Why do ponds matter?

Ponds are an ancient, natural freshwater habitat-type still commonly re-created by human activity (Biggs *et al.* 1994). Thus, although individually small in size, ponds are numerically abundant, and they remain by far the most common standing waterbody type in Britain (Table 1.1).

Table 1.1. Number and area of standing water bodies in Britain in 1990

Waterbody	Number	%	Area (ha)	%
Ponds (up to 2.0 ha[1])	297,300	97%	30,000	14%
Lakes (greater than 2.0 ha)	8,900	3%	180,000	86%

[1]Assumes that 25% of ponds in the size range 1.0-5.0 ha in CS1990 were 2.0 ha or below. Sources: Barr *et al.* 1993; Barr *et al.* 1994.

Ponds have an acknowledged societal value. They contribute to national heritage (moats, mill ponds, marl pits), they can be of local and sometimes regional scenic importance, they have a leisure value (shooting, golf hazards) and increasingly an economic function (irrigation ponds, balancing ponds, fisheries). Nationally, however, their greatest significance is, likely to be as a wildlife habitat, where ponds play an essential role protecting a high proportion of UK freshwater biodiversity.

Ponds are a very rich wetland habitat type collectively supporting at least two-thirds of Britain's freshwater plants and animal species. These include specially protected plants and animals such as Starfruit (*Damasonium alisma*), the Tadpole Shrimp (*Triops cancriformis*), the Fairy Shrimp (*Chirocephalus diaphanus*), the Glutinous Snail (*Myxas glutinosa*), the Great Crested Newt (*Triturus cristatus*) and the Natterjack Toad (*Bufo calamita*).

In both species-richness and species-rarity, ponds compare favourably with other major freshwater ecosystems, such as lakes and rivers. For example, comparison of the river invertebrate database established by the Institute of Freshwater Ecology (614 sites), with a similarly-collected but smaller data set (156 sites) from the National Pond Survey suggests that, at a national scale, small water bodies support (a) at least as many invertebrate species as rivers and (b) considerably more uncommon and rare species (see Table 1.2).

The high species-richness of ponds at national level may, in part, be due to the individually varied physical and chemical conditions ponds provide.

Table 1.2 Comparison of macroinvertebrate biodiversity in 156 pond and 614 river samples: species richness and rarity

	Species richness		Nationally Scarce spp.		Red Data Book spp.	
	Ponds	Rivers	Ponds	Rivers	Ponds	Rivers
Flatworms	8	9	1	0	0	0
Snails and orb mussels	34	33	1	2	4	2
Leeches	10	14	1	0	0	0
Shrimps, slaters and crayfish	6	10	0	0	0	0
Mayflies	19	37	0	1	1	3
Stoneflies	7	27	0	1	0	0
Dragonflies	26	13	4	2	1	0
Water bugs	45	27	2	0	1	0
Water beetles	170	100	60	27	13	4
Alderflies and spongeflies	2	3	0	1	0	0
Caddis flies	71	95	3	7	1	4
Total number of species	**398**	**368**	**72**	**41**	**21**	**13**

Sources: National Pond Survey unpublished data (see Section 1.3.2); Wright *et al.* (1996). The comparison is based on all invertebrate groups sampled in both surveys for which reliable published national distribution and status data are available.

Note: Numbers of taxa given by Wright *et al.* (1996) in their Table 1 were modified as follows to enable comparisons to be made: *Argulus foliaceus* was omitted from the Crustacea total; *Sigara (Sigara)* sp. was omitted from the Hemiptera total; water beetles in the family Scirtidae (4 taxa) were omitted from the Coleoptera total; Hydroptilidae (7 taxa) were omitted from the Trichoptera total.

Additionally, their high collective value may be partly linked to water quality. Ponds often have small catchments, so where they occur in areas of low intensity land-use their water sources may remain relatively unpolluted. In contrast, even the highest quality rivers or lakes will usually be exposed to a range of degrading human impacts from their catchment areas.

1.2.2 Current understanding of the number and quality of ponds

Recent surveys investigating trends in the number of Britain's ponds have given somewhat contradictory results. Swan and Oldham (1989), reporting the results of the National Amphibian Survey, estimated that pond loss since the Second World War was of the order of 38%. ITE's analysis of Countryside Survey 1990 results for the DOE suggested similar rates of loss (ca. 1% per annum) in the period 1984 to 1990 (Barr *et al* 1994), although interpretation of these data was hampered by difficulties in distinguishing seasonal ponds from ponds which were permanently lost. In contrast, the 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% over that period (ca.+0.5% per annum) (MAFF 1985).

Concomitant with debate over the number of Britain's ponds, conservation organisations have become concerned that ponds may be facing threats to their quality (PCG 1993, English Nature 1997). Ponds are typically small in area and volume, and are individually vulnerable to degradation from factors such as urban runoff, nutrient enrichment, acidification, pollution from agricultural biocides, abstraction and land drainage. If climate change follows predicted patterns (Environment Agency 1996a), this may result in additional impacts to pond plant and animal communities. Currently, there are few data with which to evaluate these threats.

More positively, recent changes to the Common Agricultural Policy and the introduction of environmental land management schemes, such as Countryside Stewardship, may have brought some benefits to ponds, particularly through reduced chemical inputs, and possibly through raising of water levels. However, the effects of these schemes have been little studied. Similarly, although grant-aid and advice on pond management are available, there is little information available to assess their effectiveness.

Uncertainties relating to both the number and quality of ponds in Britain led DETR (then the Department of the Environment) to initiate a project which would clarify the current status of Britain's ponds. In collaboration with the Environment Agency (then the National Rivers Authority) a scoping study was commissioned, and undertaken by Pond Action and ITE, in order:

i) to provide a rationale for the 1996 pond survey,

ii) to develop definitions of terms,

iii) to outline pond survey methodology options and their consequences.

DETR based the specifications for LPS96 on options selected from the project scoping study (Biggs *et al.* 1996), but also set limits in terms of the survey area (lowland Britain) and the number of one-kilometre squares to be surveyed (n=150).

1.3 Overall approach to LPS96 and constraints imposed by previous surveys

LPS96 is a 'thematic survey' which forms part of the Countryside Survey series. DETR currently intends that broad-based Countryside Surveys will be carried out in Britain at intervals of six to eight years, with more specialised thematic surveys (e.g. ponds, hedgerows) undertaken as required.

As a thematic survey, it was important that the Lowland Pond Survey 1996 conformed to the essential Countryside Survey rationale. Compatibility was particularly important for data relating to pond numbers as CS1984 and CS1990 surveys had both collected potentially compatible data of this type. This influenced factors such as the choice of 1-km survey squares, the size range of water bodies surveyed and the timing of the survey.

Aspects of pond quality and condition were not, however, specifically addressed during the two earlier Countryside Surveys (CS1984, CS1990). In these areas, therefore, survey methodologies were developed so as to maximise compatibility with National Pond Survey (NPS) methods (Pond Action 1994b,c). This enabled direct comparisons to be made between LPS96 and NPS pond data sets.

Because of their relevance to this report, brief summaries of the Countryside Survey and National Pond Survey are given below.

1.3.1 The Countryside Surveys

Three previous Countryside Surveys, all undertaken by ITE, are relevant to LPS96.

i) **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 therefore concentrated on mapping land cover and landscape feature. Records of water bodies included combinations of attributes to define size and associated vegetation cover (Barr *et al.* 1993).

ii) **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 was increased to 508 rural 1-km squares, with an additional 25 urban squares surveyed separately. Water bodies were mapped as part of the field survey.

iii) **Hedge Survey 1993.** Inland water bodies were recorded as part of a hedgerow survey undertaken in England and Wales only. This included re-surveying 108 1-km squares visited during CS1990, of which 62 contained water bodies (see appendix report in Barr *et al.* 1994).

1.3.2 The National Pond Survey

The National Pond Survey was initiated and undertaken by Pond Action, with support from WWF-UK, between 1990 and 1994. The NPS comprises a data set of approximately 200 ponds located in areas of semi-natural land use throughout Britain. Data gathered from each site includes physico-chemical information together with records from both macroinvertebrate and plant surveys.

There is now a consensus amongst freshwater ecologists, water managers and, increasingly, legislators, that assessments of ecological quality should be made by comparing community or ecosystem quality with reference to undisturbed examples of that habitat type (Williams *et al.* 1996). The NPS provides such a reference data set of "minimally-impaired ponds" against which the quality of LPS96's countryside ponds could be assessed objectively.

2. DEFINITIONS AND METHODS

2.1 Definition of terms

The definition of a pond used for Lowland Pond Survey 1996 was "a body of standing water 25m^2 to 2 ha in area which usually holds water for at least four months of the year". This definition specifically included seasonal ponds, an ecologically important waterbody type which typically dries-out in the summer months. A set of criteria, including the presence of wetland plants, were used to distinguish seasonal pools from permanently dry ex-ponds lost through infilling or drainage (Annexe 1 and 2).

"Lowland" areas were defined in terms of the ITE Land Classification (e.g. Barr *et al.* 1993). This classification divides Britain into 32 land classes which in Countryside Survey 1990 were aggregated into four major landscape types: pastural, arable, marginal upland and upland. "Lowland" areas comprise the arable and pastural landscape types, and are defined by 19 of the 32 land classes. Figure 2.1 shows the distribution of arable and pastural landscape types in Britain.

As in both CS1984 and CS1990, urban land (more than 75% built up) was excluded from the LPS96 survey, together with all curtilage areas directly associated with buildings. Garden and farmyard ponds were not, therefore, recorded as part of LPS96.

A rationale, describing the basis for the definitions and attributes used in LPS96, is given in the project Scoping Study (Biggs *et al.* 1996).

2.2 Differences from previous surveys

The LPS96 survey strategy was designed to maximise compatibility between LPS96 and earlier Countryside Survey data gathered in 1984 and 1990. However, a number of modifications were made, where this did not compromise the ability to compare results between years. Most modifications involved extending the range of attributes or the countryside areas surveyed.

In summary, the main differences between LPS96 and previous Countryside Surveys (CS1984, CS1990) were:

i) LPS96 was a survey of *lowland* ponds, whereas previous Countryside Surveys provided estimates for Britain's countryside as a whole (i.e. including upland areas).

ii) Earlier Countryside Surveys did not attempt to separate ponds from other inland water bodies. Thus, in both 1984 and 1990 the size of all standing waterbodies was estimated and results were presented by size class (Barr *et al.* 1994).

iii) The pond definition used in LPS96 explicitly included semi-permanent and seasonal ponds. Previous Countryside Surveys had often, but not systematically, included these sites, and where "dry ponds" were recorded they were omitted from calculations of pond stock.

iv) In LPS96 the search area within each 1-km sample square was extended to include woodlands and recreation areas (such as golf courses). These areas were not always included in previous Countryside Surveys (see Barr *et al.* 1994).

v) In LPS96 the physico-chemical, biological and amenity status of ponds were recorded for the first time.

2.3 Sampling strategy

A total census of ponds in lowland Britain is logistically impractical, so extrapolation from a sample survey is inevitably necessary. There are several sources of uncertainty in estimating the number of ponds and year-to-year changes using any sampling technique. Mostly, these relate to natural variability in the distribution of ponds and the factors which affect their loss and creation, together with the effect such variability has on the chances of obtaining representative samples. The stratified random sampling strategy used in LPS96 was chosen to strike a balance between broad coverage of regions and land-use categories on the one hand and precision of estimation on the other, within a prescribed sampling framework and number of samples. Background to the choice of sampling strategy is given in the project Scoping Study (Biggs *et al.* 1996) and Annexe 1.4.

To determine changes in pond number it was necessary to re-survey those 1-km squares that had made up the earlier Countryside Surveys. To maximise collection of information about ponds, LPS96 focused on those 1-km sample squares which included inland water bodies in either the 1984 or 1990 Countryside Surveys ('pond squares'). It was recognised that this would bias the sample towards types of land which tend to have ponds. For estimating how many new ponds had been created a sample of squares were included in which ponds had not been recorded previously ('non-pond squares').

The sampling programme was limited to 150 1-km squares in 'lowland' areas of GB (see sections 1.2.2 and 2.1). Of the 19 lowland land classes, all but one included squares with ponds.

The original sampling strategy included the 141 lowland squares which had contained ponds in the 1984 and/or 1990 surveys, plus nine non-pond squares. This was subsequently modified because access could not be gained to some squares. The final sample number was 136 pond squares and 14 non-pond squares (Figure 2.1).

2.4 Field recording

Field survey work for LPS96 was undertaken over a 10 week period between 10th July and 13th September 1996. Each 1-km sample square was surveyed by a team of two people using information from previous surveys.

2.4.1 Recording the presence of ponds

Field teams systematically searched each 1-km square to locate ponds previously recorded and to identify new ponds. Data were also collected from sites where ponds were no longer present.

The status of extant ponds was recorded in one or more of six categories listed on the field recording sheet (Annexe 2). These categories were:

- Pond not significantly different from the base map (CS1990)
- New pond
- Pond enlarged
- Pond dried out
- Pond filled in
- Pond no longer present (other)

The method used to survey ponds in the 1984 and 1990 Countryside Surveys is outlined in Annexe 1.4.

2.4.2 Recording the physical attributes of ponds

A summary of the main physical and chemical attributes measured during LPS96 is given in Table 2.1. Methods used to collect these data are described in more detail in Annexe 1.1. The field sheet pro-forma is given in Annex 2.

2.4.3 Recording biological data

The biological quality of ponds was assessed on the basis of their wetland plant community. Plants included as 'wetland species' were defined by a standard wetland plant list (Annexe 2).

Surveyors recorded all wetland plant species growing within the pond boundary as defined in Annexe 2. Species were recorded during a search of the pond edges and shallow water areas. Plants growing in deep water were collected using a grapnel thrown from the pond bank. In deep ponds, plants were surveyed from a boat.

Plant species which required specialist or microscopic examination for identification (e.g. fine- leaved *Potamogeton*, batrachian *Ranunculus*, fruiting *Callitriche* and stonewort species) were forwarded to T. Rich or N.F. Stewart for confirmation.

Uncommon vascular plants, including Fox sedge, *Carex vulpina*, which has RDB2 status (Wiggington, in prep.), were confirmed by T. Rich.

The abundance of wetland plant species was recorded using a quantified DAFOR scale:

Rare	0-5% cover
Occasional	6-20% cover
Frequent	21-50% cover
Abundant	51-90% cover
Dominant	91-100% cover

The total percentage cover of wetland vegetation was recorded in the following categories:

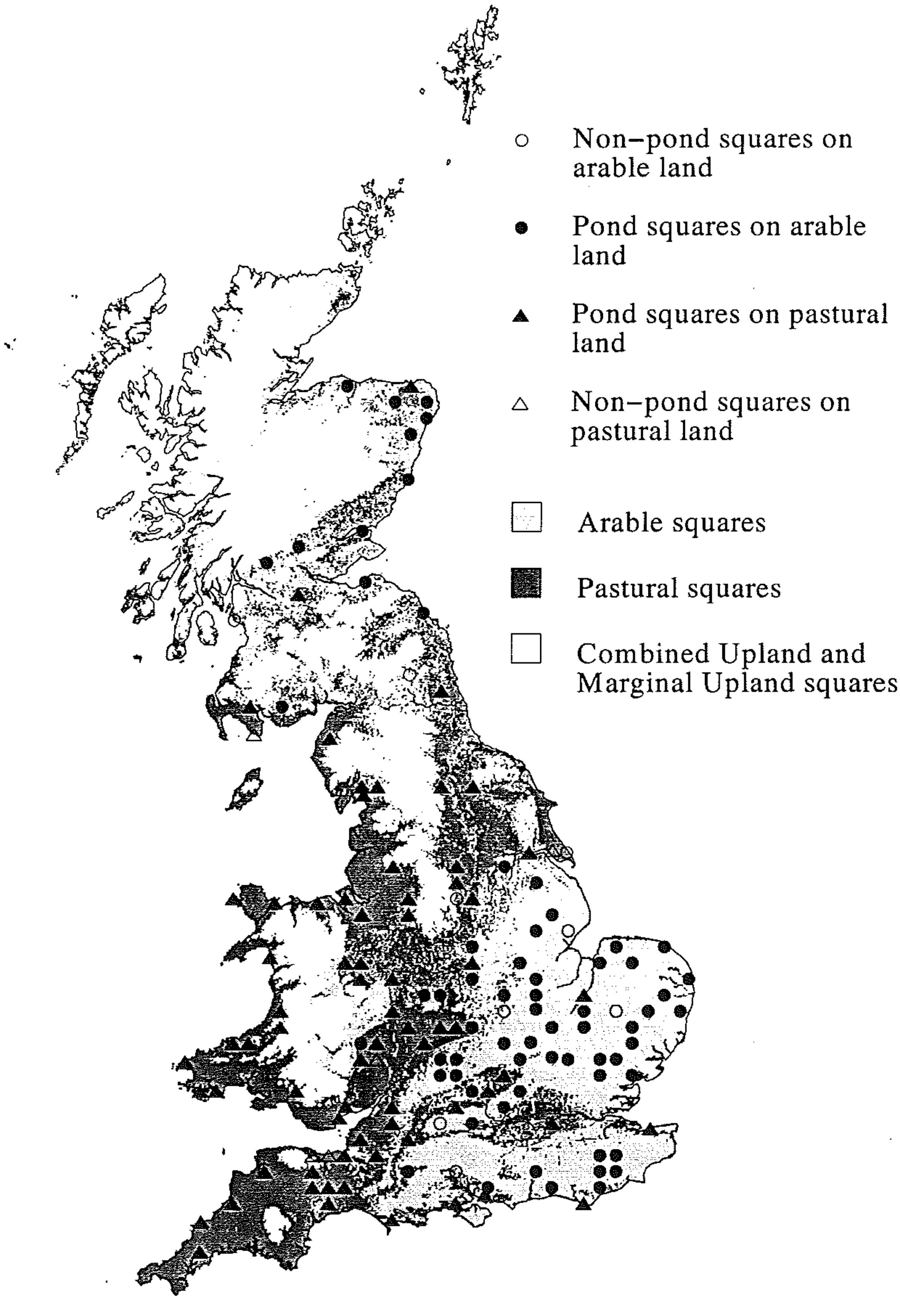
(i) emergent plants

(ii) floating-leaved plants

(iii) submerged plants

The species comprising these categories are listed in Annexe 2.

Figure 2.1 Distribution of Lowland Pond Survey 1996 1km squares



Map produced by ITE Merlewood, February 1998

Table 2.1 Physical and chemical attributes of ponds recorded in the Lowland Pond Survey 1996

Attributes	Variable analysed and how measured
Pond size	Surface area: area of the pond within the maximum level of standing (winter) water.
Water depth	Mean water depth at time of survey: mean of five measurements along perpendicular transects.
Sediment depth	Mean sediment depth: mean of five measurements along perpendicular transects.
Pond depth	Mean total depth: calculated mean water depth plus calculated mean sediment depth.
Drawdown and permanence	(i) Dry/wet pond, analysed as a dummy variable (1/0). (ii) Percentage of pond remaining water-filled: the proportion of the pond basin filled, compared to maximum winter water level (assuming winter is 100%). (iii) Drawdown height (cm): distance of water level below maximum (winter) level.
Pond base	Percentage of substrate in one or more of five categories (simplified from field data): butyl/synthetic, concrete, gravel/sand, bedrock, other).
Sediment	Percentage occurrence of four sediment type categories (simplified from field data): fine mud, sand/gravel, pebbles and rocks, coarse organic matter.
Water quality	(i) pH: measured in the field with portable meter. (ii) Conductivity ($\mu S\ cm^{-1}$) measured in the field with portable meter. (iii) Alkalinity ($mmol\ l^{-1}$) measured with field test kit. (iv) Calcium ($mg\ l^{-1}$) measured with field test kit.
Turbidity	Turbidity categories: estimated in one of four categories (clear, moderately clear, moderately turbid, turbid).
Pollution evident	(i) Visual evidence of pollution (e.g. sewage, oil): estimated on 1 to 4 scale. (ii) Rubbish and rubble: quantity ranked in one of five categories, from little rubbish to pond filled with rubbish.
Water source	Percentage of water contributed by one of six types of source: run-off, groundwater, spring/flush, stream/ditch/flood, surface water, precipitation.
Inflows/outflow	(i) Inflow present: recorded as a dummy variable (1/0). (ii) Wet inflow present: water present/absent, recorded as a dummy variable (1/0). (iii) Inflow volume: estimated in the field and ranked on 1 to 10 scale for analysis. (iv) Outflow volume: estimated in the field and ranked on 1 to 10 scale for analysis.
Adjacent wetlands and their connection to the pond	Number of lentic waterbodies, lotic waterbodies and wetlands present within three distance categories (0-5m, 5-25m, 25-100m) around pond: measured as (i) presence of a waterbody or wetland and (ii) presence of direct connection to the survey pond.
Surrounding land-use	(i) Percentage cover of each land-use type around pond: measured as cover of 17 land-use categories in three concentric zones around the pond (0-5m, 5-25m, 25-100m). (ii) Percentage cover of aggregate land use types around pond (e.g. all semi-natural): derived from field data for concentric zones around the pond (0-5m, 5-25m, 25-100m).
ITE Land Class	ITE Land Class: location of ponds in either pastural or arable ITE Land Class aggregate.
Proximity to high quality land uses	Presence of high-quality landscapes in the vicinity of the pond: data derived from EN SSSI database, OS maps, field data and other sources.
Shade	Percentage of pond shaded: measured as area of pond overhung by woody vegetation.
Occurrence of grazing	Pond grazed (e.g. by livestock, wildfowl): observed as present/absent in the field and analysed as a dummy variable (1/0).
Pond management	Evidence of pond management: analysed as a dummy variable (1/0). Management by dredging only: analysed as a dummy variable (1/0).

2.4.4 *Plant conservation value*

The conservation value of plant communities was assessed on the basis of:

i) the number of wetland plant species,

ii) the presence of uncommon plant species, measured as rarity scores and indices.

Vegetation abundance and the number of exotic species present at each site were also analysed. Methods used to calculate plant conservation value are described in more detail in Annexe 1.2.

The quality of pond sites was assessed in comparison with the National Pond Survey reference data set, which contains information on the composition of pond wetland plant assemblages minimally impaired by human activity in England, Wales and Scotland (see Annexe 1.3).

2.4.5 *Recording amenity data*

The amenity value of ponds was assessed using methods modified from Gee *et al.* (1994). Sites were ranked in terms of their potential visibility in terms of:

i) the visibility of the pond from areas to which the public had access as right of way or areas of open access (1= view obscured to 5 = pond clearly visible),

ii) the number of people likely to use these rights of way, gauged in terms of their importance (1=footpath or public access to 5=A road).

The amenity *use* of each pond was assessed using on-site evidence. Sites were scored according to the number of leisure uses (fishing or shooting etc.), which the pond provided (see Annexe 2).

2.4.6 *Quality assurance*

To check the quality of field recording, 10% of the squares were revisited by T. Rich or P. Williams (see Annexe 1.6). In addition, consistent collection of high quality field data was ensured through the following measures:

- a one-week pre-survey training course for field survey staff,
- provision of a field survey booklet and field survey pro-forma,
- use of the field survey co-ordinator to work with survey pairs in the first month of the survey,
- regular mixing of survey personnel and teams to prevent systematic temporal or spatial biases,
- desk-checks of recording sheets as they were returned.

2.5 Data entry, validation and management

2.5.1 *Spatial data*

The position of each pond in the 1-km squares was digitised using a geographic information system (GIS). This provided a record of the location of individual ponds and allowed surrounding land use information to be compared with previous survey data.

2.5.2 *Coded data*

All numeric, coded data were entered onto a computer database. Data describing the presence of ponds at different survey dates were entered twice, once at ITE Merlewood and once at Pond Action. The two spreadsheets were cross-checked and a single, definitive version was created.

2.6 Data analysis

2.6.1 *Estimating numbers of ponds*

The total number of ponds present in lowland Britain in 1996 was estimated using standard methods developed for the Countryside Surveys (e.g. Barr *et al.* 1993). Estimates of the number of ponds were made separately for 'pond squares' and 'non-pond squares' to allow for systematic differences which might exist between squares in these two categories (see Annexe 1.5). In each case, the mean number of ponds per square was calculated separately for each ITE Land Class. These means were multiplied by the number of squares in the respective land class in GB to give national estimates for the number of ponds in each ITE Land Class. The estimated Land Class totals were added together to produce a national estimate of the number of lowland ponds.

Statistics on the overall numbers of ponds were also broken down by size class (as in the reports of earlier surveys) and by land use context.

2.6.2 Estimating change from earlier surveys

Data gathered for LPS96 were directly compatible with the results of earlier Countryside Surveys in 1984 and 1990. However, since LPS96 gathered additional data for some pond types and landscape areas (e.g. for seasonal ponds, ponds in woodland areas etc.), the data sets were not identical (see Section 2.2).

The new records were used to estimate the current stock of lowland ponds but were *not* included in calculations of pond loss and gain.

2.6.3 Change in land use

Surrounding land use was recorded by LPS96 surveyors from concentric zones around each pond, at distances of 5 m, 25 m and 100 m, using National Pond Survey (NPS) methods. In earlier surveys, land use had been mapped for whole 1-km squares, so GIS was used to compute surrounding land use within the pond zones from the 1990 data.

The land cover codes used in LPS96 and the 1984 and 1990 Countryside Surveys were cross-referenced; a straightforward process since Countryside Survey codes nest well within the list of broader NPS codes used for LPS96 field recording.

2.6.4 Analysis of environmental variables

Statistical methods used in the analysis of environmental and biological data are described in Annexe 1.7.

2.7 Rainfall data

Although not used directly in the analysis of the LPS96 data, information on rainfall was important for interpreting survey results. There had, in particular, been some concern in earlier Countryside Surveys (CS1984, CS1990) about the effects of drought on the survey results.

Monthly rainfall data for England and Wales for 1981-1996 were obtained from the 10 Environment Agency regions. Data were not available from Scotland.

Table 2.2 Total rainfall in England and Wales in 1984, 1990 and 1996

	Total rainfall (proportion of long-term average)		
	CS1984	CS1990	LPS96
12 months preceding Countryside Survey (Oct-Sept)	91%	96%	78%
6 months preceding Countryside Survey (Apr-Sept)	77%	67%	72%

Long-term average rainfall data (1961-1990) was compared with rainfall data for the three periods leading up to and including the Countryside Surveys 1984 and 1990 and LPS96. For each survey rainfall was analysed over two periods: in the six months leading up to the surveys (April to September) and in the 12 months leading up to the surveys (October to September) (Annex 5).

The EA data (Table 2.2) showed that, by coincidence, the Countryside Surveys in 1984 and 1990 and the LPS96 coincided with three of the four driest summers in the period 1981 - 1996. For these three surveys, rainfall nationally was about three quarters of normal in the six months leading up to and including the surveys (67-77%). Generally, summer 1990 was slightly drier than 1996, and summer 1984 slightly wetter.

Of the twelve-month periods preceding each of the three surveys, the period preceding LPS96 included the most marked period of dry weather. Nationally, rainfall was 78% of the total expected and 8 out of 10 EA regions experienced less than 90% of 'normal' rainfall (see Annexe 5).

In contrast, in 1984 and 1990, national rainfall levels were, respectively, 91% and 96% of normal levels over the 12 months leading up to the surveys. In 1984 only one EA region had less than 90% of normal rainfall (Welsh Region). In 1990, three out of 10 EA regions had less than 90% of normal rainfall (Northumbria, Yorkshire and Anglian Regions) (see Annexe 5).

3. THE NUMBER OF PONDS IN LOWLAND BRITAIN

3.1 The number of lowland ponds in 1996

3.1.1 Number of ponds in lowland Britain

Extrapolation of LPS96 survey data suggests that in 1996 the number of ponds in lowland Britain was approximately 228,900 (±25,900)[1] (Table 3.1). Nearly 90% of these ponds were in England, where 77% of the lowland landscape type is found.

Pond densities in 1996 were 1.7, 0.4, and 1.4 ponds per km^2 in England, Scotland and Wales, respectively (Table 3.2). Data used to calculate density are given in Annexe Table 3.1.

LPS96 revised upwards the total number of ponds in lowland Britain by about 29% (from 177,000 in lowland Britain in CS1990). This increase was the result of methodological modifications which, for example, increased the countryside areas covered by the survey and refined definition of the term 'pond' to distinguish seasonal ponds from permanently dry sites (see Section 2.2).

Table 3.1 Estimated number of ponds in lowland Britain in 1996

	Estimated no. of ponds	Standard error
England	203,100	23,900
Scotland	10,100	2,700
Wales	15,700	3,500
Great Britain	**228,900**	**25,900**

3.1.2 Size of ponds

Sixty-two percent (±9%) of ponds fell into the smallest size class (25m^2 - 0.04 ha). Fewer than 2% (±0.7%) of ponds were larger than 1 ha in area. Numbers of ponds in different size classes are shown in Annexe Table A3.2.

[1] Note: numbers in parentheses are standard errors. They should not be interpreted as confidence limits.

Table 3.2 Pond density in lowland Britain in 1996

	Density of lowland ponds (no. ponds per km^2)
England	1.7
Scotland	0.4
Wales	1.4
Great Britain	**1.5**

The proportion of ponds in each of the size classes was similar in England and Wales, where more than 60% (±9%) were in the smallest size class. Scotland had proportionally more large ponds, with only 34% (±13%) in the smallest size class (see Annex table 3.2).

3.1.3 Land use context of ponds

Just over half of the ponds recorded were found on farmland, with twice as many in grassland as in arable land (Figure 3.1). About 20% (±4%) of ponds were found in woodlands. Data from CS1990 show that about 8% of lowland Britain is wooded, so these data suggest that there is an above-average density of ponds in woodland. This supports Rackham's contention that there are usually more ponds in woods than in the same area of surrounding land (Rackham, 1986).

There appeared to be similar numbers of ponds in the larger size classes (0.2-1.0 ha and 1.0-2.0 ha) in grassland (5%, ±3%) and arable land (<5%, ±4%) but more in woodland (16%, ±6%) and other land[2] (17%, ±7%).

No information about land use was obtained for about 8% (±2%) of the ponds because although surveyors were able to determine a pond was present (e.g. ponds could be seen from a distance), they could not gain access.

Figures relating to the distribution of ponds by size class, land use context and region are given in Annexe Tables A3.3a and A3.3b

[2] Other land includes: scrub, rank vegetation, gardens and parks, buildings and concrete, tracks, railway, graveyard, bare/disturbed ground, dumps, spring, canal, and saltmarsh.

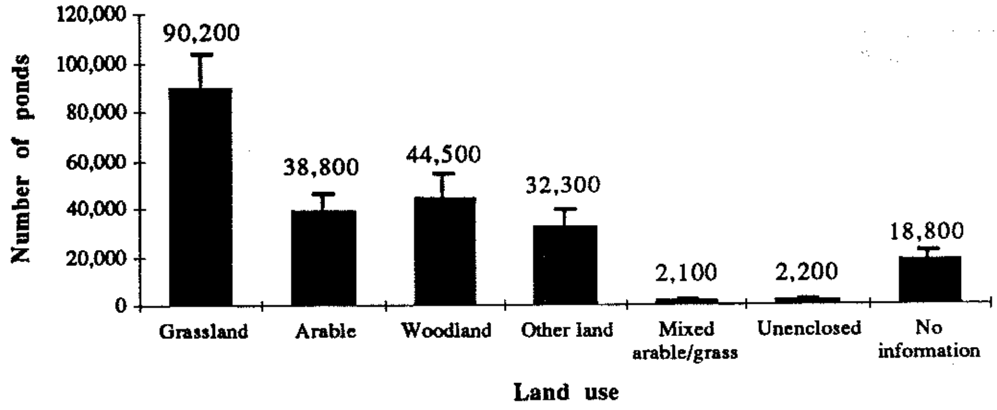


Figure 3.1 Number of ponds in different land use contexts in lowland Britain in 1996

3.1.4 Permanent and seasonal ponds

LPS96 categorised ponds, for the first time, as either permanent or seasonal (see Section 2.1). The survey results indicated that over one-third of all ponds were identified as seasonal (i.e. completely dry at the time of survey in summer 1996) (Table 3.3). Many others were almost dry or very shallow (See Section 4.2)

Table 3.3 Number of seasonal and permanent ponds in lowland Britain in 1996

	Number	Standard error	%
Seasonal			
England	74,800	12,400	33%
Scotland	1,300	700	1%
Wales	6,500	2,300	3%
Great Britain	82,500	13,900	37%
Permanent			
England	128,300	17,300	56%
Scotland	8,800	2,400	4%
Wales	9,200	1,800	3%
Great Britain	146,400	18,400	64%
Total	**228,900**	**25,900**	**100%**

The proportion of seasonal ponds was greatest in England and Wales (37%, ±6% and 41%, ±15% of ponds, respectively). In Scotland, only 13% (±7%) of lowland ponds dried out in 1996. About three-quarters of seasonal ponds (77% ±14%) were in the smallest size class, compared with 54% (±9%) of permanent ponds. However, not all seasonal ponds were small and there were a number of records of seasonal ponds of more than 0.2 ha., mostly in woodland and on 'other land' categories. Seasonal ponds made up about 37% (±9%) of the total number of ponds in the lowland landscape.

A breakdown of seasonal ponds by land-use context, region and landscape type is given in Annexe Tables A3.4a and A3.4b. Characteristics of permanent ponds are summarised in Annexe Tables A3.5a and A3.5b.

3.2 Pond creation and pond loss between 1990 and 1996

3.2.1 New ponds created between 1990 and 1996

In lowland Britain as a whole, an estimated 15,000 new ponds were created between 1990 and 1996. This represents 6.6% (±3%) of the 1996 stock of lowland ponds (see Table 3.1 and Table 3.4).

Most new ponds fell into the smallest size class ($25m^2$ - 0.04 ha) and none encountered in the survey were more than 1 ha in area (Annex Table 3.6b). Nevertheless, new ponds were, on average, larger than established ponds (mean areas 0.170 ha and 0.096 ha, respectively).

More than two-thirds (70% ±41%) of the newly-created ponds were located in pastural landscape types. However, only 31% (±13%) of ponds were directly surrounded by grassland, most having being created on land with 'other' uses within pastural areas.

A full breakdown of new ponds by land-use context, region and landscape type is given in Annexe Tables A3.6a and A3.6b.

Table 3.4 Number of new ponds created in lowland Britain between 1990 and 1996

	No. new ponds	Standard error	% of total gain
England	12,800	5,000	85%
Scotland	0[3]	0	0%
Wales	2,100	1,600	15%
Gt. Britain	**15,000**	**6,400**	**100%**

3.2.2 Ponds lost between 1990 and 1996

An estimated 17,000 (±3,900) lowland ponds were lost between 1990 and 1996, representing 7% of the 1990 total stock (see Table 3.1 and Table 3.5).

All survey ponds lost between 1990 and 1996 were from the smallest size class ($25m^2$ - 0.04 ha).

Table 3.6 shows a break-down of the reasons for pond loss. About 81% (±29%) of the lost ponds were identified as having been filled in, built over or drained (i.e. permanently dry) by the time of survey. About 19% (±9%) were lost for some other, unknown, reason (Table 3.6). In Scotland, in particular, the main reasons for loss remained largely unidentified.

In terms of land use context, the data suggest that slightly more ponds may have been lost from ITE arable landscape types than from pastural landscape types (56%, ±18% compared to 44%, ±14%). However, in terms of the land use in the immediate pond surrounds, nearly half of the lost ponds (46%, ±14%) had been in grassland, with only 14% ±7%) from crop lands.

Characteristics of lost ponds and the reasons for loss are summarised by land-use context, region and landscape type in Annexe Tables A3.7a, A3.7b, A3.8a and A3.8b.

Table 3.5 Number of ponds lost in lowland Britain between 1990 and 1996

	No. of ponds lost	Standard error	% of total loss
England	14,500	3,400	85%
Scotland	1,200	900	7%
Wales	1,300	500	8%
Great Britain	**17,000**	**3,900**	**100%**

Table 3.6 Reasons for pond loss in lowland Britain between 1990 and 1996

	Number of ponds	Standard error	% of GB total loss
Drained	5,900	2,000	35%
Filled-in	5,800	1,900	34%
Built-over	2,100	1,100	12%
Other losses	3,200	1,500	19%
Total	**17,000**	**3,900**	**100%**

Other losses include (a) pond amalgamation and (b) loss due to unknown reasons

3.2.3 Net change between 1990 and 1996

Net change in the number of lowland ponds in Britain during the periods 1984-90 and 1990-96 (Table 3.7) was estimated using net loss and gain statistics. This gave greater

[3] No new ponds were found in any of the squares surveyed in Scotland, so extrapolated estimates for Scotland could not be made. The absence of evidence for pond creation in Scotland is likely to be at least partly an artefact of the survey method. Because little of Scotland falls within the 'lowland' category, there were relatively few Scottish survey squares from which to derive a regional estimate of changes in pond numbers. Future surveys should address this issue.

precision than would have been possible using estimates of yearly totals alone (Section 2.6.2).

The results suggest that between 1990 and 1996 the was an estimated net loss of 2,000 (±7,500) ponds. Note however that because of the high standard errors associated with this figure it is not possible to state with confidence whether a real net loss occurred during the period. What is clear, however, is that the rate of pond turnover was high, at more than 1% per annum (see Section 3.2.2).

Table 3.7 Number of ponds lost and gained, and net change, in lowland Britain between 1984-90 and 1990-96

	1984-90		1990-96	
	Number of ponds	Standard error	Number of ponds	Standard error
Lost	52,055	9,255	17,000	3,900
Gained	43,909	9,226	15,000	6,400
Change	-8,144	12,787	-2,000	7,500

In terms of landscape type, there appeared to be a tendency towards net loss of ponds in lowland arable landscapes and a net gain in pastural landscapes (Table 3.8). Note, however, the high standard errors associated with these figures. Net losses were largely coincident with agricultural and woodland land uses, while the net gains were typically in 'other' and 'unknown' land-use types. All losses were from ponds in the smallest size class, whereas the gains occurred in all but one size class, though mostly in the smallest. The net change characteristics of ponds are summarised in Annexe Tables A3.8a to A3.9.

Table 3.8 Net change in pond numbers in arable and pastural landscape types between 1990 and 1996

	Gain	Loss	Net change	Standard error
Arable	4,400	9,600	-5,100	3,400
Pastural	10,500	7,500	3,100	6,600

3.3 Summary and discussion

The number of ponds

Lowland Pond Survey data suggest that in 1996 there were in the order of 229,000 (±23,900) ponds in lowland Britain, a total which, due to refinements in survey methodology, was 30-50% higher than 1990 estimates.

Pond loss and pond creation

The survey results show that a large number of countryside ponds are still being actively or accidentally drained and filled in in Britain. Between 1990 and 1996, an estimated 17,000 ponds were lost from the lowlands, an average of about 2,800 per annum, and about 7.5% of the 1990 stock over the period.

Of the cases where the reason for pond loss was known, the majority of sites (69%) had been either filled in or drained. Field observations suggested that in most cases, the cause of this loss was probably related to agricultural activities (field extension, commercial tree planting etc.). An additional 12% of sites had been built over as part of urban housing or road development. The remaining 19% were lost for unknown or unspecified reasons.

Balancing the pond loss, LPS96 data show that between 1990 and 1996 in the order of 15,000 new ponds were created in Lowland Britain.

Although it is clear that pond loss was partly offset by pond creation, the continued loss of established ponds remains an issue of concern. This is in part because there is no guarantee that existing grant levels will be maintained to ensure similar levels of pond creation will continue in future years. Partly because LPS96 is the first Countryside Survey to assess the quality of ponds, there is, as yet, no evidence to suggest whether new ponds are replacing lost sites *ecologically*, as well as numerically (see also Section 8.3.1).

Net changes in pond numbers

The balance of pond loss and gain gives a calculated net change in pond numbers of -2,000 (±7,500). Because of the high standard error associated with this figure it is, however, not possible to state whether a real loss in pond numbers occurred over the period.

Seasonal ponds

LPS96 is one of the first surveys to distinguish seasonal ponds, which naturally dry out in summer, from ponds which have been drained and are permanently dry (and which can be regarded as 'lost'). The data suggest that seasonal ponds currently make up a high proportion of the total pond stock of lowland Britain (approximately 37%). 1996 was an unusually dry year (Section 2.4.6), and some ponds may have dried for the first time. However, this is unlikely to change the overall observation that seasonal or semi-permanent ponds are a common countryside feature.

4. PHYSICAL AND CHEMICAL CONDITION OF PONDS

4.1 Introduction

LPS96 described the physico-chemical condition of ponds in terms of six major variables: (i) water and sediment depth (ii) water chemistry (iii) water source (iv) substrate (v) shading (vi) management. For each of these variables field survey data were analysed to provide:

(i) average and range statistics for the survey ponds,

(ii) national estimates of the physico-chemical condition of ponds (e.g. number of seasonal ponds, proportion of ponds in shade categories),

(iii) inter-relationships between the physico-chemical variables.

The data were also analysed to provide specific information about new and seasonal ponds, and were assessed in terms of the two Countryside Survey 1990 landscape types, lowland pastural and lowland arable (see Section 2.1).

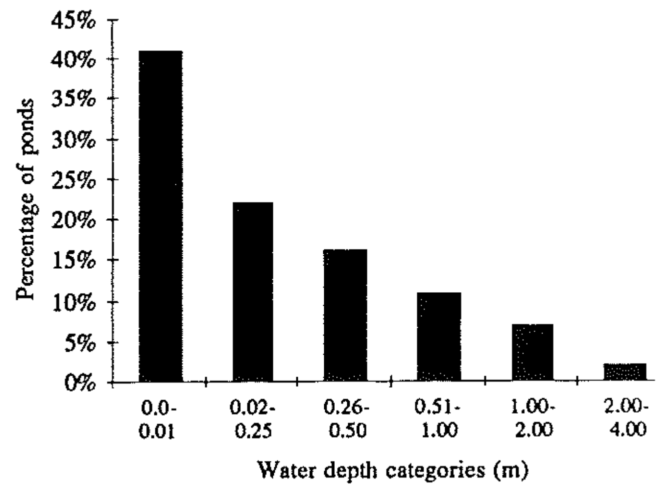


Figure 4.1 Pond water depths: proportions of ponds in different depth categories in 1996

In summer 1996 41% of lowland ponds were either seasonally dry or had less than an average of 1 cm depth of water (Figure 4.1). Many of the remaining 'wet' ponds were also quite shallow so that, in total, almost two thirds of all the ponds (63%) were either seasonally dry or retained water less than 25 cm deep (Annexe Table 4.1).

Average total pond depth (measured as the sum of water, sediment and drawdown depths) was 1.17 m. Average total depths for ponds on ITE pastural and arable landscape types were similar (1.24 m and 1.18 m respectively).

4.2 Physico-chemical variables: average and range

4.2.1 Water depth and area

The average water depth for the ponds in summer 1996 was 44 cm (63 cm excluding seasonal sites). The maximum depth measured was almost 5 m but in practice fewer than 2% of sites had summer water depths greater than 2 m (Figure 4.1).

Few ponds were 'bank-full' when the survey was undertaken in summer 1996 and, on average, the area of *water* present in the ponds was estimated to be only 52% of the ponds' winter water area (Table 4.1). This summer average does, however, include many ponds that were dry at the time of survey. When seasonal ponds are omitted from the calculation, the remaining 'wet' ponds were, on average, drawn-down to approximately three-quarters (73%) of their bank-full area.

The average of drawdown height between winter and summer levels was approximately 33 cm and this was similar in arable and pastural landscape types (Table 4.1).

4.2.2 Sediment depth

The pond sediment depth average (0.43 m) was similar to the summer water depth average (0.44 m) but the range of sediment depths was smaller (Table 4.1). Calculations of the average and maximum sediment depths may be an under-estimate, however, since field measurement of deep silt was difficult (Annexe 1.1.2).

At a national level (Annexe Table 4.2) it is estimated that 46% of ponds had relatively little soft accumulated sediment (depths less than 25 cm), a result partly caused by the inclusion of temporary ponds, many of which had a relatively hard soil base. In 6% of sites sediment depths were greater than 1 m. Average sediment depths in pastural and arable landscape types (Table 4.1) were similar (0.42 m and 0.43 m respectively).

Pond sediments typically comprised fine muds (54%) with coarser organic matter (36%) (Annexe Table 4.3). Approximately 19% of ponds contained a proportion of sand, gravel or pebble in their sediment, either because of a stream input or because of the sandy character of the underlying substrate. On average, however, these contributed only 10% towards sediment composition (Annex Table 4.3).

Table 4.1 Pond water depths, sediment depths and drawdown in 1996

	Pastural or arable land		Great Britain	
	Average		Average	Range
	Past.	Arable		
Water depth (m)	0.50	0.40	0.44	0-5.0
Water in pond	58%	48%	52%	0-100%
Drawdown (m)	0.32	0.35	0.33	0-3.00
Sediment depth (m)	0.42	0.43	0.43	0-2.50
Total depth (m)	1.24	1.18	1.20	0.09-4.60

4.2.3 Water source

Most ponds were fed by a combination of water sources. Near-surface runoff contributed the greatest percentage to pond water supply (47%), followed by inflows and groundwater in similar proportions (23% and 19% respectively), (Annex 4.4). The presence of an inflow (e.g. stream, pipe or spring) was common (55% of ponds), although at many sites (34%) the inflow was dry at the time of the survey (Figure 4.2).
Ponds in pastural landscape types were more likely to have an inflow than ponds on arable land, and the inflow was nearly twice as likely to be wet at the time of survey (Annex Table 4.4). As a consequence, ponds in pastural landscapes received a significantly greater proportion of their water from springs (P<0.05) and streams (P<0.01) than ponds in arable landscape types.

Ponds in arable landscapes were, in contrast, more likely to be fed by groundwater or surface runoff than ponds in pastural landscape types (P<0.05 and P<0.001 respectively).

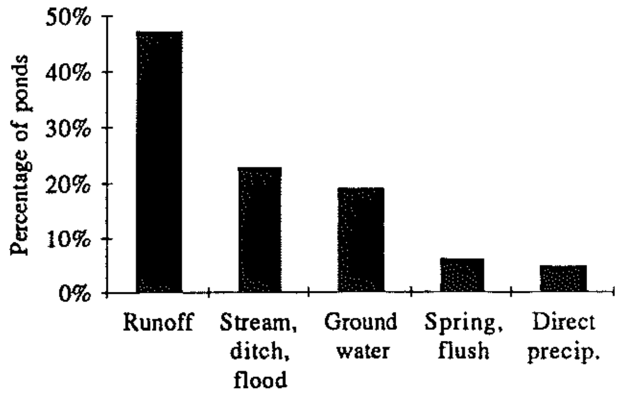


Figure 4.2 Proportions of ponds fed by different water sources in LPS96

4.2.4 Water quality

Field test kits were used to provide background information about the chemical status of LPS96 ponds (see Annex 1.1.6).

The average conductivity for all lowland ponds was high (808 μS cm^{-2}), and the mode was higher still (1190 μS cm^{-2}). Across the range, conductivity varied between 7100 μS cm^{-2} at a slightly brackish site, to the lowest 44 μS cm^{-2} in a pond on the margins of the North York Moors.

Conductivity can be used as a crude measure of nutrient status, in the absence of saline influences. The normal upper limit regarded as 'freshwater' is about 1500 μS cm^{-2}. Values below 200 μS cm^{-2} are broadly indicative of oligotrophic and mesotrophic waters, while values above this are typical of eutrophic or hypereutrophic waters (Palmer, 1989). In LPS 1996, ponds located in arable landscape types (896μS cm^{-2}) had significantly higher average conductivity values than ponds located in pastural landscape types (695μS cm^{-2}), (P<0.0001).

Most LPS96 ponds had a circumneutral pH with an average across all ponds of 7.8. The pH range was relatively narrow, varying from slightly acid (pH 5.6) to moderately alkaline (pH 10.7). Ponds in pastural and arable landscape types had a similar average pH (Table 4.2).

Calcium levels from the ponds varied between 6.4 and 248 mg l^{-1}. The average for all sites was 86.3 mg l^{-1}, but calcium concentrations were skewed towards the lower end of the range and the modal concentration was only 48 mg l^{-1}. Ponds in ITE arable landscapes typically had higher calcium levels than pastural landscape ponds ($P<0.0001$).

In terms of water clarity (Figure 4.3), ponds were fairly evenly spread across the four clarity categories (clear, moderately clear, moderately turbid and turbid). Pastural ponds were, however, significantly clearer than ponds located in ITE arable landscape types ($P<0.01$).

Table 4.2 Water quality: average data for LPS96 ponds

	Landscape type		All
	Pastural	Arable	Ponds
pH	7.8	7.8	7.8
Calcium (mg l^{-1})	71	100	86
Conductivity (µS cm^{-1})	695	896	808

Rubbish was observed in over a third of LPS96 sites (35%), although it was usually present in small quantities. At some ponds, however, there was sufficient rubbish or rubble to at least partially infill the pond. Extrapolation of the data set figures to give national figures suggests that this was true of approximately 5% of lowland ponds nationally (Annexe Table 4.5).

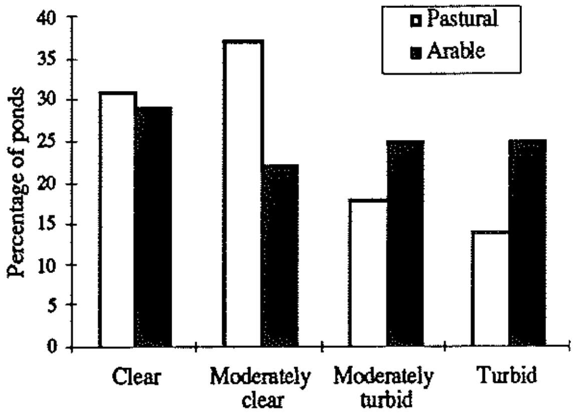


Figure 4.3 Water clarity of ponds in pastural and arable landscapes in LPS96

4.2.5 Tree cover

The average tree cover for ponds in the data set was moderately high (37% cover). As Annexe Table 4.6 shows, extrapolation of the survey data to give national estimates suggests that although almost half the sites (47%) had less than 25% tree cover, 20% of ponds were almost completely overhung (76%+ tree cover).

4.2.6 Pond management and grazing

There was evidence that pond management had been recently carried out at approximately 14% of ponds nationally (Annexe Table 4.7). This figure must represent a minimum, however, since the data was based only upon on-site evidence, such as dumped vegetation and spoil or conversations with farmers and landowners.

Table 4.3 lists the main forms of management undertaken in the survey ponds as a proportion of total management. The most common management practice for which there was evidence was pond dredging. Just under half of the managed ponds had been either partially or fully dredged since the previous survey in 1990. This represents approximately 6% of lowland ponds nationally (i.e. c.1% per annum). Removal, or addition, of wetland plants was also relatively common practice, accounting for 18% and 9% of all management respectively. The remaining forms of management were largely non-invasive and were dominated by cutting-back of bankside vegetation.

Recent pond management was associated with ponds that were deeper and more permanent. However, there was no indication of a specific relationship between *dredging* and waterbody depth or permanence.

Interestingly, statistical correlations suggest that pond management was more likely to be undertaken where a pond was located in close proximity to buildings (i.e. 5 - 100 m from the pond). There was a comparable negative correlation between management and both overhanging tree cover and woodland in the surrounds (Annex 7).

a sediment infill rate in the order of approximately 2.5 cm to 3 cm per year[4].

Table 4.3 Type of pond management undertaken

Type of management 1990-1996 (as a proportion of total management):	
Partial dredging	23%
Fully dredged or dug out	23%
Little vegetation removed	16%
Much vegetation removed	2%
Bankside plants managed	18%
Plants introduced	9%
Pond modified in size or shape	5%
Structural work: dams, overflows	4%
Straw bale added	5%
Trees planted	2%
Trees partly cut back	4%
Unspecified	2%

4.2.7 Grazing

A relatively high proportion of ponds (23%) were directly grazed by stock (by horses, cattle or sheep).

The number of grazed ponds was a little higher in pastural landscapes (27%) than in arable landscape types (20%). However, the difference was not significant.

4.3 New ponds

The characteristics of new ponds created during the periods 1984-1990 and 1990-1996 are summarised in Table 4.4.

New ponds were on average rather larger, deeper and more permanent than other countryside ponds, and these differences were significant ($P \leq 0.001$). Interestingly, new ponds were also significantly more likely to be fed by inflows than older ponds ($P < 0.001$).

Predictably, new ponds had significantly less accumulated sediment and were relatively little shaded by overhanging trees compared to more mature sites ($P \leq 0.001$). Comparison of the 1984-90 and 1990-96 data sets suggests that both shade and sediment depth showed a progressive increase with time. Thus the average percentage of tree cover overhanging the new ponds doubled (from 7% to 16%) between the two dates. Sediment depths were consistent with

4.4 Seasonal ponds

Seasonal ponds are an ecologically important but little recorded habitat type, so their physical characteristics are of particular interest. In the LPS96 data set, seasonal ponds were, on average smaller and less silty than their more permanent equivalents. They were also more likely to be shaded and have organic rich sediments. In terms of their water source, seasonal ponds were more likely to be fed by near surface runoff than more permanent ponds, and less likely to be spring fed.

Data comparing the physico-chemical characteristics of permanent and seasonal ponds are given in Table 4.4.

Table 4.4 The physico-chemical characteristics of new ponds.

	New 1990-96 (n=15)	New 1984-90 (n=11)	Older (n=351)
Pond area	1707m²	2496m²	959m²
Water depth	1.00m	0.50m	0.42m
Water in the pond	85%	80%	51%
Drawdown	0.31m	0.57m	0.33m
Sediment depth	0.09m	0.24m	0.44m
pH	8.1	8.1	7.8
Calcium	75µS cm⁻¹	93µS cm⁻¹	87µS cm⁻¹
Conductivity	733µS cm⁻¹	1431µS cm⁻¹	815µS cm⁻¹
Pond overhung	7%	16%	38%
Sediment:			
coarse organic	2%	23%	35%
pebbles and rocks	0.4%	0%	1%
gravel/sand	30%	16%	8%
fine muds	67%	60%	55%
Pond managed	26%	9%	16%
Rubbish and rubble	7%	36%	36%
Grazed	7%	18%	24%
Water source:			
groundwater	8%	18%	20%
stream/spring	50%	49%	29%
runoff	37%	29%	47%
precipitation	4%	5%	5%

[4]Calculated as average sediment depth for the periods 1984-1990 and 1990-1996 divided by nine years and three years respectively (i.e. the average number of years previous to the 1996 survey).

4.5 Correlations between physico-chemical variables

4.5.1 Intercorrelations in the data set

Relationships between the major physical chemical and landuse variables measured in the study were investigated using correlation analyses (statistical methods described in Annexe 1.7).

The LPS96 data set shows strong intercorrelations between four major physical variables: pond area, water depth, shade and sediment type. Thus ponds which were larger also tended to be deeper, more permanent and more likely to be fed by inflow streams. Larger ponds were also less likely to be extensively overhung by trees. This contrasted with a smaller, shallower pond type which was generally more shaded, likely to have a coarse organic-rich sediment and more likely to be fed by run-off water.

Inter-relationships between other physico-chemical variables (pond drawdown, sediment, water chemistry, water source, shading, grazing and land cover) are discussed further in Annex 4.

Table 4.5 The physico-chemical characteristics of seasonal ponds

	Seasonal ponds n=109	More permanent ponds n=268
Pond area	324 m²	1266 m²
Drawdown	0.37 m	0.32 m
Mean silt depth	0.3 m	0.47 m
Mean total depth	0.31 m	1.06 m
Pond overhung	53%	30%
Sediment:		
coarse organic	62%	23%
pebbles and rocks	1%	2%
gravel/sand	3%	11%
fine muds	34%	63%
Rubbish and rubble	40%	33%
Grazed	23%	23%
Pond management	5%	21%
Water source:		
groundwater	17%	21%
spring/flush	2%	7%
stream, ditch	16%	26%
runoff	60%	41%
precipitation	5%	4%

4.6 Summary and discussion

LPS96 data provides the first published national estimates describing the physico-chemical condition of ponds in lowland Britain. The survey creates both a baseline against which future results can be compared and gives some initial insights into the characteristics of lowland ponds.

4.6.1 New ponds

The pond gain figures given in Chapter 3 suggest that pond creation is still a relatively common practice in the lowland countryside. Comparisons between new and older ponds suggests that new ponds tended to be significantly larger than average countryside ponds. There was also a significant trend towards creating stream-fed ponds, rather than ponds fed mainly by surface water or groundwater sources. This trend is of interest because there is some evidence to indicate that, in the long term, stream-fed ponds may be more exposed to stream-borne pollutants than if fed by other water sources (Pond Action 1994a).

4.6.2 Seasonality and pond infill rates

LPS96 results indicate that approximately 37% of lowland ponds were seasonally dry in 1996. In addition, water depth measurements indicate that, of the remaining ponds, the proportion with shallow water was high: an estimated 42% of lowland ponds had average summer water depths of less than 25 cm.

Given accurate pond sediment infill rates, it would be possible to estimate how long a pond of known depth will take to fill with sediment and lose permanent open water habitats. In practice, however, accurate estimates are difficult to make, partly because there are few published data and partly because of inherent variability between ponds. In particular:

(i) pond infill rates can vary considerably between sites. Lower infill rates are characteristic of open grazed ponds with few sediment inputs. Higher infill rates are characteristic of ponds with inflows or ponds heavily overhung by trees.

(ii) water depths themselves vary considerably with climate between years,

(iii) the pond infill rate may slow as the sediment level nears the water surface and organic sediments oxidise at elevated rates,

(iv) factors such as plant encroachment from the pond margin or as vegetation rafts may increase the rate of succession.

Data extrapolated from the sediment depths of new LPS96 ponds (created between 1984 and 1996) and which are of known age, suggests that, in these ponds, sediment has accumulated at a rate of approximately 2.5 cm to 3 cm per year.

If this average rate of infill in the new LPS96 ponds is broadly representative of all ponds in the data set this suggests that most of the 42% of ponds currently less than 25 cm deep will either become seasonal or begin to dry out within the next 10 years. The overall infill rate for ponds based on this rate would be in the order of 5.25% per annum in the next decade.

Estimates made using a broader range of sediment accumulation rates, between 0.5 cm and 4 cm per annum would, in contrast, give rates of infill of between 0.8% and 7% per annum.

It is worth stating that an increase in seasonality of ponds would not constitute an ecological disaster. Seasonal ponds have their own value and, as shown in this report and other literature, they can support distinctive communities and many uncommon species (Bratton 1990, Collinson *et al.* 1995).

It remains true, however, that the open water habitat provided by permanent ponds is both ecologically important and aesthetically pleasing. The implication is that if we wish to maintain the current number of ponds with open water and their associated biota, either dredging or creation of new ponds is likely to be required to maintain this habitat in the long term.

4.6.3 Management

LPS96 survey data suggested that between 1990 and 1996 whole or partial dredging of ponds had been undertaken in a minimum of 1% of ponds per annum.

Dredging and other forms of management effort appeared not to be evenly spread across all countryside ponds however. Pond management was typically associated with larger ponds located near to urban areas, such as buildings or gardens and less likely to be undertaken where ponds were shaded or in woodland areas.

4.6.4 Net loss of permanent ponds through sediment infill

As discussed above, lack of specific data relating to net pond infill rates makes it difficult to give accurate estimates of the rate at which permanent lowland ponds will begin to dry up in summer. Trend analyses from future lowland pond surveys, or more detailed measurement of infill rates, using gauge boards, would be needed for accurate assessments (Biggs *et al.* 1996).

However, based on currently available data there appears to be at least a strong risk of progressive future loss of permanent ponds through the process of natural infilling. Since this loss of permanent water habitats would be additional to the losses incurred through drainage or infilling, the reduction in permanent ponds would not be compensated by pond creation processes if they remain at their current levels.

Smaller, more isolated, shaded and woodland sites seem likely to be the main pond types affected by natural infilling. The latter categories are of particular concern since, as both LPS96 results and other studies suggest, shaded and woodland ponds may also infill more rapidly than more open ponds through the frequent addition of refractory leaf matter (Pond Action 1994a).

5. ECOLOGICAL QUALITY OF LOWLAND PONDS

5.1 Aims of the survey

A major aim of Lowland Pond Survey 1996 was to provide an evaluation of the ecological quality of Britain's lowland ponds.

In the survey, ecological value was assessed using attributes of pond wetland plant assemblages (specifically, the macrophyte flora[5]) as biological indicators of pond quality. The benefits and limitations of using wetland plants as an indicator group are summarised in Annexe 1.2.

5.2 Plant attributes used for quality assessment

The 'quality' of plant assemblages was assessed using criteria (attributes) which commonly have relationship with environmental degradation. Three principle attributes of plant assemblages were used to assess pond quality:

i) ***Species richness:*** measured as the number of plant species per pond for three types of vegetation:
   - number of emergent plant species
   - number of aquatic plant species (i.e. submerged and floating-leaved species)
   - number of all wetland species (i.e. sum of emergent and aquatic species)

ii) ***Species rarity:*** measured as a Rare Species Score (RSS), a numerical weighting of taxa to reflect their rarity (see Annexe 1.2).

iii) ***Trophic Ranking Score:*** (TRS) a numerical measure which indicates plant community response to nutrient enrichment (Palmer *et al.* 1992). See Annexe 1.2.

Two additional attributes of the plant assemblages were also investigated because they can sometimes be of value as quality indicators. These were:

(iv) **Vegetation abundance:** measured as percentage cover for the three vegetation types listed in (i) above. Aquatic vegetation cover is of particular interest.

v) **Exotic species:** the number of exotic wetland species or varieties introduced relatively recently to Britain and either naturalised or planted in ponds.

More information describing these five attributes and their relationship with anthropogenic degradation is given in Annexe 1.2.

To identify the effects of environmental degradation (such as water pollution) the LPS96 ponds were compared with the National Pond Survey database of minimally impaired ponds, located in areas of lowland semi-natural land use. This, in effect, provided a reference baseline with which the quality of the wider countryside LPS96 ponds could be compared (see Annexe 1.3). LPS96 was the first Countryside Survey to investigate pond quality so it was not possible to investigate temporal trends in the quality of lowland countryside ponds by comparison with previous data.

5.3 Plant species richness in LPS96 ponds

A total of 177 vascular wetland plant species and five charophytes were recorded from 377 LPS96[6] ponds (Annexe 6). This represents approximately 55% of all vascular wetland plants occurring in Britain. In terms of wetland vegetation types, the survey recorded 57% of Britain's emergent plant species (130 species recorded) and 50% of the total aquatic list (47 species excluding charophytes).

The number of wetland species recorded from individual ponds ranged from zero to 35 and the average number of species per pond was 9.6 (Table 5.1). The mode was, however, skewed towards species-poor sites, with 62% of sites supporting fewer than 10 species of plant and no wetland plants recorded from 5% of ponds (Figure 5.1). Aquatic (submerged and floating) plant species were relatively infrequent in many survey ponds (Table 5.1) with 40% of all ponds supported no aquatic plants (Figure 5.1).

[5] Macrophytes - the larger wetland plants including: vascular species, charophytes, mosses and liverworts.

[6] This total excludes tree species, non-charophytic algae and bryophytes (including *Sphagnum* species) which were only consistently recorded as genera.

Approximately 20% of plant species recorded in the survey were found only at one pond, and few species were widespread. Only seven species were recorded from more than 25% of the ponds. These were Creeping Bent (*Agrostis stolonifera*), Bittersweet (*Solanum dulcamara*), Soft Rush (*Juncus effusus*), Common Duckweed (*Lemna minor*), Great Willowherb (*Epilobium hirsutum*), Floating Sweet-grass (*Glyceria fluitans*) and Water-plantain (*Alisma plantago-aquatica*) (Annexe 6).

Table 5.1 Number of wetland plant species recorded in LPS96

	Marginal plants	Aquatic plants	All plants
Total no. species recorded	130	52*	182*
Average no. species pond	8	1.6	9.6
Range	0-30	0-10	0-35
Average RSS	1.0	1.0	2.0
Range RSS	0-32	0-18	0-32
No. Nationally uncommon sp.	2	4	6
No. of Rare (RDB) species	1	0	1

RSS = Rare Species Score, RDB = Red Data Book,
*includes charophyte species

5.4 Exotic and other introduced species

Fifteen exotic (non-native) wetland plant species or varieties were recorded during the survey, including Giant-rhubarb (*Gunnera tinctoria*), Least Duckweed (*Lemna minuta*) and variegated varieties of both Reed Canary-grass (*Phalaris arundinacea*) and Reed Sweet-grass (*Glyceria maxima*) (Annexe 6).

At some sites there was also on-site evidence[7] of introductions of rare or uncommon *native* plant species which are widely sold by aquarists and garden centres. These included Galingale (*Cyperus longus*), Water-soldier (*Stratiotes aloides*) and Greater Spearwort (*Ranunculus lingua*).

[7] Evidence such as the occurrence of planting baskets or presence of many exotic species.

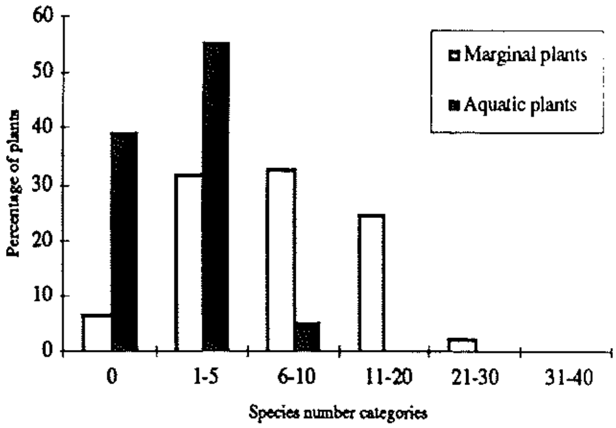


Figure 5.1 Percentage of wetland plant species recorded in LPS96

The exotic plant most commonly recorded was Canadian Pondweed (*Elodea canadensis*), which was recorded from 5.3% of LPS96 sites (Annexe 6). Nuttall's Pondweed (*Elodea nuttallii*) (2.4%) and Curly Waterweed (*Lagarosiphon major*) (2.1%) were the next most frequently recorded exotics.

New Zealand Pigmyweed (*Crassula helmsii*) and Parrot's-feather (*Myriophyllum aquaticum*), two invasive species currently considered to be of some threat to existing pond communities, were recorded from 1.6% and 0.8% of sites respectively.

The overall occurrence of non-native plants was rather high: 14% of ponds supported one or more exotic species. The number of occurrences of non-native *submerged* species was particularly disturbing: 15% (c.1 in 6) of all records of submerged plants in the LPS96 ponds were of non-native species. For emergent and floating plants the proportion of exotic plant occurrences was much smaller at 0.6% and 1.8% of all plant records respectively.

5.5 Uncommon species

The LPS96 ponds supported seven plant taxa which are known to be nationally uncommon (Table 5.2).

The most significant rare species record was for Fox Sedge (*Carex vulpina*), a species now classified as RDB2. The plant was recorded from the centre of its range in Kent in a dry seasonal pond surrounded by scrub. Nationally, *C. vulpina* is known to have declined rapidly within the last 20 years. Principal threats affecting the species are believed to include drought, water abstraction, infilling of ponds, and increasing shade through scrub encroachment (Wiggington, *in prep.*).

Table 5.2 Nationally uncommon plants recorded in LPS96

Red Data Book 2
- Fox Sedge (*Carex vulpina*)

Nationally Scarce / recorded from 100 or fewer 10 km squares in Britain
- Least Duckweed (*Wolffia arrhiza*)
- Soft Hornwort (*Ceratophyllum submersum*)
- Pedunculate Water-starwort (*Callitriche brutia*)
- Touch-me-not Balsam (*Impatiens noli-tangere*)
- Golden Dock (*Rumex maritimus*)
- Pointed Stonewort (*Nitella mucronata* var. *gracillina*)

Six nationally uncommon[8] plants were also recorded from the LPS96 ponds, including the very uncommon Least Duckweed (*Wolffia arrhiza*) and the stonewort *Nitella mucronata*[9]. The record for Pedunculate Water-starwort (*Callitriche brutia*) was the first modern record for Somerset[10].

In addition to these nationally significant species, a wide variety of generally uncommon wetland species were recorded including Frogbit (*Hydrocharis morsus-ranae*), Compressed Rush (*Juncus compressus*), Fine-leaved Water-dropwort (*Oenanthe aquatica*) and Fat Duckweed (*Lemna gibba*). The uncommon pondweed hybrid, Long-leaved Pondweed (*Potamogeton x zizii*)[11], was noted from a recently enlarged pond in Hereford & Worcester. However, this pond had a large number of introductions and it is possible that the species was introduced.

Rare Species Score (RSS) results (see Annexe 1.2) show that on average LPS96 sites had a RSS of 2.0, which is equivalent to approximately one locally uncommon species per site. The highest RSS score (32) was derived for the Fox Sedge (*C. vulpina*) pond. Approximately 45% of survey ponds supported either locally or nationally uncommon species.

Extrapolation of the survey data to give national estimates suggests that, in lowland Britain as a whole, approximately 3,500 ponds (c. 2%±1%) are likely to support RDB or nationally uncommon plant species.

[8] Species designated as Nationally Scarce or recorded from 16-100 10x10 km sqs. in Britain. Note that *C. brutia* may be under recorded.
[9] Det. N.F. Stewart.
[10] Det. T. Rich.
[11] The hybrid of *P. lucens* x *P. gramineus*; det. C. Preston.

Table 5.3 Average vegetation cover

	Landscape type		All
% cover	Pastural	Arable	
Emergent	27%	26%	27%
Floating	6%	9%	8%
Submerged	10%	6%	8%

5.6 Vegetation abundance

In terms of their vegetation cover, LPS96 ponds were, on average, just over a quarter filled with emergent plants (27%) (Table 5.3). The average cover for both floating-leaved (8%) and submerged vegetation (8%) was much lower. There was little difference in cover between landscape types (Table 5.3). Relatively few ponds (18%) were more than three-quarters filled by any type of vegetation whether submerged, emergent or floating (Figure 5.2).

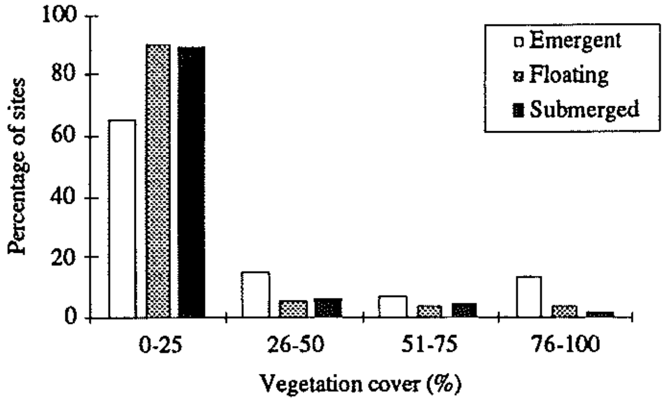


Figure 5.2 Vegetation cover in four abundance categories

5.7 Trophic Ranking Score

Trophic Ranking Scores (TRS) were calculated for aquatic species and all wetland species (aquatics plus marginals) to investigate the relationship between plant assemblages and pond nutrient status (see Annexe 1.2). Note that generally, aquatic plant TRS values are thought to show clearer relationships with water nutrient status than marginal emergent species (Palmer 1989). However, many LPS96 ponds supported few or no aquatic species. Separate TRS scores were therefore calculated for aquatic species and all wetland plants (marginal and aquatic plant species combined).

The average Trophic Ranking Scores for all wetland plants and for aquatic species only, were 8.7 and 8.2 respectively (Table 5.4). This is on the border between the mesotrophic and eutrophic nutrient status categories defined by Palmer (1989). Very few sites (<2%) fell into either low nutrient status groups (oligotrophic or dystrophic).

Table 5.4 Trophic Ranking Score

	All species	Aquatic species only
TRS: average	8.7	8.2
TRS: range	4.7-10	2.5-9.7
'Eutrophic'	33%	35%
'Mesotrophic'	66%	63%
'Oligotrophic'	0.5%	0.5%
'Dystrophic'	0%	0.5%

5.8 Overall conservation value

The LPS96 ponds were ranked into one of four conservation categories (very high, high, moderate or low) based on their species richness and rarity (Table 5.5). Annexe 1.2 describes the derivation of the conservation categories in more detail.

The results suggest that approximately 50% of LPS96 ponds were of Low value, and 48% of Moderate or High value (Table 5.6). The 2% of ponds of Very High value were all sites which supported an RDB or nationally uncommon plant species.

Extrapolation of the data to give estimates of pond numbers across Britain suggests that, nationally, in the order of 3,500 ponds are likely to support RDB or nationally uncommon plant species.

Table 5.5 Provisional categories for assessing conservation value of ponds[1]

Low	Few wetland plants (≤8 species)[2] and no local species.
Moderate	Below average number of wetland plant species (<23 species) and/or uncommon species (maximum of one local species).
High	Above average number of wetland plant species(≥23 species) and/or 2 or more local species. No nationally uncommon or Red Data Book (RDB).
Very High	Supports one or more nationally uncommon or RDB species and/or an exceptionally rich plant assemblage (≥40 species)[3].

[1]Based on NPS data: using the reference data set of lowland ponds located in areas of semi-natural landuse.
[2]The number of species in the poorest 5% of the NPS reference database sites.
[3]The number of species in the richest 5% of the NPS reference database sites.

Table 5.6 Conservation value
National estimates of the number of Britain's lowland ponds in four conservation categories in 1996

Conservation Category		Pond number (in '000)	Percentage
Very High	No.	3470	2%
	SE	*(1762)*	*(1%)*
High	No.	32850	18%
	SE	*(5917)*	*(3%)*
Moderate	No.	54800	30%
	SE	*(8662)*	*(5%)*
Low	No.	92440	50%
	SE	*(14676)*	*(8%)*

5.9 Comparison of LPS96 with the National Pond Survey

5.9.1 Introduction

To interpret the results of LPS96 the main biotic quality variables (plant species richness, rarity and Trophic Ranking Score) were compared with a reference dataset of minimally impaired lowland ponds drawn from the National Pond Survey (NPS). This dataset comprised plant species lists from 102 ponds located in areas of semi-natural landuse in the two major ITE lowland landscape types (arable and pastural). The NPS sites provide a benchmark of minimally impacted examples of the types of ponds found in the area covered by LPS96. Further information on the NPS dataset is given in Annexe 1.3.

5.9.2 Results of the LPS96/NPS comparison

Comparisons of the LPS96 and NPS data sets are summarised in Tables 5.7-5.8 and Figure 5.3.

In terms of the average species richness of all wetland plants, LPS96 ponds supported less than half the number of species (9.6 per pond) recorded from the reference NPS sites (22.6 per pond) (Table 5.3).

The aquatic plant species component of the wetland flora was particularly poor, with LPS96 ponds on average supporting only one third of the number of species seen in the relatively pristine NPS pond habitats.

Table 5.8, which shows the spread of sites in terms of species richness categories, indicates that whereas only 1% of NPS sites have no aquatic plant species, in the LPS96 almost 40% of sites lacked aquatic plants.

The differences in species richness (in terms of marginal, aquatic and total richness) between the National Pond Survey and LPS96 ponds were all highly significant (Mann-Witney U Test: $P<0.0001$).

Table 5.7 Plant species richness: LPS96 and NPS

		LPS96 (n=377)	NPS (n=102)
Number of species recorded per pond			
All species:	mean	9.6	22.6
	range	0-35	1-46
Marginal species:	mean	8.0	17.7
	range	0-30	1-42
Aquatic species:	mean	1.6	4.8
	range	0-10	0-14
Conservation value			
Mean RSS		2	7
Range RSS		0-64	0-24
Nationally uncommon species (whole survey)		6	6
Rare species: no./pond (whole survey)		1	0

RSS = Rare Species Score

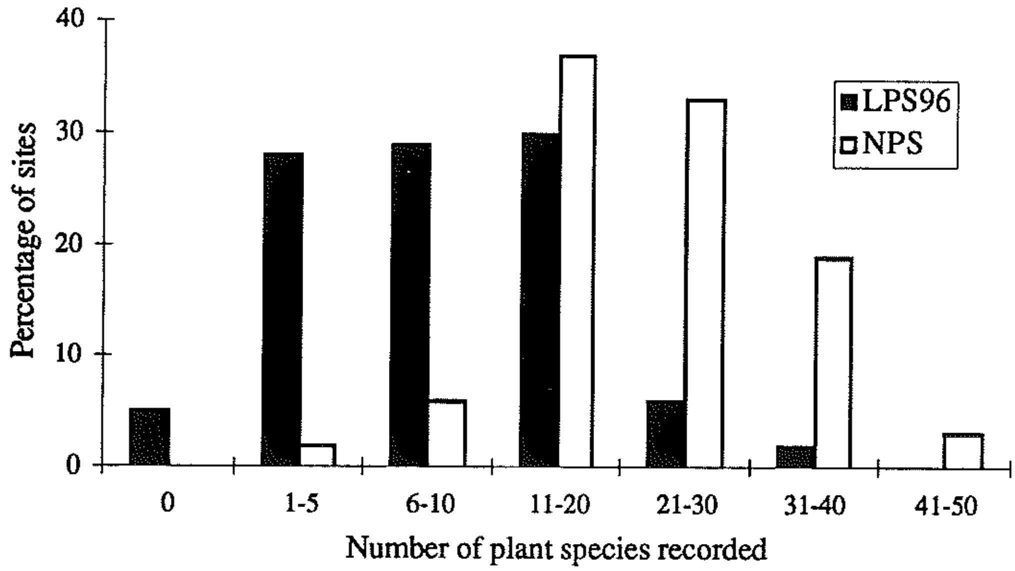


Figure 5.3 Plant species richness: a comparison of LPS96 and NPS sites

Table 5.8 Wetland plant species richness: comparison of LPS96 and National Pond Survey sites in seven species richness categories

		Number of plant species recorded						
		0	1-5	6-10	11-20	21-30	31-40	41-50
Emergent plants	LPS96	6.6%	31.8%	32.9%	24.4%	2.2%	0%	0%
	NPS	0%	5.9%	14.7%	49.0%	22.6%	6.9%	1.0%
Aquatic plants	LPS96	39.5%	55.2%	5.3%	0%	0%	0%	0%
	NPS	1%	67.7%	27.4%	3.9%	0%	0%	0%
All species	LPS96	5%	28.3%	28.7%	30%	6%	2%	0%
	NPS	0%	2.0%	5.9%	37%	33%	19%	3%

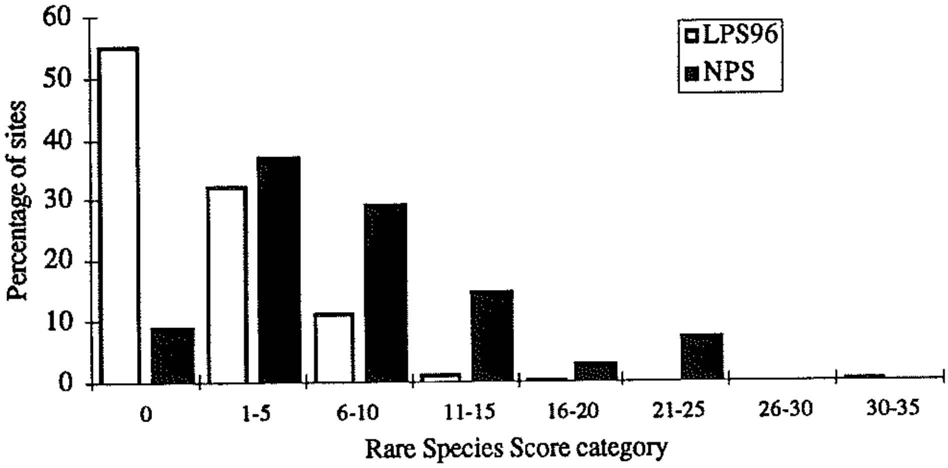


Figure 5.4 Rare Species Scores: proportion of LPS96 and NPS sites in different categories

5.9.3 Species rarity scores

Comparison of the Rare Species Scores (RSS) derived for LPS96 and National Pond Survey sites indicated that, considering all relatively uncommon taxa (including 'local' species), NPS Rare Species Scores were over three times higher than their LPS96 equivalents (Mann-Whitney U test: $P<0.0001$). Similarly:

(i) just over half of LPS96 sites had no uncommon species, compared to only 9% of sites in the National Pond Survey

(ii) whereas a 25% of NPS sites had RSS values of 11 or more, in LPS96 this was true of only 1.5% of sites (see Figure 5.4).

5.9.4 Trophic Ranking Score

Comparison of the Trophic Ranking Scores from LPS96 and National Pond Survey ponds showed that the LPS96 ponds were more enriched than the NPS sites. For example, 33% of LPS96 sites were eutrophic, compared to only 9% of NPS sites (Table 5.9). Similarly the National Pond Survey included 17% of sites classified as oligotrophic compared to 0.5% of sites in LPS96.

The differences between Trophic Ranking Scores for LPS96 and NPS sites were again highly significant for both aquatic and all wetland species ($P<0.0001$).

Table 5.9 Comparison of Trophic Ranking Scores for LPS96 and NPS ponds

	Trophic Ranking Score			
	Dys	Olig	Mes	Eutr
LPS96: all species	0%	0.5%	66%	33%
NPS: all species	0%	17%	74%	9%
LPS96: aquatic species	0.5%	0.5%	63%	35%
NPS: aquatic species	4%	18%	64%	13%

Dys = dystrophic, Olig = oligotrophic Mes = mesotrophic Eutr = eutrophic NPS = National Pond Survey

5.9.5 Conservation category

Comparison of the NPS and LPS96 data sets shows that most LPS96 ponds were either of Low or Moderate conservation value (80%) (Table 5.10). Only a fifth (20%) of LPS96 sites fell into the High or Very High conservation value categories, whereas for the NPS reference dataset, almost 70% of sites were in these top two categories.

Table 5.10 Pond conservation value: LPS96 and NPS

Conservation Category	LPS96	NPS
Very high	2%	12%
High	18%	57%
Moderate	30%	26%
Low	50%	5%

NPS = National Pond Survey

5.10 New ponds in LPS96

The plant attributes of new LPS96 ponds created in the periods 1984-1990 and 1990-1996 were compared with older ponds (Table 5.11).

The newest ponds (0-6 years old) often had similar plant attribute values to the older ponds. This was true for average species richness, number of exotics, cover of aquatic plants and average Rare Species Score. The main differences between the data sets were (i) a tendency for these very new ponds to have lower percentage cover of floating and emergent vegetation, and (ii) a lower Trophic Ranking Score, which bordered on the mesotrophic, compared to the more typically eutrophic older ponds. Differences in TRS were significant ($P \leq 0.01$ Mann-Whitney U test).

New ponds created 6-12 years ago (1984-90) and which had gone through their initial colonisation phase consistently supported higher quality plant assemblages than older ponds. They had significantly more emergent species ($P<0.01$), had higher Rare Species Scores ($P<0.05$), were apparently less enriched by nutrients, (Emergent TRS $P<0.01$) and had over double the number of ponds in the High Conservation Value category ($P<0.05$).

When the 1984-90 and 1990-96 new pond data sets were combined, it was evident that there was still a significant tendency for new ponds to support more emergent species ($P<0.01$) and to be of higher conservation value ($P<0.05$) than older ponds. There was also a significant tendency for new ponds to have lower marginal and aquatic Trophic Ranking Scores ($P<0.001$ and $P<0.05$ respectively).

5.11 Seasonal ponds in LPS96

Seasonal ponds were generally poorer in species than permanent ponds in the LPS96 database (Table 5.12). Such a result is inevitable, since ponds which dry annually have a lower potential to support aquatic species than more permanent waterbodies. However, even amongst the emergent plant group, seasonal sites supported approximately 37% fewer emergent species than other ponds.

Seasonal ponds also supported fewer invasive alien species than permanent ponds ($P<0.0001$) and fewer uncommon species ($P<0.0001$). Both trends are likely to, again, partly reflect the paucity of aquatic plants (see Section 5.4).

Despite having fewer species and a rather lower average plant rarity, it was noticeable that the rarest plant recorded in LPS96 (*C. vulpina*) and two of the six nationally uncommon plants (*Callitriche brutia* and *Rumex maritimus*) were only recorded from seasonal ponds. Statistically, therefore, seasonal and permanent ponds were just as likely to support a *nationally* rare or uncommon species (approximately 2% of sites for both groups).

Similarly, seasonal ponds were as likely to fall into the 'Very High' conservation value category as permanent ponds (2% of seasonal ponds were of Very High value, compared to 3% of permanent ponds).

Table 5.11 New ponds recorded in LPS96: species richness and conservation value

	New ponds 1990-96 (n=15)		New ponds 1984-90 (n=11)		Older ponds (n=351)	
	Mean	Range	Mean	Range	Mean	Range
Number of submerged species	0.9	0-3	1.2	0-3	0.9	0-8
Number of floating species	0.4	0-1	0.8	0-2	0.8	0-5
Number of emergent species	8.4	0-19	13	1-24	7.8	0-30
Total number of plant species	9.8	0-22	15	1-27	9.4	0-35
Number of exotic species	0.2	0-1	0.4	0-1	0.2	0-5
Emergent Rare Species Score	0.8	0-4	1.5	0-4	1	0-32
Aquatic Rare Species Score	1.3	0-4	1.4	0-6	1	0-10
Total Rare Species Score	2.2	0-6	2.9	0-8	1.9	0-32
Trophic Ranking Score: all plants	8.1	7.2-8.7	8.1	6.2-10	8.7	7.7-8.8
Trophic Ranking Score: aquatic plants	8.0	6.3-9.5	7.7	6.8-9	8.3	5.9-9.7
Vegetation cover:						
• Submerged species	8.0%	0-78%	22%	0.5-85%	7%	0-95%
• Floating species	0.4%	0-2%	9%	0-70%	8%	0-99%
• Emergent species	13.9%	0-95%	18%	0-78%	27%	0-100%
Conservation Value:						
• Very high	0%	-	0%	-	2%	-
• High	33%	-	54%	-	23%	-
• Moderate	42%	-	36%	-	32%	-
• Low	25%	-	10%	-	42%	-

5.12 Factors correlated with plant attributes

The relationships between plant attributes and environmental variables (described in Chapter 4) were investigated using five main plant assemblage attributes. These were:

- species richness (emergent, aquatic and all wetland species)
- the ratio of submerged / floating-leaved species
- Rare Species Score
- Trophic Ranking Score
- vegetation abundance

The results of correlations between biotic and physical variables are given in Annexe 7. Analytical methods are described in Chapter 3.

5.12.1 Pond area and depth

Analyses showed that larger and deeper ponds supported significantly greater numbers of plant species, and more uncommon species, than ponds which were small, shallow or seasonal. There were also strong positive correlations between permanence and the abundance of aquatic plants.

Because size, depth and permanence were themselves strongly correlated in the dataset (Chapter 4), it is difficult to distinguish which of these factors was most important in affecting the quality of the LPS96 plant assemblages. However, in general, drawdown and depth related variables were more strongly correlated with aquatic species richness and abundance parameters, whilst area was more strongly correlated with emergent species richness.

Table 5.12 Seasonal ponds: plant attributes

	Seasonal (n=109)		Permanent (n=268)	
	Mean	Range	Mean	Range
No. emergent spp.	5.3	0-25	9.1	0-30
No. aquatic spp.	0.3	0-3	2.1	0-10
Total no. spp.	5.6	0-25	11.2	0-35
No. exotic spp.	0.03	0-1	0.2	0-5
Emergent RSS	0.7	0-32	1.1	0-10
Aquatic RSS	0.1	0-2	1.3	0-10
Total RSS	0.8	0-32	2.4	0-18
TRS: all spp.	8.6	6.3-10	8.7	4.7-10
TRS: aquatics spp.	8.3	5.9-9.7	8.1	9.0-2.5
Vegetation cover:				
• Emergent	41%	0-100%	21%	0-100%
• Floating leaved	0.5%	0-40%	11%	0-99%
• Submerged	2%	0-60%	10%	0-95%
Conservation value:				
• Very high	2%	-	3%	-
• High	4%	-	31%	-
• Moderate	27%	-	34%	-
• Low	67%	-	32%	-

5.12.2 Water quality

Conductivity was negatively correlated with the richness of all plant groups, but particularly submerged species. Higher conductivity was also associated with lower submerged plant *abundance*. Species rarity showed no correlation with conductivity.

No plant species variables showed a strong correlation with pH and only aquatic plant species richness was correlated with levels of calcium. Clear water was, however, associated with both greater numbers of aquatic plant species and with greater total plant cover. The data showed no evidence of a link between water turbidity and species rarity.

5.12.3 Sediment and shade

All plant groups showed a negative relationship between species richness and the proportion of coarse organic sediment in the pond. Aquatic vegetation abundance was also reduced where coarse organic sediment was common. Plant richness was, in contrast, positively correlated with the proportion of fine muds. As described in Chapter 4, the relative proportions of organic and fine sediments were strongly correlated with greater seasonality and a higher proportion of overhanging trees. It is, therefore, probable that the correlations between sediment and plant species are, at least in part, an artefact of these permanence and shade effects.

Sediment depth showed no significant relationship with plant richness or rarity, but it was positively associated with Trophic Ranking Score. This was an interesting result since it suggests that more silty ponds were more enriched.

Both emergent and aquatic plants showed a trend towards lower species richness in more shaded ponds. The ratio of submerged:floating plant species indicated that submerged plants were more affected than floating species. Increasing proportion of overhanging vegetation was also associated with a lower Rare Species Score, higher Trophic Ranking Score (more enriched) and lower plant cover.

5.12.4 Water source and inflows

There was a positive association between groundwater and the aquatic (particularly submerged) species richness and abundance. In contrast both aquatic and emergent richness, and submerged plant cover was lower where ponds were fed by a high proportion of near-surface run-off.

There were correlations between inflow stream volume and emergent and total plant richness, where stream and ditch inflows were estimated as a proportion of total water sources this relationship is not seen. Since inflow stream volume is significantly correlated with area and depth (Annexe 7), this suggests that the inflow volume/species richness relationship may, in fact, be an artefact of the stream/area relationship (Chapter 4).

5.12.5 Relationships between plant attributes

The strongest relationships in the dataset were seen between the plant variables themselves (see Annexe 7).

There were consistent positive relationships between plant richness and rarity attributes and the proportion of vegetation cover. Thus, there were a greater number of emergent species and more rare plants in ponds with a relatively high proportion of emergent plant cover. Similarly, where aquatic plant abundance was high, there were both more aquatic plant species, and more uncommon aquatic plant species.

There were consistent negative relationships between plant richness and rarity attributes and TRS (i.e. there were more species, and more uncommon species where the water was less enriched). There was also a negative relationship between TRS and emergent and total plant cover.

5.12.6 Land Use

Correlations between plant species and land use variables suggest that the land immediately around a pond may exert a significant influence on the plant community.

There was a significant positive correlation between the proportion of unimproved grassland within 5m of the pond edge (largely the pond bank area) and the species richness of emergent and total plants.

In contrast, there was consistent evidence that a high proportion of trees or woodland in the pond bank area exerted a negative effect: greater woodland cover within 5 m of the pond was correlated with lower emergent and total species richness and abundance attributes. It was also positively correlated with TRS i.e. ponds were more enriched where trees were growing around them (although this may have been an artefact of the sediment-tree shade correlation).

In the broader surrounds beyond the pond banks (5m-25m and 25m-100m from the pond edge) there was a relationship between the occurrence of arable land and low emergent and total plant species richness. TRS was also positively correlated with arable surrounds suggesting that in arable surrounds ponds were more enriched.

In contrast, non-wooded semi-natural land uses showed positive relationships with plant species richness and emergent cover.

There was also an indication that a higher proportion of semi-natural landscapes in the surrounds was associated with a greater number of uncommon emergent plant species.

There was no strong evidence of a relationship between the occurrence of other *nearby* ponds, lakes or rivers and the number or rarity of plant attributes (but see below).

5.12.7 The importance of the wider landscape

The relationship between the two broad ITE lowland landscape types (arable, pastural) and plant assemblage attributes were analysed using dummy variables (1, 0).

Table 5.13 Plant assemblages in lowland pastural and arable landscapes

	LPS96	NPS
Lowland Pastural		
Average no. marginal spp.	9.4	18.8
Average no. aquatic spp.	1.9	4.7
Rare Species Score (RSS)	2.2	7.3
Trophic Ranking Score	8.6	7.1
Lowland Arable		
Average no. marginal spp.	6.9	17.0
Average no. aquatic spp.	1.4	5.0
Rare Species Score (RSS)	1.7	6.9
Trophic Ranking Score	8.8	7.2

A comparison of the two landscape types showed that significantly more plant species were recorded from pastural than from arable landscape types (Mann-Whitney U test: $P<0.0001$).

Comparison of the LPS96 data with the NPS reference dataset confirms this trend. Arable landscape ponds were proportionally more impoverished in plant species than their pastural counterparts (Table 5.13).

A drawback of the LPS96 data analysis is that it is difficult to evaluate the importance of landscape at a 'meso' scale. At a small scale the resolution of the LPS96 field survey was 0-100m from the pond. At landscape scale, ITE data can give average land cover information for the 19 lowland ITE Land Classes and two major lowland landscape types (e.g. Bunce *et al.* 1994, Countryside Information Service).

Many ponds will, however, be influenced by factors such as water quality which act at pond catchment scale[12]. In addition, it is very difficult to assess the current or historic effects of what may be termed 'connectedness' to other landscape features, such as relatively undisturbed semi-natural land (e.g. SSSIs) or wetland habitats (e.g. streams, ditches, fens, river valley floodplains).

For example, several ponds in Square 129 supported very rich communities including the Nationally Scarce Least Duckweed

[12] Pond catchments may vary from a few square metres around a pond, or may cover many hundreds of hectares in stream fed or groundwater fed waterbodies.

(*Wolffia arrhiza*). Ponds in this square were located in improved grassland and did not have exceptional numbers of ditches or ponds near them. However, the square is located in the Somerset Levels, which have an outstanding wetland flora with many nearby sources of uncommon plants.

To investigate the possible influence of this 'meso scale' variation at resolution levels between 100 m and Land Class a calculation was made to determine whether ponds were located near to high quality semi-natural landscapes or other wetland habitats.

The 40 highest quality sites, in terms of number of uncommon species recorded (with 2 or more uncommon species), were inspected in more detail to assess (a) proximity to SSSIs (b) location on lower river valley floodplains. In addition, it was also noted whether more than half of the 25-100m zone around the pond was in a semi-natural land-use.

These sites were compared with a similar number of ponds which had no uncommon plants, chosen by selecting every fourth pond in the list of all sites (the number of sites with uncommon species was much smaller than the number without), and ensuring that this covered the full geographical range of sites.

The results (Table 5.14) show that 60% of higher quality ponds were located in close proximity to existing wetlands (especially river valley floodplains) or in areas where semi-natural landuse predominated around the pond. Perhaps unsurprisingly, the site with the greatest number of uncommon species was in a large SSSI (the Ouse Washes).

In contrast 80% of low quality ponds were in areas of intensive land-use, and only 2% were on river floodplains (see also Annexe 8). Differences were tested with a Mann-Witney U test and were significant at $P<0.0001$ (floodplains) and $P<0.05$ (SSSIs).

It is also worth noting that even in the 40% of high quality sites located in intensively managed areas a tentative relationship with historic wetland parameters was often evident. For example pond 116/4, which supported the third highest number of uncommon species, had 92% arable cover in the 100m land-use zone. However, the site was only 750 m from the R. Arun (although not on the floodplain) and only 4 km from the extensive wetlands of the Pulborough Brooks RSPB reserve.

Table 5.14 Locational factors influencing the quality of ponds

	Semi-natural land use			Intensive land-use
	On or near SSSI	>50%. 25-100m	River flood plain	Intensive (all types)
Ponds with >2 rare plant species	3 (7%)	7 (17%)	15 (36%)	17 (40%)
Ponds with no rare plant species	0 (0%)	9 (18%)	1 (2%)	41 (80%)

5.13 Summary and discussion

5.13.1 Ponds as a freshwater biodiversity resource

The LPS96 ponds provide strong evidence that ponds are an important biodiversity resource.

Fifty-five percent of all Britain's vascular wetland plant species were recorded from a survey of 377 lowland ponds. Almost 2%(±1%) of these ponds supported rare (RDB) or nationally uncommon plant species. At a national level, therefore, around 3,500 lowland ponds may currently support plant species of national conservation importance. Many tens of thousands more ponds will currently support locally uncommon plant species.

In addition, it is important to stress that macrophytes comprise only one component of pond biodiversity, and an assessment based on this group alone will considerably underestimate pond value. For example, in the National Pond Survey, for every pond supporting a nationally important plant species, there were at least eight further ponds of conservation importance because they supported Nationally Notable or Red Data Book invertebrate species. Other groups, particularly uncommon or protected amphibians such as Great Crested Newt and Natterjack Toad, will also add to pond value.

5.13.2 Natural factors influencing pond quality

The LPS96 dataset shows clearly the strong influence of natural physico-chemical parameters, such as area, depth and shade, on wetland plant assemblages.

The strength of these primary natural variables to some extent confounds interpretation of the biotic quality data making it difficult to fully examine anthropogenic degradation factors (urbanisation, enrichment etc.) which are likely to influence pond quality.

Ideally the effect of natural variables should be removed through biotic classification and prediction techniques. Pond Action and the Environment Agency are currently developing such a system (Williams *et al.* 1996, 1998), but the method was not sufficiently well developed for use in the current analysis.

5.13.3 Evidence that many LPS96 ponds are degraded

Despite the confounding influence of natural variables, there was consistent evidence that ponds in the LPS96 dataset were degraded in comparison with ponds from more semi-natural landscapes. Several separate lines of evidence support this conclusion.

(i) LPS96 ponds had significantly lower species richness, and fewer uncommon taxa, than NPS ponds from equivalent areas of lowland Britain, but located in areas of semi-natural landuse.

(ii) LPS96 ponds had significantly higher Trophic Ranking Scores than NPS ponds, indicating greater enrichment.

(iii) There were negative correlations between LPS96 plant assemblage richness and arable land use within 100m of the pond.

(iv) There were positive correlations between species richness and (non-woodland) semi-natural land use within 100m of the pond, particularly the occurrence of semi-natural grassland.

(v) High quality ponds were more likely to be situated in, or near to, areas with traditional management (e.g. SSSIs) or long-established wetlands, such as river valley floodplains.

(vi) There was a highly significant difference between the quality of plant communities in arable and pastural lowland landscapes, with both species richness and rarity more impoverished in ponds located in arable landscape types.

(vii) There was an association between increasing Trophic Ranking Score (TRS) (nutrient enrichment) and lower species-richness and rarity.

Overall, therefore, LPS96 provides some strong evidence that factors associated with intensive land use combine to degrade the quality of many ponds in the countryside areas of Britain.

This finding is of particular interest because there is currently very little quantitative data describing either the quality of countryside ponds or the extent to which pollutants and other stresses degrade them.

LPS96 data provides evidence that many lowland ponds have partially degraded plant communities as a result of elevated nutrient levels. The specific impact of other possible pollutants such as pesticides, heavy metals and oils was not investigated in the survey and their contribution to the degradation of countryside ponds remain unknown.

5.13.4 New ponds

The LPS96 dataset indicates that new ponds had a significantly higher average conservation value than older sites and supported both more species and more uncommon species than older sites. The richness of these new waterbodies was not unexpected: many wetland plants (and macroinvertebrates) are well adapted to colonising new waterbodies and similar trends have been observed in other studies (Biggs *et al.* 1997, Williams *et al.* 1997).

More unexpected was biotic evidence from both new pond data sets (0-6 years and 6-12 years) that new ponds had a significantly lower nutrient status than older ponds. The reason for this result is likely to be straightforward: standing waters are nutrient accumulating systems that will almost all become more enriched with time. Supporting this is evidence from LPS96 data that as silt levels increased, so did nutrient enrichment levels (Section 5.12.3). LPS96 is, to our knowledge, the first dataset to demonstrate this phenomenon in ponds, however.

It is an interesting result because in lowland Britain oligotrophic and mesotrophic waters are now at a premium. New ponds may, therefore, provide a valuable habitat for more uncommon plants and animals often associated with these waters. In support of this possibility, LPS96 data showed both a positive relationship between new ponds and species rarity and, for the whole dataset, a negative correlation between Trophic Ranking Score and the species rarity of sites.

5.13.5 Seasonal ponds

A seasonal pond supported the most uncommon plant species recorded in LPS96 and, overall, seasonal waterbodies were just as likely to support nationally uncommon plants as permanent ponds.

On average, however, seasonal ponds were more likely to be of only low or moderate conservation value compared to permanent ponds. It is likely that this partly reflected their relatively species-poor characteristics: seasonal ponds have a more limited potential to support rich assemblages of aquatic and floating-leaved species, many of which are relatively uncommon (Annexe 6). However, their lower quality may also partly reflect the particular vulnerability of this small, shallow waterbody type to damage by anthropogenic stresses such as drainage and pollution.

Published data describing permanent and seasonal ponds in Britain is limited, but the LPS96 findings are directly analogous to an invertebrate survey of Oxfordshire ponds (Collinson *et al.* 1995). Here seasonal ponds were also relatively species-poor in comparison to permanent ponds, but again, a seasonal pond was the only waterbody to support a RDB species (the RDB1 water beetle *Haliplus furcatus*).

Taken together, these data suggest that although many seasonal ponds in the countryside are of only moderate value, there are important exceptions. Care therefore needs to be taken in the management of seasonal ponds to avoid thoughtless damage or destruction.

6. AMENITY VALUE

6.1 Introduction

Lowland Pond Survey 1996 included an evaluation of the amenity value of ponds assessed in terms of:

- the use of ponds for leisure activities (amenity use),
- the pond as a visual amenity.

6.2 Amenity use of ponds

Extrapolation from LPS96 data to give national estimates suggests that in total, an estimated 27,000 ponds (±5000) are used for one or more amenity or leisure activities (Figure 6.1). This is equivalent to about one in every seven ponds. It should be noted, however, that only on-site evidence and, more rarely, casual conversation with farmers and landowners, were used to determine the use of ponds in LPS96. The numbers of ponds therefore represent a *minimum* estimate of pond use.

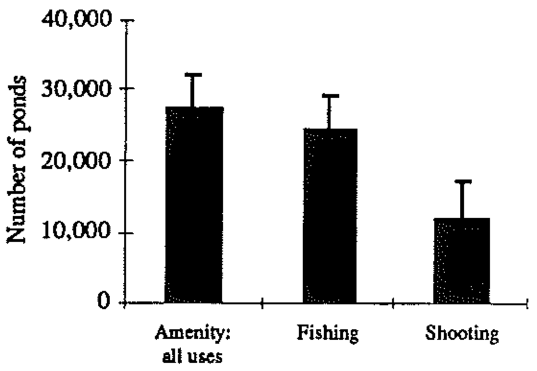


Figure 6.1 The major amenity uses of LPS96 ponds: Great Britain totals

The most common amenity use was fishing, for which evidence was present at approximately 13% of ponds (24,000 ±5,000 ponds nationally). This was followed by shooting, for which there was evidence at approximately 7% of sites (12,000 ±5,000 ponds nationally) (Figure 6.1).

Approximately 3% of ponds were stocked with either ornamental fish or wildfowl, and a further 3% were located on nature reserves or used for pond dipping. Around 1% of ponds were located on golf courses and formed a water hazard integral to the course (Table 6.1).

Table 6.1 Minor amenity uses of LPS96 ponds

	% of ponds
Ornamental fish	3%
Pond dipping, nature reserve	3%
Ornamental wildfowl	3%
Golfing hazard	1%
Boating and water sports	1%

6.3 Correlations between amenity use and other variables

Correlations between amenity use and pond physico-chemical variables showed that ponds which were used for amenity purposes were significantly larger and deeper than ponds with no amenity use. There were negative correlations between amenity use and tree shade.

There was generally a positive relationship between amenity use and plant species richness and rarity. Since amenity ponds were generally larger than average ponds, much of this relationship is, however, likely to be explained by the species/area relationship (Chapter 5). Ponds used for amenity purposes were much more likely to be managed than those which were not.

In the few cases where the reason for pond creation could be established by field surveyors, leisure activity uses seem have been a principle driving force motivating pond creation (Table 6.2). In line with this finding, new ponds had significantly more fishing and shooting activities than older ponds ($P<0.01$ and $P<0.05$ respectively).

Table 6.2 Why new ponds were created (1984-96)

	1984-90 n=12	1990-96 n=14	% total for both periods
Fishing	2	2	15%
Wildfowl	3	1	15%
Golf hazard	0	2	8%
Ornamental fish	1	1	8%
Irrigation	1	0	4%
Sewage	1	0	4%
Heritage: moat	0	1	4%
Curling	1	0	4%
Training dogs	0	1	4%
Not known	3	6	34%

6.4 Visual amenity of ponds

Table 6.3 gives national estimates for (a) numbers of ponds which could be viewed from roads, rights of way and public access areas, and (b) the ease with which ponds could be seen ('good visual amenity').

Table 6.4 gives a breakdown of visual amenity, for different types of right of way. The results indicate that 28% of ponds can be seen, to some extent, from roads and public rights of way.

In addition to those ponds visible from rights of way, approximately 12% of ponds were located in areas of open public access such as commons or greens.

Not all ponds which could be easily seen could be considered to be a visual asset, however. Approximately a third (32%) of the ponds were seasonal in 1996, a factor which must be considered to reduce their visual appeal in the summer months. Similarly 1.8% of accessible ponds contained considerable amounts of rubbish or rubble. To assess the number of ponds which provided a good visual amenity these seasonal and rubbish-filled ponds were excluded from the data set.

Table 6.3 Visibility of ponds from public rights of way

(a) Pond visible

	No. of ponds	SE
Visible	68,808	*(10,902)*
Not visible	114,745	*(16,645)*

(b) Visibility extent

	No. of ponds	SE
Good visual amenity	24,448	*(4,960)*
Poor visual amenity	151,613	*(19,397)*

Table 6.4 Proportion of LPS96 ponds which could be seen from a public right of way[1]

	Poor view	Good view	Total
Footpath	7%	9%	16%
Bridle path	1%	1%	2%
Minor road	2%	3%	5%
B Road	1%	1%	2%
A Road	1%	0.3%	1%
Total	13%	15%	28%

Using this rationale it was calculated that approximately 20% of LPS96 ponds provided a visual amenity of some kind, and 14% of these ponds could been seen easily and provided a good visual amenity from areas of public access.

There were no major correlations between site visibility from areas of public access and other pond-related variables, and no evidence that new ponds were more or less likely to be easily visible or accessible than longer-established ponds in the countryside.

[1] Figures do not include ponds (10%), which could only be viewed from private roads, tracks or paths.

Table 6.5 Overall amenity value

	No. of ponds	SE	%
Ponds with high amenity value	49,613	7,288	27%
Ponds without amenity value	133,940	18,531	73%

6.5 Overall amenity value

Combining the ponds to which (a) there was public access (b) good visual appeal (i.e. no rubbish and with water present in summer) and (c) one or more amenity uses, gives a total of 27% of ponds which could be judged to have an high amenity value (Table 6.5). Nationally, this gives a minimum of about 50,000 (±7,000) ponds which could be judged to have high value as a leisure facility or landscape feature (Table 6.5).

7. POLICY ANALYSIS

7.1 Introduction

This chapter provides a review of countryside and wildlife policies which currently influence pond protection, creation and management in Britain. The review focuses on the policy of statutory bodies within the areas of nature conservation, land-use planning and water resources management but also includes a brief resume of the influence of non-governmental organisations in these areas.

Policy analysis and recommendations, made in the light of LPS96 findings, follow in Chapter 8.

7.2. Nature conservation: legislation, schemes and policies

The Wildlife and Countryside Act, 1981 (WCA), and its subsequent amendments, provide the statutory framework for the conservation of species and habitats in the UK. It also provides the mechanism by which relevant EU directives and the provisions of international conservation treaties (Bern Convention, Bonn Convention, Ramsar Convention) are incorporated into UK law.

The interpretation of the Wildlife and Countryside Act with respect to freshwater habitats, including ponds, has recently been summarised by English Nature (EN) in its freshwater conservation action plan (English Nature 1997). A similar policy document is planned by Scottish Natural Heritage.

7.2.1 English Nature: Wildlife and Freshwater action plan

The English Nature agenda for the sustainable management of freshwater puts forward a plan of action for conservation of freshwater ecosystems. The plan focuses attention on designated sites and gives priority to those habitats which are regarded as "most natural", amongst which EN lists rivers, lakes, fens and marshes, but not ponds, which are regarded as "more artificial".

EN's main stated objectives with respect to ponds are to:

- "Maintain and enhance the plant and animal communities of ponds by managing existing ponds and encouraging schemes to create new" [ponds].
- "Promote the concept of 'buffer' zones to improve the quality of habitat surrounding ponds".

The strategy also places considerable emphasis on collaboration between the many organisations and individuals with an interest in freshwater.

7.2.2 The role of SSSIs in pond conservation

English Nature's freshwater strategy notes that:

> *"...ponds have received less statutory protection than other freshwater habitats." (EN 1997),*

and only a relatively small number of Sites of Special Scientific Interest (SSSIs) have been designated specifically for their pond interest (M. Drake, *in litt.*). In a critique of pond conservation legislation, Tydeman (1995) suggested that, in general, ponds do not fit easily into the SSSI system which is not suited to the designation of small areas. In fact, he argued, most biological SSSIs are 'medium-sized' (i.e. 10s to 100s of hectares), and smaller features are rarely designated by the country conservation agencies for their nature conservation interest.

SSSIs do, however, provide incidental protection for many ponds. The semi-natural habitats typical of SSSIs generally provide a 'pond-friendly' landscape, where there is minimal use of fertilisers and biocides and protection from urban runoff and land drainage. Consequently, ponds in SSSIs can include some of Britain's highest quality freshwater habitats. Although EN does not have statistics on pond numbers in SSSIs, it is likely that at least several thousand ponds in lowland Britain are protected in this way.

Table 7.1. Freshwater plants and animals given special protection under Schedules 5 and 8 of the Wildlife and Countryside Act

Key: ✔ = species occurring in, or associated with, ponds; * = species not given complete protection

Species	Associated with ponds	Species	Associated with ponds
Natterjack toad (*Bufo calamita*)	✔	*Margaritifera margaritifera* (a pearl mussel)	Rivers
Great crested newt (*Triturus cristatus*)	✔	Glutinous Snail (*Myxas glutinosa*)	✔
Pool Frog (*Rana lessonae*)[1]	✔	Medicinal leech (*Hirudo medicinalis*)	✔
*Common Toad (Bufo bufo)	✔	Adder's-tongue Spearwort (*Ranunculus ophioglossifolius*)	✔
*Smooth Newt (*Triturus vulgaris*)	✔	Brown Galingale (*Cyperus fuscus*)	✔
*Palmate Newt (*Triturus helvetica*)	✔	Creeping Marshwort (*Apium repens*)	Wet grassland
Sturgeon (*Accipenser sturio*)	Rivers	Fen Orchid (*Liparis loeselii*)[1]	✔
Allis Shad (*Alosa alosa*)	Rivers	Floating water-plantain (*Luronium natans*)	✔
Vendace (*Coregonus albula*)	Lakes	Grass-poly (*Lythrum hyssopifolia*)	✔
Powan (*Coregonus laveratus*)	Lakes	Slender Naiad (*Najas flexilis*)	Lakes
Burbot (*Lota lota*)	Rivers	Holly-leaved Naiad (*Najas marina*)	Lakes
Spangled water beetle (*Graphoderus zonatus*)	✔	Pennyroyal (*Mentha pulegium*)	✔
Lesser silver diving beetle (*Hydrochara caraboides*)	✔	Pigmyweed (*Crassula aquatica*)	✔
Paracymus aeneas (a water beetle)	Salt marsh	Ribbon-leaved Water-plantain (*Alisma graminuem*)[2]	✔
Fen Raft Spider (*Dolomedes plantarius*)	✔	Starfruit (*Damasonium alisma*)	✔
Atlantic Stream Crayfish (*Austropotamobius pallipes*)[4]	✔	Strapwort[3] (*Corigiola littoralis*)	✔
Triops cancriformis (a tadpole shrimp)	✔	Welsh Mudwort (*Limosella australis*)	✔
Chirocephalus diaphanus (a fairy shrimp)	✔	Multi-fruited River-moss (*Cryphaea lamyana*)	Rivers
Otter[5] (*Lutra lutra*)		Bearded Stonewort (*Chara canescens*)	✔
Water Vole (*Arvicola terrestris*)	✔	River Jelly Lichen (*Collema dichotomum*)	Rivers

1. The two forms of the Fen Orchid (*ovata* and *loeselii*) occur, respectively, in pools (mainly peat cuttings) in fens and in dune slacks (natural temporary ponds).

2. Stace (1991) describes the habitat of Ribbon-leaved Water-plantain as "shallow ponds", although the only two British populations are in a lake and a drainage ditch.

3. Stace (1991) describes the habitat of Strapwort as "on sand and gravel by ponds" although the only known native British population is now at Slapton Ley, Devon.

4. The Atlantic Stream Crayfish is typically associated with streams and rivers, but also occurs in stream-fed or spring-fed ponds.

5. The Otter is associated with a wide variety of freshwater habitats and can use ponds regularly (e.g. NRA 1993b).

7.2.3 Specially protected freshwater species

Approximately 70% of the freshwater species given special protection under the provisions of the Wildlife and Countryside Act occur in ponds. A full list of relevant species is given in Table 7.1.

7.2.4 Statutory conservation schemes affecting ponds

Species Recovery Programme

English Nature's Species Recovery Programme is directed towards the protection and enhancement of a sub-set of WCA species together with Biodiversity Action Plan species and other species considered worthy of special protection. Pond associated species included in Phases 1 and 2 of the programme are listed in Annexe Table 9. At the small number of sites at which these species occur, specific protection measures and their funding requirements have been identified.

Wildlife Enhancement Scheme

The Wildlife Enhancement Scheme provides EN's main mechanism for delivery of SSSI management agreements with landowners. The primary objective of the scheme is to support management to ensure the maintenance of wildlife interest. It operates in England only and there are currently no exact equivalents in Scotland or Wales.

The scheme provides two types of payment: an Annual Management Payment for each area of land in the scheme and Fixed Costs payments for specific work to improve the wildlife value of the land.

There is currently no centrally held information on the numbers of ponds which have received grant aid under the Wildlife Enhancement Scheme. Only in one scheme area (White Peak) are ponds specifically noted as being eligible for payments.

Reserve Enhancement Scheme

The Reserve Enhancement Scheme provides a hectarage payment for conservation works on nature reserves (such as grazing, fencing and scrub management). To date it has been taken up by 33 Wildlife Trusts, with 500 sites in the scheme so far. The total budget for the Reserve Enhancement Scheme is 1997/98 is £850,000.

Ponds are potentially eligible for payments in this scheme under the grant option for Open Water management of £20/ha. At present there is 931 ha of open water within the scheme, some of which is in "small ponds" and some in lakes (M. Massey, English Nature, *pers. comm.*). No data were available on the actual numbers of water bodies involved.

The UK Biodiversity Action Plan

The UK Government ratification of the Biodiversity Convention in 1992 has prompted the development of local and national biodiversity action plans which affect a number of species found in ponds. Ponds were not identified specifically by the UK Steering Group as a priority habitat, although more than half of the 'short-list' of freshwater species for which actions plans have been developed can be found in ponds (Annexe Table A8.1), and several are dependent on them.

After woodland, standing open waters habitats have the second highest number of species (126) "....of conservation concern....". In contrast flowing waters and fen and swamp have about half this number (75 and 74 respectively) (UK Biodiversity Steering Group 1995).

The UK Steering Group Report also lists wetland and pond creation as "....an important conservation measure....", in a list of 13 practical measures which it recommended should be seen as of equal importance for the protection of biodiversity.

7.3 Land use planning legislation relating to ponds

7.3.1 Introduction

Local planning authorities are required under the provisions of the 1947 Town and Country Planning Act (and subsequent amendments) to prepare Structure Plans and Local Plans. These provide a statutory framework for land use planning, which takes into account nature conservation. Recommendations on the principles and policies that apply to the integration of nature conservation priorities and land use planning are given in Planning Policy Guidance: Nature Conservation (DOE 1994).

7.3.2 Policy Planning Guidance: Nature Conservation (PPG 9)

PPG 9 specifically refers to ponds as an example of sites of nature conservation importance *outside* designated areas which are regarded under the provisions of the Habitats Directive as "....of major importance for wild flora and fauna."

However, it also notes that local planning authorities should only apply local nature conservation designations to sites "....of substantive nature conservation value...." and take care to avoid unnecessary constraints on development.

7.3.3 Local planning authority policies

All local planning authorities have policies for nature conservation and environmental protection, but ponds are not necessarily mentioned specifically in Structure Plans. For example, Norfolk (which has areas with high densities of ponds, and some remarkable pond complexes) does not specifically mention ponds in its Structure Plan although it does note that:

> *"....river floodplains, rivers and streams....will be particularly protected."*

In contrast Cheshire County Council, covering an area which also has high densities of ponds, including sites of high conservation interest, provides clear guidance in the Cheshire Replacement Structure Plan:

> *"Development proposals which involve loss of ponds, wetlands, heathlands, ancient grasslands or ancient woodland will not normally be allowed and their conservation will be encouraged"*
> (ENV12, Cheshire County Council)

It should also be noted that (as with other habitats of high nature conservation importance) major infrastructure projects are only partially constrained by such policies. Frequently in these situations, ponds will be infilled and new ponds created elsewhere to mitigate the loss of habitat. In many cases the effectiveness of such measures is still unclear. This is particularly where the existing ponds support rare or uncommon species. New ponds are valuable waterbodies in their own right, but they may not be appropriate for supporting the uncommon taxa which are characteristic of more mature ponds.

7.3.4 Local planning authority pond conservation schemes

Local planning authorities formerly administered grants provided by the Countryside Commission for the conservation of landscape features including ponds. The Countryside Commission has discontinued this scheme and funds available by this route have subsequently dropped.

However, local authorities have continued to provide some grants for pond conservation work. For example, in Cheshire in 1996/97 grants of £16000 were available for pond conservation work, covering 40 ponds in 23 separate applications (Ian Marshall, Cheshire County Council, *pers. comm.*).

In Norfolk, the total funding available from the County Council for pond conservation work is currently less than £5000 annually. Taking the average of 12 counties[1] for which statistical information was obtained (approximately £5000) and multiplying it by the number of counties (47) this suggests that there may be in the region of £250,000 spent annually on pond management by local authorities. If a grant of £500 were awarded to each scheme this would reach 470 ponds, approximately 0.1% of all ponds in Britain.

Local planning authorities also provide advice about pond conservation, usually through information leaflets. There are no statistics about the number of ponds influenced by this mechanism.

7.4 Water resource management legislation and schemes relating to ponds

7.4.1 Designation as Controlled Waters

Many ponds (arguably the majority in the 'countryside') fulfil the criteria necessary to be regarded as Controlled Waters by the Environment Agency, and are therefore subject to the statutory requirement placed on the Agency to control pollution in such

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[1] Bedford; Berkshire; Cambridgeshire; Carmarthenshire; Cheshire; Derbyshire; Devon; Hampshire; Hereford & Worcester; Hertfordshire; Norfolk; Wiltshire.

waterbodies. Specifically, Controlled Waters include:

> *"....inland freshwaters, that is to say, the waters of any relevant lake or pond or of so much of any relevant river or watercourse as is above the freshwater limit...."*
> (WRA[1] 1991, subsection 104/1c)

where relevant lake or ponds means:

> *"....any lake or pond whether it is natural or artificial or above or below the ground which discharges into a relevant river or watercourse or into another lake or pond which is itself a relevant lake or pond...."*

The Environment Agency has generally interpreted the term 'discharge' to include discharge to groundwater as well as rivers and other controlled waters. Since almost all small water bodies discharge at least to groundwater, the WRA definition of controlled waters includes virtually all ponds, excluding only lined, off-stream ponds such as butyl-lined farm irrigation ponds and garden ponds.

In practice, there is, as yet, no national programme of pollution monitoring in small water bodies, although Environment Agency staff do occasionally respond to individual requests for pond quality assessments (Williams *et al.* 1996).

The Agency's recent draft Water Quality Policy (Environment Agency 1996) contains no mention of ponds. However, new biological methods for assessing still water quality (including ponds) are currently being developed by the Environment Agency (Williams *et al.* 1996), and this could provide the basis for a more systematic approach to pond quality assessment in the future.

In addition to the statutory duty placed on the Environment Agency to control *pollution* in ponds which are controlled waters, the Agency also has a general *conservation* duty:

> *"....to such an extent as it considers desirable, generally to promote the conservation of flora and fauna which are dependent on an aquatic environment..."*
> (Section 6, Environment Act 1995)

[1] WRA = Water Resources Act, 1991.

7.4.2 Environment Agency Strategy for the Environment

The Environment Agency has interpreted its many statutory responsibilities through a recently published series of strategy documents. These include one overall plan, "Our Strategy for the Environment" (Environment Agency 1996a), with a further eleven Function Strategies covering specific topics such as Conservation, Fisheries, Water resources and Flood Defence. Relevant aspects of these documents are considered below.

The Environment Agency draft Strategy for the Environment lists the 11 principal aims of the Agency of which three appear particularly relevant to ponds:

> *"To achieve significant and continuous improvement in the quality of air, land and water, actively encouraging the conservation of natural resources, flora and fauna."*
>
> *"To manage water resources to achieve the proper balance between the needs of the environment and those of abstractors and other water users"*
>
> *"To conserve and enhance inland and coastal water...."*
> (Environment Agency Draft Strategy for the Environment)

In its Strategy for the Environment, the Environment Agency notes that its principal tasks will include:

> *"preventing or minimising pollution of the water environment"*
>
> *"helping to protect and improve > 1500 km of top quality rivers and 200,000 ha of wetland Ramsar site".*
> (Environment Agency Draft Strategy for the Environment)

Further, more detailed aims, are outlined in individual Function strategy plans.

7.4.3 Environment Agency Nature Conservation Strategy

The Environment Agency has a statutory duty in respect of features of special conservation interest:

1. *"to further, wherever possible, conservation when carrying out water management functions"*

2. *"to have regard to conservation when carrying out pollution prevention and control functions."*

The draft nature conservation strategy places a strong emphasis on rivers and wetlands (Environment Agency 1996b). However, the term wetland is nowhere specifically defined. Potentially, aquatic habitats such as ponds, lakes, ditch systems, temporary waters, canals and brackish lagoons could all be regarded as wetlands using a broad definition of the term, such as that used for the Ramsar Convention (Scott and Jones, 1995).

Although the Environment Agency's future approach to pond conservation is unclear, in the past the Environment Agency has (as the NRA) undertaken a range of pond conservation projects at regional and national level. Amongst the most significant national outputs have been the production of general pond conservation guidelines (NRA 1993a) and the creation[1] and long-term monitoring of a pond complex in Oxfordshire (Biggs *et al.* 1995).

7.4.4 Local Environment Agency Action Plans

The day-to-day work of the Environment Agency is driven by region wide Local Environment Agency Plans (LEAPs). Based on the concept of the NRA Catchment Management Plan, these provide the framework for consultation about water management issues, including water-related nature conservation projects and programmes.

The Environment Agency is currently in the process of updating the Catchment Management Plans prepared under the auspices of the NRA to cover the broader requirements of an Environment Agency LEAP. To date, about 15 local plans have been produced nationally out of a total of approximately 130 to be completed to the consultation stage by 1999.

In general LEAPs have not yet established targets for pond conservation and contain relatively few mentions of ponds.

[1] In association with Thames Water Utilities Limited

7.5 Agricultural legislation and schemes relating to ponds

Agriculture-related legislation and schemes influence pond conservation in four main areas:

- through the impact of the Common Agricultural Policy (CAP) on land management,
- in voluntary schemes to encourage environmentally sensitive farming promoted by the Ministry of Agriculture Fisheries and Food (MAFF),
- regulatory controls, e.g. for pesticide use, to control agricultural development in SSSIs etc.
- in MAFF funded advice on countryside conservation provided by the Farming and Wildlife Advisory Group (FWAG) and FRCA.

7.5.1 Reform of the CAP: "agri-environment regulation"

From 1992, adoption of EC Council Regulation 2078/92, the "agri-environment regulation", has made CAP funds available to encourage environmentally sensitive agricultural practices (MAFF 1996).

Several of the general objectives of agri-environment schemes are relevant to pond conservation. These include aims to:

- reduce the use of fertilisers and/or plant protection products, or promoting organic farming
- promote more extensive forms of crop production or the conversion of arable land to extensive grassland
- remove farmland from agricultural production for at least 20 years for environmental purposes (MAFF, 1996).

All three objectives have the potential to bring benefits for pond quality and integrity. However, monitoring data are not yet available directly describing the effects of agri-environment related schemes on small waterbodies.

In promoting these objectives, the agri-environment regulation has prompted further development and expansion of a range of land-use management schemes of which the Environmentally Sensitive Areas scheme, Countryside Stewardship (England) and Tir

Cymen (Wales) are potentially the most important for pond conservation.
As well as encouraging de-intensification, all of these schemes include payments for the maintenance or creation of ponds (see below).

7.5.2 Environmentally Sensitive Areas

The Environmentally Sensitive Areas scheme includes 22 areas in England[1], 10 in Scotland[2] and five in Wales[3] covering about 10% of agricultural land. In England about half of the total area designated as ESA was under agreements in 1995/96 (409962 ha).

Each ESA typically has four or five major environmental objectives. Although these often include measures which might be expected to be beneficial to ponds (e.g. in the Upper Thames Tributaries ESA - "to revert arable land to wet grassland for increased benefit to the wildlife") none of the areas have pond conservation as a specific objective. However, in England, conservation grants for restoration and creation of ponds are now available in all ESAs, provided at a level of 50% of the total capital cost of works.

Farm Conservation Plans in ESAs

Within ESAs farmers may undertake one or two year Farm Conservation Plans, an option first introduced in 1992. Under the terms of the plan farmers may claim a percentage of the costs of a range of work, including pond restoration and creation.

In Scotland, payments for pond conservation work (as part of the Farm Conservation Plan) are available in five of the 10 ESA areas: Cairngorm Straths, Central Borders, Stewartry, Breadalbane and Loch Lomond ESAs.

MAFF is currently committed to providing approximately £100,000 of funding for the restoration of 97 ponds, and a further £8,000 for the creation of 9 ponds in England (Steve Morgan, MAFF, *in litt.*).

7.5.3 Countryside Stewardship

The objectives of Countryside Stewardship are to:

- sustain the beauty and diversity of the landscape;
- improve and extend wildlife habitats;
- conserve archaeological sites and historic features;
- improve opportunities for countryside enjoyment;
- restore neglected land or features;
- create new habitats and landscapes.

The scheme is available throughout England and is not restricted to any designated areas (but is not usually available in ESAs or in conjunction with other grant schemes).

Countryside Stewardship is targeted on a variety of landscape types and features. Of relevance to pond conservation are the following eligible types of landscape, habitats and features: waterside land, old meadows and pasture, historic landscapes and features, field margins on arable land and countryside around towns.

Of perhaps the greatest significance is the waterside land category, which includes:

> *"....land around...lakes and ponds...."* (MAFF 1996)

Eligible work in this landscape category can include restoration or creation of ponds.

Pond restoration can also be undertaken in all the remaining eligible landscape categories. In field margins of arable land eligible work can include the creation of buffer zones around ponds.

No statistics are available in England for the number of ponds which have been managed or created in the course of Countryside Stewardship. However, although ponds are not the subject of specific regional targets, the scheme encourages pond conservation work generally, with individual decisions made at officer level. Grants are available at the rates shown in Table 7.2.

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[1] ESAs in England: Breckland, The Broads, North Peak, The Pennine Dales, Clun, The Somerset Levels and Moors, The South Downs, Suffolk River Valleys, The Test Valley, West Penwith, The Avon Valley, Exmoor, The Lake District, The North Kent Marshes, The South Wessex Downs, The South West Peak, The Blackdown Hills, The Cotswold Hills, Dartmoor, The Essex Coast, The Shropshire Hills, The Upper Thames Tributaries.

[2] ESAs in Scotland: Central Borders, Central Southern Uplands, Western Southern Uplands, Stewartry, Loch Lomond, Breadalbane, Cairngorms Straths, Argyll Islands, Machair of the Uists and Benbecula, Barra and Vatersay, Shetland Islands.

[3] ESAs in Wales: Ynys Mon, Clwydlan Range, Lleyn Peninsula, Cambrian Mountains, Preseli.

Table 7.2. Rates of grant aid available for pond conservation in Countryside Stewardship schemes

Pond creation:	first 100 m^2	£3/m^2
	thereafter	£0.50/m^2
Pond restoration:	first 100 m^2	£2/m^2
	thereafter	£0.50/m^2
Scrape creation:	first 100 m^2	£1.25/m^2
	thereafter	£0.25/m^2

7.5.4 Tir Cymen

Tir Cymen, which is broadly equivalent to Countryside Stewardship in Wales, provides a basic payment for the whole farm being entered into the Tir Cymen Code. In addition to this, payments may then be made for specific work.

Table 7.3. Number of ponds restored or created in the Tir Cymen scheme pilot areas

Area	Created	Restored	Lagoons
Meirionnydd	25	16	1
Dinefwr	103	85	2
Swansea	61	87	1
Total	**189**	**188**	4

The Code requires landowners to protect water features, including ponds, on the farm, and recommends that they should:

> *"....keep the water clean and of good quality and keep the water table high throughout the year (as far as this is within [the control of the farmer]...."*

Specifically for ponds farmers are advised to:

> *"....clean ponds no more than once in 10 years...."*

Payments for the restoration and creation of ponds, and creation of shallow lagoons, are similar to those for Countryside Stewardship.

The maximum payment available for pond creation or management is £750.

Numbers of ponds created or managed under the Tir Cymen scheme after four years of operation in three pilot areas are shown in Table 7.3. The total number of ponds reached by Tir Cymen to date is about 1% of ponds in Wales.

7.6 MAFF Code of Good Practice for the Protection of Water

The MAFF Code of Good Practice for the Protection of Water covers all surface waters, including lakes and ponds. The code includes comprehensive advice on the control of pollution, particularly that due to organic farm wastes. Although the code is intended for all inland waters, most of the examples given indicate that it is primarily orientated towards the protection of streams, rivers or ditches. This may partly reflect a lack of research data on the impacts of agriculture on small standing water bodies.

7.7 Advice given by FWAG and FRCA

7.7.1 FWAG advisory visits

The Farming and Wildlife Advisory Group (FWAG) have county conservation advisors throughout England and Scotland. Officers (part funded by DETR and MAFF) provide a free advisory service to farmers and landowners, and about half of all farm visits include advice on ponds. Table 7.4 shows the number of visits made by FWAG advisors in England and Scotland and the frequency of advice given about ponds (FWAG does not have advisors in Wales at present). Note that the categories are not mutually exclusive.

7.7.2 FRCA

MAFF fund the Farming and Rural Conservation Agency (FRCA, formerly ADAS) to provide free on-farm conservation advice and, separately, free pollution advice.

FRCA conservation advice to farmers

In 1995/96 FRCA (ADAS) conservation advice covered 804 ponds in England in a total of 1495 visits. Advice given probably covered similar areas to that given by FWAG (see Table 7.4).

Table 7.4. Visits to farms made by FWAG advisors dealing with ponds (1995-1996)

	No of visits made (1995-96) (no. of ponds in parentheses)	
Type of advice	**England**	**Scotland**
Pond management	1015 (1801)	243 (284)
Pond restoration	778 (1098)	60 (51)
Pond creation	755 (772)	202 (158)
Total visits by FWAG advisors	3835	1904

FRCA pollution advice to farmers

In the three years 1994/95 to 1996/97 FRCA advisors made a total of 9000 free pollution advice visits to farmers, although clearly many of these visits would have paid less attention to ponds than streams, ditches and rivers. The primary focus of this advice was the prevention or minimisation of point source pollution. A recent economic evaluation of the service indicated that awareness amongst farmers of point-source pollution issues is now high and that the current service was no longer cost-effective. From March 1997 it was discontinued to be replaced by a more targeted service dealing with diffuse pollution and poor soil management.

Numbers of ponds reached by FWAG and FRCA

If all *conservation* related visits are assumed to deal with different ponds, FWAG and FRCA advisors are reaching about 1% of ponds per annum in Britain. It is not possible to asses the proportion of pollution control visits which might be relevant to ponds.

7.8 Rural Action

The Rural Action initiative aims to help rural communities take action to protect and improve their local environment (Rural Action, 1992). Rural Action is jointly funded by English Nature, the Countryside Commission and the Rural Development Commission. It operates in England.

Approximately 9% of grants awarded by Rural Action deal with ponds (a total of 250 projects since the first grant awards were made in December 1992). Table 7.5 shows the proportion of different projects.

7.9 Non Governmental Organisation projects

There are many projects operated by NGOs which affect the conservation of ponds, from individual surveys by members of organisations such as the British Dragonfly Society to the larger co-ordinated programmes of Pond Action and the BTCV. This section deals only with the larger projects specifically dealing with ponds, particularly those with important practical conservation implications. At present organisations such as British Trust for Conservation Volunteers (BTCV) and the Wildlife Trusts Partnership do not maintain statistics about pond management work, although both play a major part in pond conservation. However, much of this work is on designated sites (e.g. SSSIs).

Table 7.5. Grants awarded by Rural Action for pond conservation since December 1992

Activity	**No. of schemes**
Creation of new ponds	36
Restoration/improvement of existing ponds	134
Pond surrounds, access, pondside planting, dipping platforms	29
Surveys, management plans, feasibility studies, etc.	32
Interpretation (leaflets, boards, etc.)	8
Activities (pond- dipping, etc.)	9
Total	**248**

Source: Graham Kirkham, Rural Action, *in litt.* Categories are mutually exclusive.

7.9.1 British Trust for Conservation Volunteers

The BTCV promotes conservation volunteering in the UK, and is involved in a large number of practical pond conservation projects.

Although BTCV maintains detailed statistics on its volunteer activities, these do not specifically identify the number of projects or volunteer days specifically concerned with pond conservation.

However, important pond-related activities in BTCVs programme have included:

- the National Pond Campaign (14-29 September 1996) when BTCV local offices and groups organised at least 145 practical pond conservation projects nationally (Louise Edge, BTCV, *in litt.*);
- the recent publication of a set of pond conservation leaflets.

7.9.2 The Pond Conservation Group

The Pond Conservation Group is an informal consortium of organisations involved in pond conservation and protection.

The PPG includes: British Dragonfly Society, British Herpetological Society, British Waterfowl Association, Council for the Protection of Rural England, Ian Benton Ponds, Pond*Life* Project (Liverpool John Moores University), Pond Action, Surrey Wildlife Trust/The Wildlife Trusts Partnership, Wildfowl & Wetlands Trust and WWF-UK. English Nature and the Environment Agency are represented on the group in an advisory capacity.

In 1993 the PCG published 'A future for Britain's Ponds: An Agenda for Action' which included a six point plan calling for more widespread monitoring of pond quality, greater legislative powers to protect ponds, and financial incentives for creation and maintenance of ponds and surrounding buffer zones.

7.9.3 Toads on Roads Project

The Toads on Roads project is funded by the Department of Transport and co-ordinated by Frog*Life*. The project is responsible for co-ordinating approximately 500 sites (mainly in England) at which amphibian (especially toad) migration routes across roads are patrolled by volunteer herpetologists. Local authorities provide appropriate 'toad on the road' signs to warn motorists that they are approaching an amphibian migration route.

7.9.4 Pond Action

Pond Action is a non-profit organisation founded in 1988 to promote freshwater conservation. The group provides technical advice on the conservation of freshwaters to statutory bodies, environmental organisations, local authorities and members of the public.

Pond Action is a national centre for information and advice on the conservation and management of ponds. Pond Action initiated and undertook the National Pond Survey and is currently working on the development of new biological techniques for assessing the quality of standing waters for the Environment Agency.

7.9.5 PondLife Project

The Pond*Life* project is an EC LIFE funded programme co-ordinated by Liverpool John Moores University.

The aim of the project, which began in 1994, is to promote the conservation of ponds in agricultural landscapes through survey, education and practical action. The project has made a number of grants to community groups for pond conservation work. An important part of the Pond*Life* project has been the Pond Warden Scheme, which currently has 150 volunteers 'keeping an eye' on local ponds (J Boothby, Pond*Life* Project, *in. litt.*).

7.9.6 Biodiversity Challenge

Biodiversity Challenge is a consultative document prepared by a group of voluntary conservation organisations (BC, FOE, Plantlife, RSNC, RSPB WWF 1994). It outlined targets for pond conservation suggesting that:

(i) there should be a 1% increase in pond numbers per annum;

(ii) 10% of all ponds with RDB species, which need management, should be managed annually;

(iii) the percentage of ponds that have an effective buffer zone should be increased by at least 1% per annum.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

In this chapter the main results of LPS96 are reviewed, and the implications for future policy development discussed.

8.2 The importance of ponds

8.2.1 Pond ecological value

There is now extensive information to show that ponds play an important role in sustaining and protecting Britain's freshwater biodiversity (see Chapter 1). Many plant and animal species depend on ponds as their primary habitat, and recent research indicates that ponds have a conservation value at least equal to other major freshwater habitat types such as rivers.

The LPS96 wetland plant data provide additional evidence of the ecological significance of ponds. The survey recorded 55% of all Britain's vascular wetland plant species from 377 lowland ponds. Since the survey ponds represented less than 0.2% of lowland pond stock, the total wetland plant resource is likely to be rather greater.

In addition, approximately 2% of the survey ponds supported Red Data Book or nationally uncommon plant species. At a national scale, this suggests that approximately 3,5000 lowland ponds may support plant species of national conservation importance.

LPS96 considered only wetland plants, a group which comprise just one component of pond biodiversity. The LPS96 assessment will, therefore, inevitably underestimate the overall importance of ponds. For example, in the National Pond Survey, for every pond supporting a nationally significant plant species, there were at least eight further ponds of conservation importance because they supported Rare or nationally uncommon aquatic invertebrate species. Extrapolation of this figure to LPS96 data suggests that, nationally, in the order of 45,000 ponds could contain Rare or Nationally Scarce plant and animal species.

LPS96 also provides information describing the value of seasonal ponds. In Britain a decade ago, summer-dry countryside ponds would have been regarded as 'lost' or valueless. More recently, studies have shown that, although seasonal ponds are often relatively poor in species, they can support distinctive plant and animal assemblages including a range of rare and uncommon taxa (Bratton 1990, Collinson *et al.* 1995).

The LPS96 findings fully concur with the results of these other studies. Thus, although on average, the LPS96 seasonal ponds supported significantly fewer wetland plant species than permanent sites, seasonal ponds were just as likely to support nationally uncommon plants as permanent ponds. In LPS96 the only Red Data Book species recorded in the survey, Fox Sedge *Carex vulpina* (RDB2 Vulnerable), was recorded from a seasonal pond.

8.2.2 Amenity value

The amenity value of ponds has rarely been assessed and LPS96 data provides the first national estimates for their use.

The results, which are minimum figures (based only on on-site evidence), show that 15% of ponds were used directly for an amenity activity. Nationally this translates to the use of at least 27,400 (±5,100) ponds for amenity purposes. In addition about 20% of ponds (c.24,400 ±5,000) provide an important visual amenity.

8.2.3 The number of ponds

LPS96 data show that small water bodies are a numerically abundant freshwater habitat in lowland Britain. The total lowland pond stock estimated from LPS96 data is 228,900 (±25,900), an average density of 1.5 ponds per km^2.

The 1996 stock levels are 30-50% greater than the estimated stock of small water bodies derived from CS1990. The difference is due largely to the inclusion of areas not systematically included in previous surveys (such as woodland) and the introduction of a more precise definition of the term 'pond' (see Chapters 2 and 3).

8.3 The main pressures on ponds

Because ponds are small water bodies they can be highly vulnerable to damage. The range of stressors which can degrade ponds is wide; varying from pollution caused by agricultural chemicals and urban run-off to infilling, drainage and drought. LPS96 results help to clarify and quantify the importance of some of these pressures. The study also serves to highlight areas where further information is required.

The significance of some of the principal pressures on ponds is discussed below.

8.3.1 Pond loss due to in-filling and drainage

LPS96 data show that a large number of ponds are still being actively or accidentally drained and filled in. Between 1990 and 1996, an estimated 17,000 (±6,000) ponds were lost from lowland Britain, an average of about 2,800 per annum and about 7.5% of the 1990 stock over the period.

Of the cases where the reason for pond loss was known, just over half (57%) had been deliberately filled in for agricultural purposes or urban development. The remaining 43% were drained, usually in the course of agricultural activities.

In numerical terms, the loss of ponds was largely offset by creation of new ponds. However the rate of loss remains an issue of concern. In particular:

1. The ability to maintain ponds at their current levels in the countryside depends on pond creation rates of c.1% per annum. Continued pond creation relies partly on maintenance of existing grant levels, and this cannot be guaranteed.
2. It is likely that a proportion of lost ponds will be of high biological and amenity importance. Future Countryside Survey data will be required to establish whether this is the case.
3. New waterbodies are unlikely to provide an adequate replacement for lost ponds. New ponds are valuable in their own right, but a range of evidence suggests that they support different communities to older and more mature ponds (Biggs *et al.* 1994, Williams *et al.* 1996). The plants and animal communities of new ponds are not, therefore, likely to directly replace those of ponds which are lost.

A small number of physical pond attributes were measured in previous Countryside Surveys in 1984 and 1990, and this allowed at least some assessment of the physical and landscape differences between new and recently-lost waterbodies. The results broadly suggested that new ponds were, on average, larger and more likely to be located in ITE lowland pastural landscape types. Although woodlands suffered a net loss of ponds over the six-year period they currently support an above-average density of ponds (Chapter 3).

The full ecological significance of changes in pond size and context seen between 1990 and 1996 in the LPS96 dataset is unknown. However, the gains in larger ponds in pastural landscape types may represent a net benefit, since both attributes are associated, in the 1996 data set, with higher quality plant communities. In contrast, many new ponds were stream-fed and in the long-term may, therefore, be more exposed to stream-borne pollutants than ponds fed by surface water or groundwater.

8.3.2 Loss of permanent ponds through natural succession and in-filling

The natural succession process, during which ponds progressively fill with sediment or vegetation, has often been regarded as a major cause of pond loss.

In practice, although ponds can fill rapidly with sediment and lose permanent water, the transition to *dry* land, and the complete loss of the pond as a freshwater habitat, is typically a very slow process. The reason for this is clear: once pond sediments reach the water surface in summer, oxidation rates increase and sediment accumulation rates are considerably reduced. As a result, ponds can often persist in a seasonal state for a far

longer period than the duration of their permanent water phase (Gray 1988; Collinson *et al.* 1995).
The transition from permanent to seasonal water is a natural and predictable phenomenon to which many pond species are well adapted, either moving to new permanent sites or exploiting the specialised conditions provided by temporary water habitats. As noted previously, seasonal-phase ponds created by this process can sometimes be valuable habitats supporting assemblages of high conservation importance.

LPS96 provided clear evidence that seasonal ponds are a relatively abundant pond type in the countryside, with at least 37% of LPS96 ponds seasonally dry. 1996 was an unusually dry year (Section 2.4.6), and some ponds may have dried for the first time. However, this is unlikely to have significantly influenced the general survey finding that seasonal or semi-seasonal ponds are a common countryside feature.

In addition to demonstrating the high frequency of seasonality among ponds, LPS96 showed that many of the remaining 'permanent' water bodies were relatively shallow, with an estimated 42% of permanent lowland ponds having average summer water depths of less than 25 cm.

Neither the occurrence of large numbers of seasonal ponds, nor the transition from permanent to temporary waters is inherently undesirable. Seasonal ponds are a natural waterbody type to which many freshwater plants and animals are well adapted. However, it remains true that the habitat provided by permanent ponds is ecologically rich and important for many species of invertebrates, aquatic plants and some amphibians which cannot use seasonal sites. In addition permanent ponds have both aesthetic and amenity values which seasonal ponds cannot often attain.

As a large proportion of permanent ponds are quite shallow, and given observed rates of sedimentation, LPS96 results suggest that many of the existing permanent ponds could undergo a transition from a permanent to a semi-permanent or seasonal state in the relatively near future. This process might be expected to be exacerbated by climate change (see 8.3.3 below).

Lack of specific data relating to net pond in-fill rates makes it difficult to give general estimates of the rate at which permanent lowland ponds might become seasonal. However, using a conservative estimate of the rate of in-fill of 1.5 cm yr^{-1} (only half the rate of in-fill actually observed in new LPS96 sites 0-12 years old), ponds which were shallow but permanent in 1996 might be expected to be becoming seasonal at a rate of c. 2.5% per year.

Overall, therefore, the results of the LPS96 suggest that it is desirable to provide a strategy for ensuring the maintenance of permanent-water ponds. Methods for doing so are discussed further in Sections 8.4.1 and 8.5 below.

8.3.3 Climate change and drought

There is currently fairly widespread scientific acceptance that climatic change is likely to progressively shift Britain's climate towards hotter, dry summers and warm, wetter winters, with a net reduction in water availability (Environment Agency 1996a).

For ponds, the greatest impact of such a change would probably be to marginal pond habitats and, particularly, to the communities of shallow and temporary waters. Indeed Grime and Callaghan (1990), in an analysis of the effect of climate change on Britain's plant assemblages, suggested that wetland and aquatic species, including pond floras, would become one of the assemblages *most* at risk from such changes at a national level.

It is clear that high quality temporary ponds, such as LPS96's Fox Sedge (*Carex vulpina*) pond, and many others nationally, are specifically at risk from a drier climate. A moderate drop of 10 cm in average water levels might be expected, for example, to have relatively few damaging impacts on deep permanent ponds. Such a change would, however, completely alter the periodicity of wet and dry phases at seasonal sites and, in many, would completely destroy the integrity of the pond and its community.

If ponds dry earlier in the season, species which normally complete the aquatic part of their life cycle during spring and early summer may no longer be able to do so. Even longer-lived species which can tolerate occasional years of reproductive failure may be extinguished as the chance of consecutive years' failure increases.

Clearly, lower water levels also have the potential to increase the rate at which shallow permanent ponds become seasonal, speeding-up the process of natural succession and reducing the extent of open water. This again provides a threat to aquatic biodiversity as permanent water habitats become more scarce.

Although LPS96 provides no direct evidence of the effects of groundwater abstraction on ponds, abstraction is known to represent a threat to ponds across some parts of lowland Britain (English Nature 1996). LPS96 data indicates that high quality ponds often occur on river floodplains. Since floodplains are an area where abstraction might be expected to have particularly significant impacts, this is an issue of concern (M. Drake *in litt.*). Climate change and increasing demands for water (agricultural, industrial and potable) would be likely to exacerbate such effects.

8.3.4 Water quality and pollution

There are currently few quantitative data describing the extent to which land-use practices influence the ecological quality of ponds. LPS96 results are therefore of particular interest in that they are amongst the first to provide such information.

Comparison of LPS96 ponds with the minimally impaired sites of the National Pond Survey showed that LPS96 ponds were of generally lower ecological quality than sites located in areas of semi-natural land use (such as unimproved grasslands, woodlands and lowland heathland). Thus, on average, NPS ponds supported twice as many plant species as LPS96 ponds, and whereas 70% of NPS ponds fell into the top two conservation value categories (High and Very High), only 20% of LPS96 ponds did so.

Overall, the results of LPS96 suggest that the quality of ponds in the countryside is significantly impaired where they occur in association with intensively managed land (e.g. arable land, urbanised areas). Within the LPS96 the clearest indication of this effect was seen in arable farmland.

LPS96 data also suggested that isolation may contribute to the poor quality of many ponds. An interesting study finding was the strong correlation between high quality plant communities and the location of ponds in traditionally wet areas, particularly river valleys. Thus, there was a suggestion that the effects of intensive land use may be partly mitigated in naturally wet areas, perhaps because wetlands provide a continual source of colonising propagules. Stated another way, interactions between ponds and other wetlands may be of considerable importance in maintaining the overall ecological integrity of ponds. The absence of high quality wetland areas (marshes, streams, pools etc.) from large areas of the intensively drained lowland landscape may, therefore, also be a significant factor contributing to the widespread occurrence of lower quality ponds in many countryside areas.

Although both LPS96 and NPS data indicate that ponds in semi-natural areas are of high quality, it is important to recognise that even the highest quality ponds (e.g. within SSSIs, NNRs) may be exposed to degrading factors. Atmospheric deposition, groundwater abstraction, climate change and stream inflow-borne pollutants all have the potential to subtly impact semi-natural areas. Currently, little is known of the significance of these factors, but their potential to reduce the value of some of the highest quality ponds is of concern.

8.4 Current policies and potential solutions

This section evaluates methods for ameliorating stresses which the LPS96 results suggest affect pond quality. The adequacy of current policies and schemes which aim to protect these water bodies is also considered.

8.4.1 Pond management and creation

Paradoxically, permanent ponds are an inherently ephemeral type of water body. In *natural* landscapes, loss of permanent water ponds through time is compensated for by the natural creation of new ponds. In intensively managed agricultural and urban landscapes natural pond creation processes are, in contrast, rare, and ponds must be either (i) managed or (ii) deliberately created to persist in the landscape.

Of the two processes, pond management and pond creation, it is pond creation which is arguably the more essential. Thus, although pond dredging and pond creation both have the potential to compensate for 'loss' of permanent ponds through succession to temporary waters, only pond creation can begin to compensate for the estimated 2,800 (±650) lowland ponds lost annually to drainage and deliberate in-filling.

LPS96 data suggest that currently there may be more or less adequate rates of pond creation to compensate for existing levels of pond destruction (at least in numerical terms and albeit with a small calculated shortfall, see also Section 8.3.1). However, it seems likely that permanent water habitats may increasingly decline as ponds fill in through natural successional processes to become seasonal.

On balance this implies a need for either more widespread pond creation or greater levels of pond management to maintain permanent water habitats and compensate for natural succession processes. The comparative advantages and disadvantages of pond management and creation as options for sustaining permanent ponds in the landscape are summarised in Tables 8.1 and 8.2 and discussed below.

Pond management

The benefits of pond management are not always clear-cut. Dredging and vegetation removal will deepen ponds and increase open water, but these invasive techniques can also severely damage the quality of existing pond communities resulting in net loss of conservation value (Biggs *et al.* 1994). Similarly, whilst pond dredging can be beneficial in removing polluted and nutrient enriched pond sediments, little long-term benefit is gained if ponds simply re-fill with polluted sediment, and remain degraded.

Table 8.1 The benefits and disadvantages of pond dredging

Benefits of pond dredging	Disadvantages of pond dredging
• Where ponds are not managed they inevitably become seasonal through time. As a result, species-richness will usually decline and specialist *permanent* water biota will be lost. • Both visual amenity and leisure potential decline as ponds dry up. Pond management is therefore necessary for many ponds with high public interest. • Many countryside ponds will have enriched and polluted sediments and extensive dredging may be the most effective means of removing these.	• All stages of succession are valuable for pond plants and animals (Biggs *et al.* 1994). Shallow-water and seasonal ponds are often destroyed by dredging and this can result in the loss of distinctive, and sometimes exceptional, plant and animal communities. • Dredging or plant removal can damage the existing value of ponds even where they are already deep or permanent. This is particularly likely to occur where dredging and removal is extensive and there are few sources for re-colonisation from the surrounds. • Dredged ponds located in intensively managed surrounds may simply fill-in again with polluted sediment, and remain degraded habitats. • Where ponds have deep sediments dredging is difficult, expensive and often only partially successful, since much sediment is usually left behind. • Dredging-out sediments from ponds of heritage interest (fish ponds, moats etc.) destroys their sediment record and is strongly discouraged by agencies such as English Heritage.

Current pond management policies

The possible damage associated with invasive management is not currently reflected in most existing grant giving policies. Only Tir Cymen specifically recommends that it is inadvisable to manage ponds more than once every 10 years, and few grant giving bodies stipulate the extent or type of management appropriate for different pond types.

Ideally grants which aim to encourage pond management for the benefit of wildlife should also encourage good practice. In particular, care should be taken not to damage the existing interest of ponds by wholesale dredging or plant removal.

Unfortunately there are no prescriptive rules which can be given to ensure that pond management will always be ecologically neutral or even beneficial. Only by surveying sites might it be possible to achieve this objective. Ecological surveys are an ideal which should be actively promoted. However, they are unlikely to be a practical option for most countryside ponds. It is therefore necessary to urge general caution in pond management.

Some simple 'best practice' guidelines attached to pond management grants (e.g. retain half of existing plant stands, in the absence of survey data do not deepen seasonal ponds) could be used to increase the benefits of, and reduce the possible damage caused by, pond management.

Pond creation

LPS96 results suggest that an estimated 2,500 (±1,100) new ponds are created each year in the lowland countryside. Ecological data from LPS96 ponds indicates that new sites were typically of high quality. In particular there was evidence that, on average, new ponds had: (i) greater species richness, (ii) more uncommon species and (iii) lower Trophic Ranking Scores than older water bodies. As discussed previously (Section 8.3.1), this result does not suggest that older ponds can be simply replaced by new ponds and are therefore expendable. Many existing ponds are of high value and support species which cannot easily persist at new sites. It does, however, indicate that new ponds are of considerable ecological value in their own right.

Evidence that new ponds had consistently lower Trophic Ranking Scores than older sites was of particular interest because it suggests that new ponds have the advantage of relatively reduced nutrient status in their early years. This allows new sites to support more plant (and potentially animal) species typical of oligotrophic and mesotrophic waters than is typical of older ponds. In the often over-enriched freshwater habitats of lowland Britain, such water bodies and species are at a premium.

A decade ago, evidence of the relatively high quality of new ponds would have been a surprising result. Since then, a number of studies have provided evidence which support the findings of the Lowland Pond Survey. In particular it is now known that:

- new ponds often colonise rapidly with both plants and macroinvertebrates (Biggs *et al.* 1995; Williams *et al.* 1997),
- new ponds can support distinctive plant and animal communities, including uncommon species not found in later stages of pond succession (Biggs *et al.* 1994)

In addition, LPS96 data show that new ponds are often of considerable amenity benefit. Correlation analysis indicated that new ponds had significantly greater amenity use than older ponds, and in the few cases where field surveyors could directly gather information from farmers and landowners, the data suggested that most ponds were specifically created for amenity use (Chapter 6).

In practice, as with pond management, using pond creation as a tool for maintaining ponds in the countryside has both advantages and disadvantages. These are summarised in Table 8.2.

Table 8.2 The benefits and disadvantages of pond creation

Benefits of new ponds	Disadvantages of pond creation
• New pond creation is a 'natural' and sustainable technique for retaining ponds in the landscape. New ponds mature into older ponds and ultimately sustain plant and animal communities associated with the full range of pond succession stages.	• New ponds cannot *immediately* provide an adequate replacement for high quality mid- or late-succession sites. Thus, where a mature pond supports uncommon species, careful management is the best, and often only, option for retaining those species.
• New ponds can be carefully located so their future pollution inputs are minimised (i.e. siting in semi-natural areas, or surrounded by buffers). This will maximise their conservation potential throughout their life-span and help to prevent the degradation common in ponds in the wider countryside.	• Differences between type and location of new ponds compared to older sites could result in undesirable shifts in pond type or biotic assemblage quality. Note however there is currently little evidence of this from the LPS96 survey except in the tendency for new ponds to be stream fed (see Section 8.2).
• Pond creation adds to the stock of permanent water ponds, replacing ponds that are destroyed and compensating for open water ponds that are becoming seasonal without loss of the seasonal sites.	• The location of new ponds needs to be chosen carefully and sensitively to avoid damage to existing high quality habitats.
• The creation of new ponds starts from a clean slate, so they can be specifically shaped and designed to maximise their value for wildlife and/or other uses.	
• New ponds often quickly attain a high wildlife value and support distinctive communities. This can include plant species associated with a lower nutrient status than is typical for the wider countryside.	

Implications for pond creation policies

On balance, pond creation has considerable advantages as a technique for maintaining ponds in the countryside. In particular, it does not have the potential to damage existing pond habitats and it allows much greater freedom in the location and design of ponds.

The latter point is of particular importance because, if new ponds are well designed and sited, it is possible not only to create very high quality sites but to *retain* high pond value in perpetuity. In contrast, managing a poorly located existing pond may be relatively ineffective in wildlife terms, if it maintains a site which will always receive polluted inputs and which can never support an unimpaired biotic assemblage.

The potential for carefully designed and located pond creation schemes to bring significant wildlife benefits is exemplified by the Pinkhill Experimental Wetland site. This scheme, a mosaic of new ponds created in a small (2 ha) Thames-side field in 1990, was found to support approximately 20% of Britain's wetland plants and larger macroinvertebrates within five years of their creation (Biggs *et al.* 1995, Williams *et al.* 1997). The value of similar small-scale projects, if undertaken on a national basis, could be considerable.

The benefits associated with pond creation (Table 8.2) provide a strong argument for greater promotion of pond creation schemes.

A particularly effective use of grant funding would be to target pond creation in areas of relatively low intensity land use. Ponds often have very small surfacewater catchments, and adequate protection of this catchment would be feasible in many farmland and other countryside areas. Such a strategy has the potential to bring long term improvements in lowland pond quality through a relatively cost-effective mechanism.

Further ecological benefits would be likely to accrue from:

- policies to encourage pond creation in traditionally wet places such as river valleys and wetlands (wet grasslands, undrained heathland, fen and marsh areas etc.). Note that this must avoid damaging existing high quality wet or dry habitats.
- provision of good advice on pond design which incorporates the results of recent research (e.g. Biggs *et al.* 1995, Williams *et al.* 1997).
- relative increases in grant aid for pond creation schemes designed and implemented specifically for wildlife. Currently, limited evidence from LPS96 suggests that most new ponds are created for amenity or economic purposes (Chapter 6). Few pond creation schemes appear to be specifically nature conservation led. Unfortunately, ponds created for purposes such as fishing or irrigation may not always be optimal for wildlife in the long term (Williams *et al.* 1997).

Currently there is little information about the balance of effort and resources allocated to pond management and creation by the principal grant and advice giving bodies. However the schemes for which data are available suggest a focus on pond management rather than pond creation:

- MAFF in English ESAs currently provides support mainly for pond management (in financial year 1997/8, grants of £100,000 have been allocated to 97 restoration schemes compared to £8,000 for 9 pond creation projects),
- Tir Cymen in Wales provides similar levels of funding for creation and management,
- FWAG predominantly advises on pond management (about 2/3 of pond related advisory visits deal with restoration or management).

Greater promotion of pond creation within such schemes would be likely to be of benefit.

8.4.2 Land management and buffer zones

The pond quality results from LPS96 emphasise the need to increase the extent to which ponds are protected from the effects of intensive rural land management.

For most ponds, buffer zones (areas of semi-natural land around a water body) are likely to offer the most realistic method of protecting pond quality in the long term. Buffer zones are not a panacea. They may have little effect on the quality of ponds fed by streams which are not themselves buffered. Similarly, for ponds that are already extensively affected by temporally persistent pollutants (phosphate, heavy metals etc.), buffer zones may bring relatively few short term improvements unless accompanied by other measures such as dredging to remove the existing polluted sediments.

More positively, pond buffer zones are likely to be immediately effective in reducing the extent to which degradable and non-persistent pollutants (e.g. pesticides, nitrates) can reach and affect a pond system. Buffer zones also provide additional habitats for the many aquatic animal species which have a terrestrial phase and, as discussed above, they provide an essential means of helping to protect and maintain the quality of new ponds.

Currently most pond conservation schemes are focused on physical management (dredging, desilting, cutting back trees, removing vegetation). In practice relatively few provide for the protection of the catchment of the pond, and the maintenance of water quality.

Environmental land management schemes, such as ESAs and Countryside Stewardship are an exception and have objectives that should be highly beneficial for pond conservation. However, although these schemes appear at first sight to influence a large part of the countryside, of the 10% of agricultural land designated as ESAs, only half of the land inside the boundaries of ESAs has been entered into schemes. Significantly, even for most entered areas, the principle result has been maintenance of the *status quo* and only a small proportion of land has been taken into the top tiers of the scheme where de-intensification and increasing waterlevels may be an objective.

Of the remaining pond or land management schemes only Countryside Stewardship includes an option to create buffer zones around ponds and, as yet, it is not known how widely this option has been taken up.

8.4.3 Pond protection

Ponds in existing SSSIs are relatively well-protected both legally and in terms of control of adverse environmental impacts.

However, as LPS96 results show, there are many thousands of ponds in the wider countryside supporting communities of exceptional value including RDB and Nationally Scarce species of national conservation importance.

For most of these ponds, designation under the SSSI system is not likely to be an option. SSSI criteria (size, naturalness etc.) are not ideal for assessing the quality of small water bodies, and consequently few ponds have been designated in their own right. English Nature themselves recognise this, stating that "...ponds have received less statutory protection than other freshwater habitats" (English Nature 1997).

Lack of statutory protection has important knock-on effects for the conservation of ponds because much conservation effort is directed by the designation of sites as SSSIs (e.g. the Environment Agency Conservation Strategy and local planning authority Structure Plans, both of which place highest priority on designated sites).

There is, therefore, an argument for more effective policies or legislation which would promote a greater degree of statutory protection for ponds and provide a more effective mechanism for protecting high quality ponds.

8.4.4 The need for monitoring and assessment

To formulate appropriate countryside polices for ponds, it is necessary to understand the factors that affect waterbody quality. Monitoring and assessment are, therefore, essential pre-requisites in order to provide this information. For ponds, monitoring would be particularly valuable in three main areas: pond numbers, water permanence and pond quality.

Monitoring pond numbers

LPS96 data indicate that a substantial turnover of lowland ponds occurred between 1990 and 1996. Relative changes in the rates at which ponds are destroyed and created could therefore have a considerable effect on lowland pond numbers. An implication of this is that there is a clear need to maintain monitoring projects to assess future trends in pond numbers.

Countryside Surveys (both general and thematic) provide a viable means of gathering such data. Specifically, they have the benefit of being representative and, with sufficient survey data, have the potential to allow rather subtle changes in pond numbers to be adequately evaluated. Ideally, future general and thematic surveys should include Marginal Upland and Upland landscapes to properly evaluate trends and impacts in these regions.

Monitoring water permanence

Previous sections (8.3.3, 8.3.4) suggested that increased pond seasonality, caused by natural succession and climate change, is a potential threat to the number of permanent ponds sustained in the countryside. Additional data relating to average sediment accumulation rates and current pond management effort would help to clarify the likely extent of such threats.

In addition, periodic monitoring would be beneficial in order to measure the relative changes in water level and sediment accumulation which lead to increased pond seasonality. As stated in the scoping study for LPS96 (Biggs *et al.* 1996), gathering water and sediment data is not simple, as factors such as regional and annual climate differences make it difficult to interpret temporal trends. Surveys like LPS96 can only make such assessments through trend analysis over successive surveys. If such surveys are to be undertaken only once every 5 years, it would be difficult to use the Countryside Survey approach to make such assessments quickly. Regular (monthly/annual) monitoring of fixed gauge boards or installation of automatic water level recorders located at specific sites would be preferable as a means of assessing the relative importance of falling water levels and sediment in-fill through time.

The effect of climate change on shallow and seasonal pond faunas and floras is of particular concern. Although shallow waters have been identified as a habitat at particular risk, no agency is currently monitoring small or temporary ponds to investigate the extent of the impact of climate change. Furthermore, shallow and seasonal pond sites are not specifically included as monitored freshwater systems in the multi-agency Environmental Change Network (ECN). A number of species of high conservation importance associated with seasonal and semi-permanent ponds may be at particular risk (e.g. Starfruit (*Damasonium alisma*), Adder's-tongue Spearwort (*Ranunculus ophioglossifolius*), the tadpole shrimp *Triops cancriformis* and the fairy shrimp *Chirocephalus diaphanus*).

Monitoring pond quality

LPS96 and NPS data indicate that the ecological quality of many countryside ponds is degraded compared to a baseline of relatively unimpaired sites. It seems highly likely that many countryside ponds owe their reduced ecological value to poor water quality. There is, however, little information about the types or sources of the pollutants impacting ponds in either semi-natural areas or the wider countryside.

The Environment Agency, which is responsible for monitoring water quality in England and Wales, has, as yet, no programme of pollution monitoring for small water bodies. New biological methods for assessing ponds are currently being developed by the Environment Agency (Williams *et al.* 1996), and this could theoretically allow the development of a more systematic approach to pond quality assessment within 1-2 years.

Further thematic Countryside Surveys would also be of considerable value in assessing trends in pond quality. In the current survey (LPS96), the inclusion of wetland plants was of considerable value in giving both an indication of the biodiversity value of ponds and indicating their quality (i.e. the extent to which some are degraded). Inclusion of an additional aquatic invertebrate species component in future thematic surveys would be of still greater value since aquatic invertebrates are a highly biodiverse group which are useful for water quality monitoring and of considerable conservation importance in their own right.

8.5 Recommendations

Evaluation of existing wildlife and countryside policies in the context of LPS96 findings has identified a number of areas where changes in policy emphasis could be highly beneficial. A summary of recommendations based on these findings is given below.

8.5.1 Pond creation

The high rates of turnover observed in countryside ponds (ca.1% per annum) suggests that it should be possible to use pond creation incentives (grants, advice etc.) to achieve long-term improvements in the ecological quality of countryside ponds. It is likely that most benefit would be derived by:

- specifically encouraging and promoting high quality pond creation schemes. This process might be enhanced by, for example, increasing grant level differentials to favour pond creation,

- linking pond creation grants (or grant rates) to factors such as pond location, design and specific uses (e.g. wildlife conservation) in order to ensure long-term protection of pond quality,
- providing updated information and advice on good pond design.

8.5.2 Pond management

Pond management has much value as a method for retaining the number of permanent ponds in the countryside. However, wholesale dredging carries considerable risks of environmental damage. The ecological benefits derived from existing pond management grants would almost certainly be increased by:

- including simple stipulations for good management practice as part of the grant conditions e.g. retain half of existing plant stands.
- providing clear and simple recommendations for good pond management in literature describing and accompanying grant awards.

8.5.3 Land use and pollution

LPS96 data showed clearly that many countryside ponds have an ecological quality which lies well below their full potential. Measures to improve pond catchment quality are likely to be the most effective means of increasing the quality of these ponds in both the short and long term.

It is therefore recommended that:

- There is active promotion and extension of schemes for buffer zone creation around new and existing ponds, both to reduce their exposure to pollutants and to improve the habitat quality of the pond surrounds.
- 'Good agricultural practice' advice, relating to minimising pond pollution, is updated and widely promoted.

8.5.4 Pond protection

Ponds are acknowledged to have received less statutory protection than other freshwater habitats. There are currently likely to be many thousands of ponds which support exceptional plant and animal communities of national importance but which are without any form of statutory protection.

It is therefore recommended that:

- there is further investigation of the potential for regulation to enhance the protection of ponds of high wildlife and landscape value.
- Local Authorities include ponds systematically in structure plans, local plans and unitary development plans.

8.5.5 Public awareness

In view of their considerable biodiversity importance, ponds are still generally undervalued as a freshwater habitat. This is partly because much information describing pond ecology and management is of recent origin. As a result, many pond conservation issues are poorly appreciated by ecologists, conservationists and the wider public alike.

Awareness campaigns could be of considerable value in increasing understanding of pond-related issues such as the importance of seasonal ponds and the damaging spread of exotic species. Greater public awareness of pond creation and management issues would also be valuable to encourage grant take-up and promote development of independent pond creation and management schemes.

Education campaigns need to be undertaken with care, however, since the message is often complex: promotion of schemes to increase the number of permanent ponds would be valuable for example, but not if it occurs through drastic deepening and loss of particularly valuable shallow or seasonal ponds.

8.5.6 Monitoring recommendations

The formulation of appropriate pond polices relies on a good understanding of the factors that affect waterbody number and quality. Monitoring is an essential pre-requisites to provide this information. Recommendations for future pond monitoring include:

- Initiation of a national quinquennial programme of biological water quality monitoring in ponds based on a stratified survey of pond types and qualities.

- Continuance of Countryside Survey monitoring to evaluate trends in pond numbers and condition at a national level.
- Initiation of further and more detailed investigations of the relative effect of sediment in-filling and climate change on the persistence of permanent and seasonal sites.
- Investigation of the biological effect of climate change on the biota of shallow and seasonal ponds. This might be achieved by, for example, including a greater range of small water body sites in the Environmental Change Network programme.

9. GLOSSARY

Aquatic plants: A group combining both submerged and floating-leaved species.

BTCV: British Trust for Conservation Volunteers.

CAP: Common Agricultural Policy.

CS: Countryside Survey.

Curtilage: land legally attached to buildings, forming one enclosure with those buildings (e.g. gardens, farmyards).

DETR: Department of the Environment, Transport and the Regions.

Distribution status: Distribution status (Common, local, etc.).

DOE: Department of the Environment (now the Department of the Environment, Transport and the Regions).

Dystrophic: Very low nutrient status e.g. typically Total P<0.005 mg l^{-1}, Inorganic N <0.02 mg l^{-1}, pH <6.

ECN: Environmental Change Network.

Emergent plants: Wetland species which typically have most of their leaves above water level, e.g., tall emergent species such as Bulrush (*Typha latifolia*) and Soft Rush (*Juncus effusus*); wetland herbs such as Water Forget-me-not (*Myosotis scorpioides*) and low-growing grasses such as Creeping Bent (*Agrostis stolonifera*).

EN: English Nature.

ESA: Environmentally Sensitive Area.

Eutrophic: High nutrient status e.g. typically Total P 0.03 - 0.10 mg l^{-1}, Inorganic N 0.5 - 1.5 mg l^{-1}, pH >7.4

Floating-leaved plants: Aquatic plants with most of their leaves floating on the water surface, e.g., Common Duckweed (*Lemna minor*), water lilies.

FRCA: Farming and Rural Conservation Agency (formerly Agricultural Development Advisory Service ADAS).

FWAG: Farming and Wildlife Advisory Group.

Hypereutrophic: Very high nutrient status e.g. typically Total P >0.10 mg l^{-1}, Inorganic N >1.5 mg l^{-1}.

ITE: Institute of Terrestrial Ecology.

LPS96: Lowland Pond Survey 1996.

Macrophyte: Larger plant species. In the context of the LPS96 this group includes vascular wetland plants, mosses, liverworts and charophyte species.

MAFF: Ministry of Agriculture Fisheries and Food.

Mesotrophic: Moderate nutrient status e.g. typically Total P 0.01 - 0.03 mg l^{-1}, Inorganic N 0.3 - 0.65 mg l^{-1}, pH around 7.

Nationally Uncommon plant: A species designated as Nationally Scarce or recorded from 100 or fewer 10 km squares in Britain.

NNR: National Nature Reserve.

NPS: National Pond Survey.

NRA: National Rivers Authority (now the Environment Agency).

Oligotrophic: Low nutrient status e.g. typically Total P 0.005 - 0.01 mg l^{-1}, Inorganic N 0.02 - 0.4 mg l^{-1}, pH 6-7.

PA: Pond Action.

PCG: Pond Conservation Group.

pH: A measure of the acidity or alkalinity of a substance based on the number of hydrogen ions in a litre of solution. pH 7 represents neutrality, smaller values are acid, larger values are alkaline.

PPG: Planning Policy Guidance.

RDB: A nationally uncommon species listed in the Red Data Book for that taxonomic group. For plants, RDB species are those recorded from only 1-10 10 km squares in Britain. Three RDB categories are recognised: RDB3 = rare species, RDB2 = vulnerable species, RDB1 = endangered.

RSS: Rare Species Score. Value representing sum of numerical scores given to uncommon species in order to reflect their rarity value i.e. 2= locally common species, 64 = RDB1.

Species richness: The number of plant or animal species recorded.

SRI: Species Rarity Index. A numerical assessment of the average species rarity of a particular community or sample. Calculation of SRIs is explained in Appendix 6.

SSSI: Site of Special Scientific Interest.

Submerged plants: Aquatic plants which are generally submerged for most of the year (except for flowers), e.g., hornworts (*Ceratophyllum* spp.), water milfoils (*Myriophyllum* spp.).

TRS: Trophic Ranking Score. A biotic measure of water body nutrient status.

WCA: Wildlife and Countryside Act, 1981.

Wetland plants: All wetland plant species, including those which are emergent, floating-leaved, and submerged. Plants included as 'wetland' in this study are defined by the LPS96 Wetland Plant List. See Annex 2.

WRA: Water Resources Act, 1991.

10. REFERENCES

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. (1994). *Countryside Survey 1990. Inland water bodies.* Countryside 1990 Series Volume 6. Department of the Environment, London.

Biggs, J., Corfield, A., Walker, D., Whitfield, M. and Williams, P. (1994). New approaches to the management of ponds. *British Wildlife*, 5, 273-287.

Biggs, J., Corfield, A., Walker, D., Whitfield, M. and Williams, P. (1995). *Experimental management of wetland habitats at Pinkhill Meadow.* NRA R&D Project Record 383.

Biggs, J., Corfield, A., Walker, D., Whitfield, M. and Williams, P. (1997). *Monitoring of wetland habitats at Pinkhill Meadow. Phase II (1995-1997).* Interim Report to the Environment Agency. Pond Action, Oxford.

Biggs, J., Williams, P., Corfield, A., Whitfield, M., Barr, C.J. and Cummins, C. (1996). *Pond Survey 1996. Stage 1 Scoping Study.* Pond Action, Oxford and ITE, Merlewood.

Bratton, J.H. (1990). Seasonal pools, an overlooked invertebrate habitat. *British Wildlife*, 2, 22-29.

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*, edited by Fuller, R.M., 39-46 (ITE symposium no 10.). Institute of Terrestrial Ecology, Cambridge.

Bunce, R.G.H, Barr, C.J., Benefield, C.B., Howard, D.C. and Lane M. (1994*). The ITE Land Classes - Distribution and descriptions (Draft).* Project T02051m5. Institute of Terrestrial Ecology, Merlewood.

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.

DOE (1994). *Planning policy guidance: nature conservation.* PPG 9. Department of the Environment, London.

Environment Agency (1996a). *Our strategy for the environment. An integrated approach to management of the environment.* Environment Agency, Bristol.

Environment Agency (1996b). *Conservation strategy.* Draft for consultation. Environment Agency, Bristol.

English Nature (1996). *Impact of water abstraction on wetland SSSIs.* English Nature, Peterborough.

English Nature (1997). *Wildlife and freshwater an agenda for sustainable management.* English Nature, Peterborough.

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

Grime, J.P. and Callaghan, T.V.G. (1990). *Direct and indirect effects of climate change of plant species, ecosystems and processes of conservation and amenity interest.* Contract report T07020b1. DOE.

MAFF (1985). *Survey of environmental topics on farms, England and Wales: 1985.* Prepared by the Government Statistical Service.

MAFF (1996). *House of Commons Select Committee on agriculture inquiry: Environmentally Sensitive Area and other schemes under the agri-environment regulation.* Memorandum of evidence submitted by: the Ministry of Agriculture, Fisheries and Food.

NRA (1993a). *Ponds and Conservation. A rough guide to pond restoration and creation.* NRA, Bristol.

NRA (1993b). *Otters and river habitat management. Conservation technical Handbook No. 3.* NRA, Bristol.

Pond Action (1994a). *The Oxfordshire Pond Survey.* 2 vols. Pond Action, Oxford.

Pond Action (1994b). *The National Pond Survey: 1989-1993. Interim report to the World Wide Fund for Nature.* Pond Action, Oxford.

Pond Action (1994c). *The National Pond Survey Methods Booklet.* Pond Action, Oxford.

Palmer, M. (1989). A botanical classification of standing waters in Great Britain. *Surveys in Nature Conservation 11.* Nature Conservancy Council

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.

Perring, F.H. and Farrell, L. (1983). *British Red Data Books: 1: Vascular plants.* 2nd ed. Royal Society for Nature Conservation, Lincoln.

Perring, F.H. and Farrell, L. (1962). *Atlas of the British Flora.* Thomas Nelson & Sons, London.

Preston, C.D. and Croft, J.M. (1997). Aquatic plants in Britain and Ireland. Harley Books, Colchester.

Rackham, O. (1986). *The history of the countryside.* Dent, London.

Rich, T.C.G. and Woodruff, E.R. (1990). *BSBI Monitoring Scheme 1987-1988.* NCC Chief Scientists Directorate, Report No. 1265. Nature Conservancy Council, Peterborough.

Rural Action (1992). *Rural Action for the environment. An introduction.* Rural Action, 1992.

Scott, D.A. and Jones, T.A. (1995). Classification and inventory of wetlands: a global overview. *Vegetatio*, 118, 3-16.

Stace, C.A. (1991). *New flora of the British Isles.* Cambridge University Press, Cambridge.

Swan, M.J.S. and Oldham, R.S. (1989) *Amphibian communities. Final Report.* Nature Conservancy Council, Peterborough.

Stewart, A., Pearman, D.A. and Preston, C.D. (1994). *Scarce plants in Britain.* JNCC, Peterborough.

Tydeman, C. (1995). Legislation affecting ponds: the role of Sites of Special Scientific Interests (SSSIs) in pond protection. In Biggs, J. and Aistrop, C. (eds.) *Protecting Britain's Ponds*, Pond Conservation Group, Oxford.

UK Biodiversity Steering Group (1995). *Biodiversity: the UK Steering Group Report.* 2 vols. HMSO, London.

Wiggington, M.J.W. (in press). *British Red Data Books. 1. Vascular Plants*, 3rd edn. Joint Nature Conservation Committee, Peterborough.

Williams, P., Biggs, J., Corfield, A., Fox, G., Walker, D. and Whitfield, M. (1997). Designing new ponds for wildlife. *British Wildlife*, 8, 137-150.

Williams, P., Biggs, J., Dodds, L., Whitfield, M., Corfield, A. and Fox, G. (1996). *Biological techniques of still water quality assessment: Phase 1 Scoping Study.* R&D Technical Report E7. Environment Agency, Bristol.

Williams, P., Biggs, J., Whitfield, M., Corfield, A., Fox, G. and Adare K. (1998). *Biological techniques of still water quality assessment: Phase 2 Method development.* R&D Technical Report E56. Environment Agency, Bristol. Draft.

Wright, J.F., Blackburn, J.H., Gunn, R.J.M., Furse, M.T., Armitage, P.D., Winder, J.M. and Symes, K.L. (1996). Macroinvertebrate frequency data for the RIVPACS III sites in Great Britain and their use for conservation evaluation. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 6, 141-167.

11. ANNEXES

ANNEXE 1. METHODS

1.1 LPS96 Field protocols

The field protocols used to measure the main variables in LPS96 are outlined below.

1.1.1 Pond size

At each pond, surveyors updated an enlarged 1:10,000 scale base map, marking in the pond outer boundary.

Pond area was measured using a tape and compass or by pacing. All surveyors were trained in pacing techniques and their pace measured over 100 m distance. For most ponds including those with complex shapes, the pond was sketched onto graph paper. For the largest ponds, the existing map outline of the site was used as the basis for area calculations where the outline appeared accurate.

1.1.2 Water and sediment depth

Water and sediment depths were assessed using a mean of five readings made along two perpendicular transects.

Sediment and water less than 1.5 m deep were measured by wading using a graduated surveying pole. In deeper ponds an inflatable boat was used.

Where water depths were greater than 2.0 m a plumb line was deployed. It was not possible to gather accurate measurements of silt depth in such ponds. In a few ponds, particularly where there was deep silt and little or no water, it proved impossible to access ponds to make depth measurements even by boat.

1.1.3 Geology

The lithology of the pond base was assessed using available field evidence to help identify the probable water source. Information on pond base was not used in any further analysis.

1.1.4 Drawdown and permanence

The degree to which a pond had dried down compared to its maximum winter level was measured spatially in terms of the percentage of water remaining in the pond and in terms of the height difference between maximum and current water levels.

1.1.5 Pond base and sediment type

The character of the pond sediment was assessed by eye in terms of the percentage of four main grades and types of organic and inorganic sediments. The type of substrate lining the base of the pond was assessed by observation and probing with the survey pole.

1.1.6 Water chemistry

Water chemistry was measured in the field using kits and meters. Only field kits for determinands known to give at least moderately reliable results in a summer survey were used. Specifically, these were:

(i) alkalinity - Aquamerck 8048

(ii) calcium - Aquamerck 1110

(iii) pH - Phillip Harris pHandy 100 portable meter

(iv) conductivity - Hanna Dist 3WP portable meter

In practice, pH and conductivity meters occasionally gave some problems with waterlogging and calibration. Where there were difficulties a water sample was taken and analysed using the kits of an adjacent field team or returned to the laboratory for analysis.

An unexpected error arose with the measurement of alkalinity. The test kit suppliers changed the test method without drawing attention to this change, thus old kits measured carbonate (as putative carbonate binding capacity), new kits measure acid (as milli-equivalents of acid added). This change resulted in a two-fold difference in readings depending on the age of the kit. Repeat measurements of the alkalinity of samples from pond 358/2, for example gave readings of 1.7 and 0.85m/mol for the old and new kits respectively. It has proved impossible to retrospectively determine which kits were used for which ponds during the survey and alkalinity records were, therefore, not used in subsequent analysis.

Nutrient kits for nitrate and phosphate were not used in the survey. This was partly because field test kits measuring nutrient levels have relatively poor accuracy and precision. More importantly, LPS96 was a summer survey. Useful inter-pond comparisons of nitrate and phosphate levels require measurements made in winter/early spring. Summer results are of little use because nutrients can be extensively taken-up into algal and macrophyte biomass in spring and summer growth - thus a waterbody with high plant growth will often show low or undetectable N or P levels in summer when in reality it has a high nutrient status (see also Trophic Ranking, Annex 1.2.1).

1.1.7 Turbidity and pollution

Water turbidity and colour was assessed qualitatively by looking down into approximately 30 cm depth of water (where available) and recorded on four point scale between clear and turbid.

The presence and extent of dumped rubbish or water pollution (oil, sewage) was noted and described.

1.1.8 Inflows and outflows

Discrete inflows and outflows to the pond were recorded if present. Average wet channel width and depth were recorded and the flow rate was measured using a floating object or by placing the inflow in one of five categories:
1 - dry
2 - imperceptible; 0-10 cm s^{-1}
3 - slow; 11-50 cm s^{-1}
4 - moderate; 51-200 cm s^{-1}
5 - fast; 201+ cm s^{-1}

1.1.9 Water source

The probable sources of water which contribute to filling the pond was assessed from knowledge of the nature of the pond base, the surrounding topography and the permanence and volume of inflows. The percentage contribution of one or more of eight water source categories to the pond was estimated (see Annexe 2), however some categories (e.g. springs and streams) were combined in analysis.

Pond water source is one of the most difficult parameters to assess in a single field visit, and the results need to be treated with caution.

1.1.10 Adjacent waterbodies and wetlands and their connection to the pond

The occurrence of nearby lentic waterbodies, lotic waterbodies and wetlands was identified in terms of (i) how many waterbodies and wetland types were present in the vicinity of the survey pond and (ii) how each of these waterbodies was connected to the survey pond. The occurrence of waterbodies and wetlands was identified within three distance categories from the pond: 0-5 m, 5-25 m and 25-100 m.

1.1.11 Surrounding land-use

Field estimates were made of the percentage of 17 categories of landuse in three concentric distance zones away from the pond edge (0-5 m, 5-25 m and 25-100 m). Where a pond was located near to the edge of a 1 km square, land use data was also determined for the portion of the three distance zones lying within the 1 km square. This gave the potential for hindcast comparisons with land use data collected in previous Countryside surveys in 1990 and 1984.

The categories of landuse estimated were:
- Deciduous trees and woodland
- Coniferous trees and woodland
- Scrub and hedges
- Moorland and heath
- Bog
- Fen, marsh, flush
- Rank vegetation
- Unimproved grassland
- Improved and semi-improved grassland
- Arable
- Gardens and parks
- Buildings and concrete
- Metalled roads
- Rock, stone, gravel
- Ponds and lakes
- Streams and ditches
- Others, (which in practice included tracks, railways, disturbed ground etc.)

1.1.12 Shade

Shade was assessed in terms of the percentage of the pond directly overhung by large woody vegetation or other overhanging structures.

1.1.13 Pond management

Pond management was assessed in terms of direct evidence of recent management work (plant clearance, dredged spoil etc.). Surveyors also recorded management information provided in conversation with farmers and landowners.

1.1.14 Use of ponds by animals

Records were made relating to whether stock had access to the pond and casual records were given of the use of the pond by other wildlife such as wildfowl, amphibians and fish.

1.1.15 Photographs

A photograph was taken of each pond as a reference for future surveys, to convey an instant impression of the site for non-survey staff, and as an additional aid during the process of data checking. All ponds and old pond sites were identified by a pond code number in the photograph foreground. Trials showed that the best distance to allow the pond code number to be read was approximately 5 m from the camera.

1.2 Methods used to assess wetland plant conservation value

1.2.1 Wetland plants as indicators of pond quality

The characteristics of the wetland plant community was described in terms of five main attributes:

(i) Species richness

(ii) Species rarity

(iii) Trophic Ranking Score

(iv) Vegetation abundance

(v) Exotic species

Of these attributes, plant species richness and rarity values were used as the main indicators of site quality. Trophic Ranking Score was used to indicate the biotic response to pond nutrient levels. Vegetation abundance and the number of exotic plant species were included as additional factors of general interest, but were of lesser value as indices of overall pond quality.

The five main plant attributes used to assess the ponds are described briefly below:

Species richness
Plant species richness was assessed simply by totalling the number of wetland plant taxa recorded from each site.

For LPS96 species richness was defined using a standard list of wetland species (Annexe 2) and was considered as the following variables:

- number of emergent plant species
- number of aquatic plant species (i.e. submerged and floating-leaved species)
- number of all wetland species (i.e. sum of emergent and aquatic species)

Non-charophyte algae and wetland tree species were not included in these totals.

Recent research suggests that, in ponds, the number of both marginal and aquatic plant species recorded from a site are strongly correlated with the extent to which ponds have been subjected to anthropogenic impacts (Williams *et al.* 1998). Plant species richness can therefore provide a good measure of pond quality (i.e. the extent to which ponds are degraded by human impacts).

Note, however, that species richness can *naturally* vary between ponds, with some waterbody types typically species-poor (e.g. shaded ponds, seasonal ponds). Assessments therefore need to be made with care.

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. Sites with high numbers of uncommon species are likely to be of nature conservation significance. In addition there is evidence that sites with high rarity scores are generally likely to be less impaired by anthropogenic impacts (Williams *et al.* 1998). Site plant rarity values are, therefore, of value for assessing overall site quality.

The occurrence of uncommon species in the LPS96 ponds was quantified numerically by weighting each species on the basis of its rarity using the criteria given in Annexe Table A1.1.

A Rare Species Score (RSS) was calculated as the sum of all uncommon species scores (i.e. scores between 2-32). In the present study RSS has been used instead of a rarity index (i.e. rarity score/number of species). This was done to avoid bias associated with the use of very short species lists when calculating rarity indices (Pond Action 1994a), as these made up a large proportion of the LPS96 dataset.

Table A1.1 Species rarity terms and scores

Status	Score	Status
Common	1	Recorded from >700 10x10 km grid squares in Britain
Local	2	Recorded from between 101 and 700 grid squares in Britain
Nationally Scarce B	4	Nationally Scarce. Recorded from 31-100 grid squares in Britain
Nationally Scarce A	8	Recorded from 16-30 grid squares in Britain
RDB3	16	Red Data Book: Category 3 (rare)
RDB2	32	Red Data Book: Category 2 (vulnerable)
RDB1	64	Red Data Book: Category 1 (endangered)

Note: exotic species are given a score of 1, as are uncommon native species (e.g. Water Soldier, *Stratioides aloides*) which are known to have been introduced to a site.

The rarity status divisions for Scarce and RDB species are based on existing definitions. The definition of 'local' has been used to define species which are not uniformly common and widespread in Britain: specifically, species recorded from between 101 and 700 10 x 10 km squares (approximately 25% of all 10 km in England, Wales and Scotland).

The distinction of common and local species was based on national distribution information given in Perring and Walters (1962) updated by data from Preston and Croft (1997) and data gathered for the Botanical Society of the British Isles Monitoring Scheme 1987-1988 (Rich and Woodruff, 1990).

Scarce and Red Data Book plant species were defined using data from Perring and Farrell (1983), Stewart *et al.* (1994) and Wiggington (in press).

Trophic Ranking Score
Trophic Ranking Score (TRS) is a numerical measure which describes the extent to which a plant species is associated with nutrient enrichment. Scores typically vary between one (dystrophic) and ten (eutrophic).

The method can be used to indicate waterbody nutrient status. More importantly it gives a biologically meaningful indication of a plant community's response to waterbody nutrient levels. The observed chemical levels of nutrients in a waterbody are often of limited biological relevance since there is little knowledge of the levels at which any chemical species becomes biologically effective or damaging. Where the aim of a study is to identify the effect of nutrients on biota the most effective method is, therefore, to look directly at the response of the plant community, not at the water.

The Trophic Ranking Scores used in the present study were based on work undertaken on still waters by Palmer (1989).

Abundance of vegetation
The abundance of aquatic vegetation is of interest in terms of both the environmental factors affecting vegetation cover, and the relationship between plant species richness and abundance.

In some cases vegetation cover can be a good indicator of ecological quality and many countries make regular assessment of vegetation abundance in lakes as a measure of ecological quality (Williams *et al.* 1996).

The relationship between plant abundance and anthropogenic impacts is not always straightforward however. For example generally, water bodies which have experienced severe eutrophication have greatly reduced macrophyte abundances. However, in less nutrient-rich sites, and in sites exposed to other degradation factors, responses in aquatic vegetation are often not linear.

Because of uncertainties in the response of vegetation abundance attributes to anthropogenic impacts, this factor was not used as an indicator of pond quality.

Exotic/alien species
The total number of exotic (i.e. recently introduced non-native) species recorded at each site was calculated for use as variables in analysis.

Increases in the number or proportion of exotic and alien species have often been seen to be linked with increases in anthropogenic degradation (reviewed in Williams *et al.* 1996). In practice, however, recent pond research showed little relationship between the number of exotics present and the degree to which ponds were subject to pollution or other impacts. Exotic species richness was not, therefore used as a pond quality indicator in the current study.

1.2.2 Overall conservation value assessment

The LPS96 ponds were ranked into one of four conservation categories (very high, high, moderate or low) based on their species richness and rarity.

The conservation categories are modified from those developed for the Oxfordshire Pond Survey (Pond Action 1994a, Collinson *et al.* 1995), but have been updated using NPS data for LPS96 sites. Plant communities were divided into four categories of conservation value, low, moderate, high, very high, on the basis of the richness of the plant community and the occurrence of local and Nationally Scarce species. The categories used are shown in Table A1.2.

Table A1.2 Provisional categories for assessing conservation value of ponds[1]

Low	Few wetland plants (≤8 species)[2] and no local species.
Moderate	Below average number of wetland plant species (<23 species) and/or uncommon species (maximum of one local species).
High	Above average number of wetland plant species(≥23 species) and/or 2 or more local species. No Nationally Scarce or Red Data Book (RDB).
Very High	Supports one or more Nationally Scarce or RDB species and/or an exceptionally rich plant assemblage (≥40 species)[3].

[1]Based on NPS data: using the reference data set of lowland ponds located in areas of semi-natural landuse.
[2]The number of species in the poorest 5% of the NPS reference database sites.
[3]The number of species in the richest 5% of the NPS reference database sites.

1.2.3 Limitations on using wetland plants as an indicator

LPS96 used wetland plant attributes to indicate the quality and value of lowland countryside ponds.

It is, however, important to recognise that macrophytes are only one component of pond biodiversity, and only one of the useful biotic assemblages for indicating pond quality.

Thus, the number of LPS96 ponds identified as having high or very high biodiversity/conservation value represents the bare *minimum* number of high value ponds in the LPS96 data set. Inevitably, an unknown number of additional sites would have been of significant value on the basis of their other biotic components (invertebrates, amphibian, diatoms etc.).

Similarly, although it is clear that macrophyte community characteristics can be a useful indicator of the extent to which sites have become generally degraded through human impacts (Williams *et al.* 1998), plants will not respond maximally to all the stresses which can degrade pond communities. (e.g. high response to herbicides, low response to pesticides). As a result, plant-based attributes are unlikely to measure all the degrading effects which can influence pond communities (Williams *et al.* 1996). The LPS results are likely, therefore, to provide only a minimum estimate of the extent to which ponds are degraded in lowland Britain.

1.3 National Pond Survey Reference data set

1.3.1 Comparison of the value of the ponds using an external benchmark

There is now a consensus amongst freshwater ecologists and water managers that assessments of ecological quality should be made by comparing community or ecosystem quality with reference to 'undisturbed' examples of the habitat type (Williams *et al.* 1996).

Thus, in order to evaluate the results of LPS96, the pond quality data was assessed with respect to an independent external pond benchmark. The National Pond Survey database, which is based on surveys of ponds from relatively undisturbed sites throughout Britain, provided such a database.

1.3.2 The NPS database

The aims of the National Pond Survey were to describe the physical, chemical and biological characteristics of ponds in Britain, and to use this information to classify ponds and improve understanding of pond conservation techniques.

The NPS dataset is the largest and most comprehensive body of information about ponds in Britain. It is of high quality and has been systematically gathered by professional biologists.

The survey consists of approximately 200 ponds located in semi-natural habitats (e.g. unimproved grasslands, semi-natural woodland, lowland heath etc.). A standard techniques manual is available for the NPS (Pond Action 1994c).

Lowland NPS ponds are directly comparable to LPS96 ponds in terms of geographical spread, geology, soil types etc. The National Pond Survey sites were originally chosen to represent the range of ITE Land Classes. Within each Land Class ponds were stratified to include locations within 'typical' semi-natural land-use types based on a land-use area and land-use type basis.

Biotic data gathered included a wetland plant species list (used in the current study for comparison with LPS96 sites), together with macroinvertebrate species data collected in three seasons (spring, summer and autumn). A wide range of biological and chemical information was also collected about each pond.

1.4 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.

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 Barr *et al.* (1994).

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.

1.5 Sampling strategy for the Lowland Pond Survey 1996

1.5.1 Countryside Surveys

The most efficient selection of sample sites is dependent upon a variety of factors. While stratification (in this case the ITE Land Classification) offers the potential to improve efficiency, the number of squares selected per strata (or land class) should be determined by factors such as variability of the sampled feature and the area of the land class. Where change in a feature is important, the selection of sites becomes even more critical in determining the sample size necessary to make statements with any confidence.

The selection of samples for the Countryside Surveys (CS) has shown both development and modification since the first sample squares were selected in 1977-78. The rationale for selection and location of CS squares was important to the selection of squares for LPS96, in that the information gained on previous surveys could be used to define the sample size for the present survey.

Table A1.3 The size of land classes in the 'all squares' classification and sample numbers used in Countryside Surveys.

Lowland landscape land classes are shaded in grey.

Land Class	Area (squares)	1978	1984	1990
1	14159	8	15	28
2	14463	10	12	24
3	15452	11	18	30
4	9012	4	6	10
5	3873	3	4	6
6	10360	9	13	23
7	2532	8	13	13
8	4412	9	12	14
9	11781	13	16	21
10	13905	12	17	22
11	8895	13	19	22
12	3543	5	9	10
13	7266	9	14	17
14	933	4	6	6
15	4195	5	7	9
16	3089	8	10	11
17	12999	10	16	28
18	6732	6	9	13
19	5421	2	4	7
20	2508	2	4	4
21	9717	9	16	19
22	12549	11	16	25
23	6951	10	14	17
24	7207	8	12	15
25	10552	12	18	24
26	6876	8	14	15
27	6881	8	12	15
28	7464	8	12	14
29	5465	9	11	11
30	4254	7	14	14
31	3018	7	11	11
32	3779	6	10	10

The first national survey in 1978 visited 256 squares, 8 squares from each of the 32 land classes. The squares were located on the intersections of a 15 kilometre grid (1228 points for Great Britain (GB)). The second survey, 1984, revisited the original squares and increased the sample size to 12 squares per land class (384 squares in total). The squares were also drawn from the grid, although the land class of some other squares had been identified. In the late 1980s, every 1 km square in GB was allocated to land class, although the statistical techniques used caused some original squares to change land class. Where this occurred the changes were conservative with squares simply moving between similar land classes; the estimates of national figures produced using the two classifications showed no significant differences. In 1990, 508 squares were surveyed, but with changes in land class, and the addition of extra squares targeted at making the sample size proportional to the area of the land class, no simple relationship between land class area and sample size can be stated.

The value of a sample being proportional to area is in giving greater statistical confidence to the larger areas and consequently producing national statistics usually with lower error terms. The earlier, even, sample intensity was designed to characterise the land classes and guarantee large enough samples to describe and compare individual land classes. Table A1.3 shows the size (in numbers of squares) and sample size for the land classes using the 'all squares' classification.

1.5.2 Lowland Pond Survey 1996

The targeting of samples should reflect the question to be answered. Unfortunately, as in most cases, the aim is not to answer just one question but several and the questions which are asked may require conflicting strategies. If the goal is to produce national estimates, unbiased samples (including squares with no ponds) must be surveyed. If the goal is to describe ponds and their environment, squares with no ponds have very limited value.

National estimates made from the data collected included the total number of ponds, total pond area, the number of ponds of different size classes and change in pond numbers since 1990. Small ponds are more common than large ponds and are inherently more susceptible to change.

Using the information from the squares visited in 1984 and 1990, it was possible to produce a sampling strategy with different intensities for each land class so as to minimise the total population variance. The relationship took into account both the land class area and the variability recorded in the sample. Table A1.4 shows the allocation of 150 squares in the lowland landscape types, proportional to land class area and with different features taken into account.

Land classes 3 and 13 show the least homogeneity, while classes 4, 5, 9 and possibly 25 show one of the sampling themes as markedly bigger. The sample squares should be considered to be a new random sample from each land class.

1.5.3 Selection of squares - strategy

If the previously visited squares will be the only squares to be surveyed, an assumption can be made that squares which did not have ponds in 1984 or 1990 will not have gained them by 1996. The result is an effective doubling of the sample size since just over half of the squares did not have ponds.

Table A1.4 Sampling strategies based on different research goals

Land Class	LC area	Size	No. of ponds	Small ponds	Change
1	14	9	14	19	13
2	15	10	8	4	14
3	16	14	41	33	22
4	8	3	10	9	37
5	4	18	1	1	0
6	11	4	9	8	9
7	2	1	2	2	0
8	3	3	4	5	2
9	11	48	12	12	8
10	14	18	9	9	5
11	9	2	4	6	4
12	4	0	1	2	0
13	7	11	18	23	18
14	1	0	0	0	0
15	4	1	2	2	3
16	3	1	3	3	5
25	11	1	3	4	5
26	6	2	4	5	1
27	7	5	4	4	3

There are 103 re-surveyed squares (1984 - 1990) in lowland landscape types which contained ponds in one year or the other (or both). The total surveyed sample was 232 squares (3 squares could not be re-surveyed due to not being granted permission), leaving 129 without ponds. If the 103 squares are revisited, extra squares can then be drawn with the intention of testing the hypothesis that squares without ponds will not have gained ponds and for improving the sample efficiency for describing 1996.

There is no statistical method which will prove that the squares which previously had no ponds still have no ponds - other than revisiting them all. However, if sample squares are revisited, and found still to have no ponds, the sample size can be considered to have enlarged to 232 squares. A sample of approximately 5% should give a good indication about the acceptability of the assumption.

In 1990, some squares were visited for the first time. The report on changes in number of ponds between 1984 and 1990 largely ignored these squares, but they could be used in LPS96 to add in new squares. The distribution by land class and the number of squares with ponds are shown in Table A1.5.

Table A1.5 The occurrence of surveyed squares with ponds in 1990, divided into repeated squares and new

LC	Squares (1984-90)	Ponds (1984-90)	Squares (1990)	Ponds (1990)
1	15	10	13	8
2	12	3	12	4
3	18	10	12	10
4	6	3	4	1
5	4	4	2	
6	13	5	10	5
7	13	5	0	
8	12	7	2	1
9	16	6	5	2
10	17	8	5	3
11	19	10	3	
12	9	3	1	
13	14	7	3	
14	6	0	0	
15	7	4	2	1
16	10	4	1	
25	18	6	6	1
26	14	5	1	1
27	12	3	3	1
Total	232	103	85	38

Once again, an assumption about squares not having ponds not gaining ponds can be made (and tested). As there are 38 squares with ponds, this leaves only 9 squares to be chosen where no ponds are expected.

This strategy has the advantage of maximising the pond information collected in CS1990, but does not optimise the sample for ponds. Unless totally new squares are surveyed, the improvement in sample targeting is likely to be minimal.

The pond free squares were selected at random (Table A1.6).

The sampling strategy shown in Table A1.6 maximises the information already collected about ponds and is the best strategy to adopt if the question is about pond *loss*. However, only 9 squares are being used to check pond-free squares (5% of the total). Although the smaller the sample size, the less likely new ponds are to be found, if a new pond was found in one of those squares, the production of national estimates would be questionable if the sample was increased.

Table A1.6 Sampling strategy, showing number of squares visited by land class, revisiting all squares with ponds and a small number of pond-free squares

LC	1984 - 90	1990	Absent	Total
1	10	8	1	19
2	3	4	1	8
3	10	10	1	21
4	3	1	1	5
5	4			4
6	5	5	1	11
7	5			5
8	7	1		8
9	6	2	1	9
10	8	3		11
11	10			10
12	3			3
13	7		1	8
14	0		2	2
15	4	1		5
16	4			4
25	6	1		7
26	5	1		6
27	3	1		4
Total	103	38	9	150

The scoping exercise described the production of national estimates for Great Britain (GB), England, Scotland and Wales. It was suggested that the survey should cover all GB, but the contract targeted the work at lowland landscapes as defined by the ITE land classes (Bunce, *et al.*, 1994).

1.6 Quality control

1.6.1 Methods

15 1 km squares were revisited for complete or partial re-survey by Tim Rich or Penny Williams. Table A1.7 shows the number of ponds re-surveyed. The significance of differences between the field survey teams and the quality control visits were tested using Wilcoxon Signed Rank test.

1.6.2 Results

There were no significant differences between the environmental variables compared in the quality control analysis except for Landuse 5-25m: rivers, streams and ditches (var 59) and Landuse 25-100m: Ponds and lakes (var 70).

Table A1.7 Quality control survey squares

Squares	Recorder	Number of ponds surveyed
120	T. Rich	4 ponds repeated
205	T. Rich	3 ponds repeated
225	T. Rich	2 ponds repeated
230	T. Rich	1 ex-pond surveyed
244	P. Williams	5 ponds repeated
269	P. Williams	1 ex-pond surveyed
295	T. Rich	3 ponds repeated
333	P. Williams	1 ex-pond surveyed
335	P. Williams	1 ex-pond surveyed
366	T. Rich	3 ponds repeated
436	T. Rich	3 ponds repeated
594	T. Rich	2 ponds repeated
625	T. Rich	1 ex-pond repeated
929	T. Rich	2 ponds repeated
224	P. Williams	1 ex-pond surveyed

1.7 Analysis of environmental variables

Associations between environmental variables and measures of pond quality were investigated using correlation analysis. Many variables had highly skewed distributions, and could not be normalised using standard transformations. Correlations were therefore undertaken using non-parametric Spearman's rank correlation. To avoid consideration of variables which explained relatively little variation in the data set only correlations that were significant at $P<0.001$ were considered further in the analysis. Presence/absence data (pond grazed, pond seasonal, pond managed etc.) were entered using dummy variables (1,0).

The Mann-Witney U-test was used for paired comparisons. Wilcoxon's signed-ranks test was used to assess the significance of differences in quality control data and the field survey team's data.

The number of ponds used in environmental variable analyses (n=377) was smaller than those used for stock and change estimates. This was because, largely for permission reasons, it was not always possible to gather environmental data from ponds which were evident in the field.

ANNEXE 2. FIELD RECORDING SHEET LOWLAND POND SURVEY 1996

ANNEXE 2. LPS96 Field Recording Sheet (1)

ITE Series number ______________________ **Date** ______________________

Pond Code number ______________________ **Code number marked on base map?** ☐ Tick

Grid ref.(4 figs) within the 1km square ______________ **Surveyors** ______________

Time spent surveying the pond ______________

Current state of the pond

Tick box(es)

Record any changes in the state of the pond in comparison with the base map in the following categories:

1. Newly created or recorded for the first time: a new water body has been dug or dammed, or otherwise created, apparently on a permanent basis. If yes, indicate whether pond appears to be newly dug or is well established and proabably missed in previous surveys. ☐

____

____

2. Enlarged: active enlargement has taken place, as opposed to seasonal changes. ☐

3. Filled in: a clear reduction in the overall size since 1990. Active change has been recorded (i.e. there is evidence of change). This does not include seasonal drying up. ☐

If yes, record the probable reasons for this change (e.g. land drainage, deliberate infilling)

____

____

____

4. Dried out: the water body is dry at time of survey. ☐

If box is ticked - is there any evidence that the pond is seasonal i.e. holds water for some of the year? e.g. presence of the following:

wetland plants	soft sediments	strandline deposits	water marks
☐	☐	☐	☐

Other: please state ____

5. No longer present: Water body is absent and there is no evidence to suggest what has happened; ie this does not include 'filled in' or 'dried out' water bodies where evidence is available. ☐

6. Pond not significantly different from the base map. ☐

Give a brief description of the pond (or ex-pond site):

____

____

____

Take a photograph to show the pond (or ex-pond site if it has been lost). Show the ITE and pond number in the foreground. Note the photograph exposure number of the print film. ☐

ANNEXE 2. LPS96 Field Recording Sheet (2)

Completing the rest of the field sheet

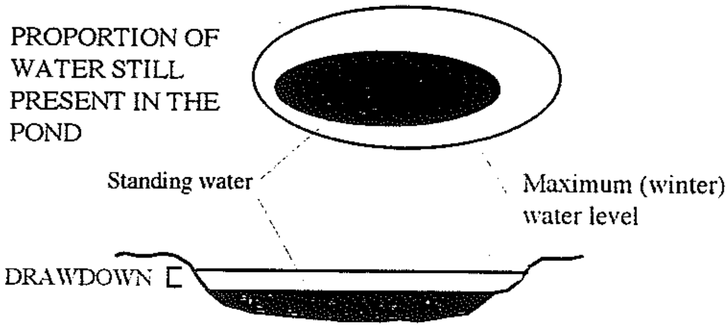
If the pond is wet - complete all remaining sections of the field sheet.
If the pond is seasonal (currently dry) - record as much of the field sheet as possible.
If the pond is no longer present - complete only sheet 4 (Land Use and Adjacent Waterbodies sections).

Pond size: estimate from base map or your own sketch map

Pond area (m^2) [ ]

Maximum and minimum dimensions (m) (e.g. 10mx 4m) [ ]

Seasonal water fluctuation



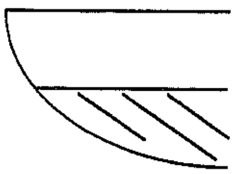
Proportion of water area present in the pond

[%]

Drawdown
The height difference between maximum water levels and current water levels

[cm]

Sediment and water depths



	Transect A (longest dimension)			Transect B (right angles to A)	
	1/4	1/2	3/4	1/4	3/4
Water depths (cm)					
Silt depth (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

Approximate % of the following:

Decomposing leaves and twigs ________
Coarse organic debris (c.0.05mm-10mm diam) ________
Ooze (i.e. non-particulate) ________
Gravel/sand (often stream-borne) ________
Others (specify) ________

ANNEXE 2. LPS96 Field Recording Sheet (3)

ITE series and pond number________________

Water quality

pH [ ]

Conductivity (us cm^{-1}) [ ]

Alkalinity (m mol^{-1}) [ ]

Calcium (mg l^{-1}) [ ]

Turbidity* (tick)

[ ]	[ ]	[ ]	[ ]
Clear	Moderately clear	Moderately turbid	Turbid

Water colour ______________________________

Probable source of colour (e.g. green = algae, brown = tanins, grey = silt etc.) ________________

Note any obvious pollution (e.g. oil, dumped rubbish) ____________________

Water source

Estimate the importance of the following water sources (NB this is a very difficult estimation - use '?' where very unsure):

Water source	%	Water source	%	Water source	%
Groundwater/water table	____	Runoff & near surface water	____	Direct precipitation	____
Spring (<25m long)	____	Stream or ditch	____	Other (state)	____
Flood water	____	Flush	____		

Inflows and outflows

Does the pond have any inflows or outflow channels (either dry or wet)? Tick if yes [ ]

If yes, estimate their average width and depth. Where possible note the flow rate. Where this is difficult, estimate the flow category:

1 - dry at time of survey
2 - imperceptible; 0-10 cm/sec
3 - slow; 11-50 cm/sec
4 - moderate; 51-200 cm/sec
5 - fast. 201+ cm/sec

INFLOWS

	Water width(cm) (if wet)	Water depth(cm) (if wet)	Flow rate or Flow category
1			
2			
3			
4			

OUTFLOWS

	Water width(cm) (if wet)	Water depth(cm) (if wet)	Flow rate or Flow category
1			
2			
3			
4			

*1. Estimate turbidity by looking down into c.30cm depth of water in the pond

ANNEXE 2. LPS96 Field Recording Sheet (4)

History and use of the pond

Note any evidence of the following:

The origin of the pond (if known) ______________________________

Use of the pond by animals (e.g. grazing animals, ducks) ______________________________

Pond management (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 [ ]

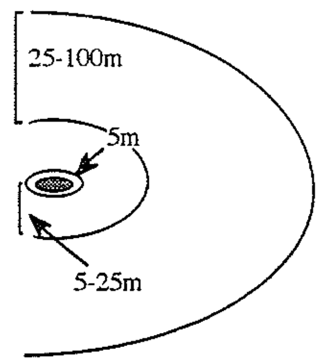
Record the species and abundance of fish and amphibians where known. ______________________________

____

Surrounding land-use / land cover

Estimate the percentage of surrounding land-use within three distance zones from the perimeter of the pond. In each distance zone, estimate % cover for (i) complete zones (ii) parts of zones which lie within the ITE 1km survey square.

	5m		5-25m		25-100m	
	Complete	In 1 km	Complete	In 1 km	Complete	In 1 km
Deciduous woodland						
Coniferous woodland						
Scrub/hedge						
Moor/lowland heath						
Bog						
Fen/marsh/flush						
Rank vegetation						
Unimproved grassland						
Improved grassland						
Arable						
Gardens and parks						
Buildings and concrete						
Roads (metalled)						
Rock, stone, gravel						
Ponds and lakes						
Streams and ditches						
Other (state) ________						
________						



Land-use zones

Other adjacent wetlands & water bodies and their connections to the pond

Are there any OTHER wetlands within 100m of the pond? [ ] If so, record the number of each type of waterbody and note whether the pond is connected to the adjacent wetland using the following codes:
P - permanent connection; T - temporary connection - including flooding; N - not connected.

Waterbody/ wetland	Wetlands/waterbodies adjacent to the pond		
	<5m (connections)	5-25m (connections)	25-100m (connections)
Pond/lake (perm.)			
Temporary Pond			
Ditch/stream/river			
Fen/marsh			
Bog			
Other (specify)			

Assessing amenity value

1. Is there a clear view of the pond (or pond site) from the following public rights of way?

Score each on a five point scale (1 = totally obscured; 5 = clearly visible)

- footpath ________
- bridle path ________
- A road ________
- B-road ________
- minor road

Other public road or track (please state)

____________________ ________

2. Is the pond located in areas of open public access?

Yes ☐ No ☐

3. Note any evidence of formal amenity use:

	Tick
• Fishing (e.g. fishing platforms, pegs, swims, embayments)	☐
• Shooting (e.g. hides, blinds)	☐
• Ornamental fish (e.g. goldfish, Koy carp)	☐
• 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, boathouse)	☐
• Model boating	☐
• other (please state) ________________________	☐

Graph paper for estimating pond area etc.

ANNEXE 2. LPS96 FIELD RECORDING SHEET (7)

Cross through all wetland plants within the outer boundary of the pond (ie limit of maximum - winter - water level). For each species present, record its abundance (0-5%=Rare, 6-20%=Occasional, 21-50% Frequent, 51-90% Abundant, 91-100% = Dominant).

Emergent wetland plants

Achillea ptarmica
Acorus calamus
Agrostis stolonifera
Alisma lanceolatum
Alisma plantago-aquatica
Alopecurus aequalis
Alopecurus geniculatus
Anagallis tenella
Andromeda polifolia
Angelica archangelica
Angelica sylvestris
Apium nodiflorum
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 curta
Carex demissa
Carex diandra
Carex disticha
Carex flacca
Carex hostinana
Carex laevigata
Carex lasiocarpa
Carex lepidocarpa
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
Crassula helmsii
Crepis paludosa
Cyperus longus
Dactylorhiza fuchsii
Damasonium alisma
Deschampsia caespitosa
Drosera rotundifolia
Eleocharis acicularis
Eleocharis multicaulis
Eleocharis palustris
Eleocharis quinqueflora
Eleocharis uniglumis
Equisetum fluviatile
Equisetum palustre
Epilobium hirsutum
Epilobium nerteroides
Epilobium obscurum
Epilobium palustre
Epilobium parviflorum
Epilobium tetragonum
Epipactis palustris
Erica tetralix
Eriophorum angustifolium
Eriophorum latifolium
Eriophorum vaginatum
Eupatorium cannabinum
Filipendula ulmaria
Galium boreale
Galium palustre
Galium uliginosum
Geum rivale
Glyceria declinata
Glyceria fluitans
Glyceria maxima
Glyceria plicata
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
Lotus uliginosus
Lychnis flos-cuculi
Lycopus europaeus
Lysimachia nemorum
Lysimachia nummularia
Lysimachia vulgaris
Lythrum hyssopifolia
Lythrum portula
Lythrum salicaria
Menyanthes trifoliata
Mentha aquatica
Mimulus guttatus
Mimulus luteus
Molinia caerulea
Montia fontana
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
Petasites hybridus
Phalaris arundinacea
Phragmites australis
Pilularia globulifera
Pinguicula vulgaris
Polygonum amphibium
Polygonum hydropiper
Polygonum lapathifolium
Polygonum persicaria
Potentilla erecta
Potentilla palustris
Pulicaria dysenterica
Ranunculus flammula
Ranunculus lingua
Ranunculus hederaceus
Ranunculus omiophyllus
Ranunculus sceleratus
Rhynchospora alba
Rorippa amphibia
Rorippa palustris
Rorippa sylvestris
Rumex hydrolapathum
Rumex maritimus
Rumex palustris
Sagina procumbens
Saggitaria sagittifolia
Schoenoplectus lacustris
  ssp lacustris
  ssp tabernaemontani
Schoenus nigricans
Scrophularia auriculatas
Scutellaria galericulata
Senecio aquaticus
Senecio fluviatilis
Sium latifolium
Solanum dulcamara
Sparganium erectum
Stachys palustris
Stellaria alsine
Stellaria palustris
Symphytum officinale
Thalictrum flavum
Thelypteris palustris
Tofieldia pusilla
Tricophorum cespitosum
Triglochin palustris
Typha angustifolia
Typha latifolia
Valeriana dioica
Veronica anagallis-aquatica
Veronica beccabunga
Veronica catenata
Veronica scutellata
Viola palustris

Bryophytes:
Fontinalis antipyretica
Riccia fluitans
Ricciocarpus natans
Sphagnum sp.

% Total cover of emergent spp.

Floating-leaved species

Azolla filiculoides
Lemna gibba
Lemna minor
Lemna minuscula
Lemna polyhriza
Lemna trisulca
Luronium natans
Hydrocharis morsus-ranae
Nuphar lutea
Nymphaea alba
Nymphoides peltata
Potamogeton natans
Potamogeton polygonifolius

% Total cover of floating-leaved spp.

Trees and shrubs:
Alnus glutinosa
Frangula alnus
Populus sp.
Salix sp.

% of pond overhung by trees

Submerged Species

Apium inundatum
Aponogeton distachyos
Callitriche hamulata
Callitriche hermaphroditica
Callitriche obtusangula
Callitriche platycarpa
Callitriche stagnalis
Callitriche truncata
Callitriche sp. (undetermined)
Ceratophyllum demersum
Ceratophyllum submersum
Egeria densa
Elatine hexandra
Elodea canadensis
Elodea nuttallii
Eleogeton fluitans
Groenlandia densa
Hippuris vulgaris
Hottonia palustris
Isoetes lacustris
Juncus bulbosus
Lagarosiphon major
Littorella uniflora
Lobelia dortmann
Myriophyllum alterniflorum
Myriophyllum aquaticum
Myriophyllum spicatum
Myriophyllum verticillatum
Oenanthe aquatica
Oenanthe fluviatilis
Potamogeton alpinus
Potamogeton berchtoldii
Potamogeton coloratus
Potamogeton crispus
Potamogeton friesii
Potamogeton gramineus
Potamogeton lucens
Potamogeton obtusifolius
Potamogeton perfoliatus
Potamogeton pectinatus
Potamogeton praelongus
Potamogeton pusillus
Potamogeton trichoides
Potamogeton hybrid(s)
Ranunculus aquatilis
Ranunculus baudotii
Ranunculus circinatus
Ranunculus fluitans
Ranunculus peltatus
Ranunculus penicillatus
Ranunculus trichophyllus
Sagittaria sagittifolia
Sparganium angustifolium
Sparganium emersum
Sparganium minimum
Stratiotes aloides
Subularia aquatica
Utricularia australis
Utricularia intermedia
Utricularia minor
Utricularia vulgaris
Wolffia arriza
Zannichellia palustris

Algae:
Enteromorpha sp.
Filamentous
Planktonic
Chara sp. (send off to be identified)
Nitella sp. (send off to be identified)
Tolypella sp. (send off to be identified)

% Total cover of submerged spp.

Other species recorded

____

____

____

ITE Series and pond number __________

NB If this sheet is separated from the main survey sheet please make sure it is re-attached after completion.

ANNEXE 3. NUMBERS OF PONDS IN BRITAIN IN 1996

Table 3.1 Pond density in 1996
Numbers of squares and numbers of ponds by lowland landscape type and country.

	Number of ponds in 1996 ('000)	No squares in Arable Lowland Landscape ('000)	No squares in Pastural Lowland Landscape ('000)	Total No squares in lowland landscape types ('000)	Density of ponds per lowland km square ('000)
England	203,100	66.0	51.7	117.8	1.7
Scotland	10,100	14.6	8.5	23.1	0.4
Wales	15,700	0.9	10.4	11.3	1.4
GB	228,900	81.5	70.7	152.2	1.5

('000) = thousands of ponds

Table 3.2 Numbers of lowland ponds in 1996.
Extrapolated data for England, Scotland, Wales and GB, and in Arable and Pastural landscapes, by size class.

		Size class				
		0.0025 - 0.04 ha	0.04 - 0.2 ha	0.2 - 1.0 ha	1.0 - 2.0 ha	TOTAL
England	No. ('000s)	129.4	55.8	14.5	3.4	203.1
	SE	*(18.7)*	*(8.6)*	*(3.4)*	*(1.3)*	*(23.9)*
Scotland	No. ('000s).	3.4	4.8	1.5	0.5	10.1
	SE	*(1.3)*	*(1.7)*	*(0.7)*	*(0.4)*	*(2.7)*
Wales	No. ('000s)	9.4	5.0	1.1	0.3	15.7
	SE	*(2.0)*	*(2.2)*	*(0.4)*	*(0.1)*	*(3.5)*
GB	No. ('000s)	142.2	65.5	17.0	4.1	228.9
	SE	*(19.8)*	*(10.3)*	*(3.6)*	*(1.5)*	*(25.9)*
Arable	No. ('000s)	83.3	32.4	8.3	1.4	125.4
	SE	*(16.8)*	*(5.7)*	*(2.6)*	*(0.9)*	*(20.7)*
Pastural	No. ('000s)	58.9	33.1	8.7	2.7	103.5
	SE	*(10.6)*	*(8.6)*	*(2.5)*	*(1.2)*	*(15.5)*

No. ('000) = Pond numbers in thousands, SE = Standard error

Table 3.3a (1996 STOCK). ***Numbers and Standard Errors ('000) of lowland ponds in GB, by land use context, by country and by landscape type, in 1996***

		Great Britain	England	Scotland	Wales	Arable landscape	Pastural landscape
Grass	No.	**90.2**	77.9	6.0	6.4	38.8	51.4
	SE	*(13.3)*	*(12.3)*	*(1.9)*	*(1.1)*	*(8.9)*	*(9.9)*
Crops	No.	**38.8**	37.4	0.4	1.0	30.9	7.9
	SE	*(7.8)*	*(7.7)*	*(0.4)*	*(0.3)*	*(7.5)*	*(2.4)*
Mixed crops/grass	No.	**2.1**	2.0	0	0	2.1	0
	SE	*(1.3)*	*(1.3)*	*0*	*0*	*(1.3)*	*0*
Unenclosed	No.	**2.2**	1.3	0.5	0.4	0.5	1.7
	SE	*(1.2)*	*(0.8)*	*(0.4)*	*(0.3)*	*(0.5)*	*(1.1)*
Woodland	No.	**44.5**	39.6	1.5	3.3	25.8	18.7
	SE	*(10.1)*	*(9.0)*	*(1.1)*	*(1.9)*	*(7.5)*	*(6.7)*
Other land	No.	**32.3**	28.2	0.6	3.4	18.2	14.1
	SE	*(7.9)*	*(6.6)*	*(0.4)*	*(1.7)*	*(4.5)*	*(6.5)*
No information	No.	**18.8**	16.6	1.1	1.2	9.1	9.7
	SE	*(4.2)*	*(3.8)*	*(0.6)*	*(0.3)*	*(3.0)*	*(3.0)*
TOTAL	**No.**	**228.9**	**203.1**	**10.1**	**15.7**	**125.4**	**103.5**
	SE	*(25.9)*	*(23.9)*	*(2.7)*	*(3.5)*	*(20.7)*	*(15.5)*

Table 3.3b (1996 STOCK). ***Numbers and Standard Errors ('000) of lowland ponds in GB, by land use context, by size class, in 1996***

	Size class									
	A	*(SE)*	B	*(SE)*	C	*(SE)*	D	*(SE)*	TOTAL	*(SE)*
Crops	21.8	*(5.1)*	15.1	*(3.6)*	1.1	*(0.8)*	0.8	*(0.7)*	38.8	*(7.8)*
Grass	57.6	*(10.0)*	27.7	*(6.3)*	3.9	*(1.6)*	0.9	*(0.7)*	90.2	*(13.3)*
Mixed crops/grass	0.7	*(0.7)*	0.6	*(0.6)*	0.8	*(0.9)*	-	-	2.1	*(1.3)*
Unenclosed	1.4	*(0.8)*	-	-	0.4	*(0.5)*	0.4	*(0.4)*	2.2	*(1.2)*
Woodland	24.4	*(7.3)*	12.9	*(5.2)*	5.8	*(1.9)*	1.4	*(0.9)*	44.5	*(10.1)*
Other land	19.4	*(7.1)*	7.4	*(2.5)*	4.9	*(1.7)*	0.6	*(0.6)*	32.3	*(7.9)*
No information	17.0	*(4.1)*	1.7	*(1.0)*	0.1	*(0.1)*	-	-	18.8	*(4.2)*
TOTAL	**142.2**	*(19.8)*	**65.5**	*(10.3)*	**17.0**	*(3.6)*	**4.1**	*(1.5)*	**228.9**	*(25.9)*

A = 0.0025 - 0.04 ha; B = 0.04 - 0.2 ha; C = 0.2 - 1.0 ha; D = 1.0 - 2.0 ha
- = no ponds

Table 3.4a (1996 STOCK - SEASONAL). ***Numbers and Standard Errors ('000) of seasonal lowland ponds in GB, by land use context, by country and by landscape type, in 1996***

		England	Scotland	Wales	Arable landscape	Pastural landscape	GB
Crops	No.	15.1	-	0.5	13.0	2.7	15.7
	SE	*(3.5)*	-	*(0.3)*	*(3.4)*	*(1.2)*	*(3.6)*
Grass	No.	29.0	0.6	1.6	16.5	14.7	31.2
	SE	*(7.3)*	*(0.4)*	*(0.5)*	*(5.4)*	*(5.7)*	*(7.8)*
Mixed crops/grass	No.	0.7	-	-	0.7	-	0.7
	SE	*(0.7)*	-	-	*(0.7)*	-	*(0.7)*
Unenclosed	No.	0.3	-	0.1	-	0.4	0.4
	SE	*(0.3)*	-	*(0.1)*	-	*(0.5)*	*(0.5)*
Woodland	No.	11.8	-	1.4	6.2	7.1	13.2
	SE	*(3.4)*	-	*(1.0)*	*(2.5)*	*(3.1)*	*(4.0)*
Other land	No.	11.1	-	2.4	5.2	8.3	13.5
	SE	*(4.9)*	-	*(1.7)*	*(1.9)*	*(6.2)*	*(6.5)*
No information	No.	6.8	0.6	0.4	4.0	3.9	7.9
	SE	*(2.7)*	*(0.3)*	*(0.2)*	*(2.4)*	*(1.6)*	*(2.9)*
TOTAL	**No.**	**74.8**	**1.3**	**6.5**	**45.5**	**37.0**	**82.5**
	SE	*(12.4)*	*(0.7)*	*(2.3)*	*(9.8)*	*(9.8)*	*(13.9)*

- = no ponds

Table 3.4b (1996 STOCK - SEASONAL). ***Numbers and Standard Errors ('000) of seasonal lowland ponds in GB, by land use context, and by size class, in 1996***

	Size class									
	A	*(SE)*	**B**	*(SE)*	**C**	*(SE)*	**D**	*(SE)*	**TOTAL**	*(SE)*
Crops	13.3	*(3.3)*	2.3	*(1.1)*	-	-	-	-	15.7	*(3.6)*
Grass	23.8	*(5.6)*	7.4	*(5.1)*	-	-	-	-	31.2	*(7.8)*
Mixed crops/grass	0.7	*(0.7)*	-	-	-	-	-	-	0.7	*(0.7)*
Unenclosed	0.4	*(0.5)*	-	-	-	-	-	-	0.4	*(0.5)*
Woodland	8.7	*(2.9)*	3.9	*(2.7)*	0.7	*(0.7)*	-	-	13.2	*(4.0)*
Other land	10.0	*(6.1)*	2.4	*(1.5)*	1.1	*(0.8)*	-	-	13.5	*(6.5)*
No information	6.9	*(2.8)*	1.0	*(0.7)*	-	-	-	-	7.9	*(2.9)*
TOTAL	**63.9**	*(11.8)*	**16.9**	*(6.7)*	**1.7**	*(1.1)*	-	-	**82.5**	*(13.9)*

A = 0.0025 - 0.04 ha; B = 0.04 - 0.2 ha; C = 0.2 - 1.0 ha; D = 1.0 - 2.0 ha
- = no ponds

Table 3.5a (1996 STOCK - PERMANENT). ***Numbers and Standard Errors ('000) of permanent lowland ponds in GB, by land use context, by country and by landscape type, in 1996***

		England	Scotland	Wales	Arable landscape	Pastural landscape	GB
Crops	No.	22.3	0.4	0.5	18.0	5.2	23.2
	SE	*(5.5)*	*(0.4)*	*(0.2)*	*(5.2)*	*(2.0)*	*(5.6)*
Grass	No.	48.8	5.4	4.8	22.3	36.7	59.0
	SE	*(9.0)*	*(1.8)*	*(0.9)*	*(6.0)*	*(7.8)*	*(9.9)*
Mixed crops/grass	No.	1.4	-	-	1.4	-	1.4
	SE	*(1.0)*	-	-	*(1.0)*	-	*(1.0)*
Unenclosed	No.	1.0	0.5	0.3	0.5	1.3	1.8
	SE	*(0.7)*	*(0.4)*	*(0.2)*	*(0.5)*	*(1.0)*	*(1.1)*
Woodland	No.	27.9	1.5	1.9	19.7	11.6	31.3
	SE	*(7.0)*	*(1.1)*	*(1.0)*	*(6.4)*	*(3.8)*	*(7.5)*
Other land	No.	17.2	0.6	1.1	13.0	5.8	18.8
	SE	*(4.1)*	*(0.4)*	*(0.4)*	*(3.6)*	*(2.3)*	*(4.3)*
No information	No.	9.8	0.4	0.7	5.1	5.9	11.0
	SE	*(2.5)*	*(0.3)*	*(0.3)*	*(2.0)*	*(2.0)*	*(2.8)*
TOTAL	**No.**	**128.3**	**8.8**	**9.2**	**79.9**	**66.4**	**146.4**
	SE	*(17.3)*	*(2.4)*	*(1.8)*	*(15.3)*	*(10.2)*	*(18.4)*

- = no ponds

Table 3.5b (1996 STOCK - PERMANENT). ***Numbers and Standard Errors ('000) of permanent lowland ponds in GB, by land use context, and by size class, in 1996***

	Size class									
	A	*(SE)*	**B**	*(SE)*	**C**	*(SE)*	**D**	*(SE)*	**TOTAL**	*(SE)*
Crops	8.4	*(2.9)*	12.8	*(3.4)*	1.1	*(0.8)*	0.8	*(0.7)*	23.2	*(5.6)*
Grass	33.8	*(7.4)*	20.3	*(3.7)*	3.9	*(1.6)*	0.9	*(0.7)*	59.0	*(9.9)*
Mixed crops/grass	-	-	0.6	*(0.6)*	0.8	*(0.9)*	-	-	1.4	*(1.0)*
Unenclosed	1.0	*(0.7)*	-	-	0.4	*(0.5)*	0.4	*(0.4)*	1.8	*(1.1)*
Woodland	15.7	*(5.7)*	9.1	*(3.1)*	5.1	*(1.8)*	1.4	*(0.9)*	31.3	*(7.5)*
Other land	9.4	*(3.2)*	5.0	*(1.8)*	3.8	*(1.5)*	0.6	*(0.6)*	18.8	*(4.3)*
No information	10.1	*(2.8)*	0.8	*(0.7)*	0.1	*(0.1)*	-	-	11.0	*(2.8)*
TOTAL	**78.4**	*(13.8)*	**48.6**	*(6.8)*	**15.3**	*(3.4)*	**4.1**	*(1.5)*	**146.4**	*(18.4)*

A = 0.0025 - 0.04 ha; B = 0.04 - 0.2 ha; C = 0.2 - 1.0 ha; D = 1.0 - 2.0 ha
- = no ponds

Table 3.6a (1996 NEW). ***Numbers and Standard Errors ('000)* of new lowland ponds in GB, by land use context, by country and by landscape type, in 1996***

		England	Scotland	Wales	Arable landscape	Pastural landscape	GB
Crops	No.	0.6	-	-	0.6	-	0.6
	SE	*(0.6)**	-	-	*(0.6)*	-	*(0.6)*
Grass	No.	4.2	-	0.4	1.2	3.4	4.6
	SE	*(1.8)*	-	*(0.3)*	*(0.9)*	*(1.7)*	*(1.9)*
Mixed crops/grass	No.	-	-	-	-	-	-
	SE	-	-	-	-	-	-
Unenclosed	No.	-	-	-	-	-	-
	SE	-	-	-	-	-	-
Woodland	No.	0.9	-	0.1	-	1.0	1.0
	SE	*(0.9)*	-	*(0.1)*	-	*(1.0)*	*(1.0)*
Other land	No.	6.2	-	1.5	1.9	5.7	7.7
	SE	*(4.5)*	-	*(1.5)*	*(1.4)*	*(5.8)*	*(6.0)*
No information	No.	1.0	-	0.1	0.7	0.4	1.1
	SE	*(0.8)*	-	*(0.1)*	*(0.7)*	*(0.5)*	*(0.8)*
TOTAL	**No.**	**12.8**	-	**2.1**	**4.4**	**10.5**	**15.0**
	SE	*(5.0)*	-	*(1.6)*	*(1.9)*	*(6.1)*	*(6.4)*

****note high standard errors associated with many numbers***

- = no ponds

Table 3.6b (1996 NEW). ***Numbers and Standard Errors ('000)* of new lowland ponds in GB, by land use context, and by size class, in 1996***

	Size class									
	A	*(SE)*	**B**	*(SE)*	**C**	*(SE)*	**D**	*(SE)*	**TOTAL**	*(SE)*
Crops	-	-	0.6	*(0.6)*	-	-	-	-	0.6	*(0.6)*
Grass	2.8	*(1.3)*	1.2	*(0.9)*	0.6	*(0.6)*	-	-	4.6	*(1.9)*
Mixed crops/grass	-	-	-	-	-	-	-	-	-	-
Unenclosed	-	-	-	-	-	-	-	-	-	-
Woodland	-	-	-	-	1.0	*(1.0)*	-	-	1.0	*(1.0)*
Other land	6.9	*(6.0)*	-	-	0.8	*(0.9)*	-	-	7.7	*(6.0)*
No information	0.4	*(0.5)*	0.7	*(0.7)*	-	-	-	-	1.1	*(0.8)*
Total	**10.2**	*(6.1)*	**2.5**	*(1.3)*	**2.3**	*(1.4)*	-	-	**15.0**	*(6.4)*

****note high standard errors associated with many numbers***

A = 0.0025 - 0.04 ha; B = 0.04 - 0.2 ha; C = 0.2 - 1.0 ha; D = 1.0 - 2.0 ha

- = no ponds

Table 3.7a (1996 LOST). ***Numbers and Standard Errors ('000)* of lost lowland ponds in GB, by land use context, by country and by landscape type, in 1996***

		England	Scotland	Wales	Arable landscape	Pastural landscape	GB
Crops	No.	2.3	-	-	1.8	0.5	2.3
	SE	*(1.2)*	-	-	*(1.1)*	*(0.5)*	*(1.2)*
Grass	No.	5.9	1.0	0.9	3.1	4.8	7.9
	SE	*(1.7)*	*(0.9)*	*(0.3)*	*(1.7)*	*(1.6)*	*(2.3)*
Mixed crops/grass	No.	-	-	-	-	-	-
	SE	-	-	-	-	-	-
Unenclosed	No.	0.9	0.1	-	0.7	0.4	1.1
	SE	*(0.8)*	*(0.1)*	-	*(0.7)*	*(0.4)*	*(0.8)*
Woodland	No.	2.3	-	0.2	1.7	0.9	2.6
	SE	*(1.4)*	-	*(0.2)*	*(1.3)*	*(0.9)*	*(1.5)*
Other land	No.	3.1	-	0.1	2.3	0.9	3.2
	SE	*(1.3)*	-	*(0.1)*	*(1.1)*	*(0.7)*	*(1.3)*
No information	No.	-	-	-	-	-	-
	SE	-	-	-	-	-	-
TOTAL	**No.**	**14.5**	**1.2**	**1.3**	**9.6**	**7.5**	**17.0**
	SE	*(3.4)*	*(0.9)*	*(0.5)*	*(3.1)*	*(2.4)*	*(3.9)*

****note high standard errors associated with many numbers***

\- = no ponds

Table 3.7b (1996 LOST). ***Numbers and Standard Errors ('000)* of lost lowland ponds in GB, by land use context, and by size class, in 1996***

	Size class									
	A	*(SE)*	**B**	*(SE)*	**C**	*(SE)*	**D**	*(SE)*	**TOTAL**	*(SE)*
Crops	2.3	*(1.2)*	-	-	-	-	-	-	2.3	*(1.2)*
Grass	7.9	*(2.3)*	-	-	-	-	-	-	7.9	*(2.3)*
Mixed crops/grass	-	-	-	-	-	-	-	-	-	-
Unenclosed	1.1	*(0.8)*	-	-	-	-	-	-	1.1	*(0.8)*
Woodland	2.6	*(1.5)*	-	-	-	-	-	-	2.6	*(1.5)*
Other land	3.2	*(1.3)*	-	-	-	-	-	-	3.2	*(1.3)*
No information	-	-	-	-	-	-	-	-	-	-
Total	**17.0**	*(3.9)*	-	-	-	-	-	-	**17.0**	*(3.9)*

****note high standard errors associated with many numbers***

A = 0.0025 - 0.04 ha; B = 0.04 - 0.2 ha; C = 0.2 - 1.0 ha; D = 1.0 - 2.0 ha

\- = no ponds

Table 3.8a (LOST). ***Numbers and Standard Errors ('000)* of filled-in and other lowland ponds in GB, present in 1990 but not in 1996, by country and by landscape type.***

		England	Scotland	Wales	Arable landscape	Pastural landscape	GB
Filled-in	No.	5.2	0.1	0.6	3.2	2.6	5.8
	SE	*(1.7)*	*(0.1)*	*(0.3)*	*(1.5)*	*(1.2)*	*(1.9)*
Built over	No.	1.7	-	0.4	0.6	1.5	2.1
	SE	*(0.9)*	-	*(0.3)*	*(0.6)*	*(0.9)*	*(1.1)*
Drained	No.	5.5	0.2	0.2	4.2	1.7	5.9
	SE	*(1.9)*	*(0.2)*	*(0.1)*	*(1.7)*	*(1.1)*	*(2.0)*
Other loss[1]	No.	2.2	0.9	0.1	1.6	1.6	3.2
	SE	*(1.0)*	*(0.9)*	*(0.1)*	*(1.2)*	*(0.9*	*(1.5)*
TOTAL	**No.**	**14.5**	**1.2**	**1.3**	**9.6**	**7.5**	**17.0**
	SE	*(3.4)*	*(0.9)*	*(0.5)*	*(3.1)*	*(2.4)*	*(3.9)*

***note high standard errors associated with many numbers**

A = 0.0025 - 0.04 ha; B = 0.04 - 0.2 ha; C = 0.2 - 1.0 ha; D = 1.0 - 2.0 ha

- = no ponds

[1] includes: (a) pond amalgamation and (b) pond no longer present but cause of change unknown.

Table 3.8b (LOST). ***Numbers and Standard Errors ('000)* of filled-in and other lowland ponds in GB, present in 1990 but not in 1996, by land use context.***

		Land use context							
		Crops	Grass	Mixed	Unencl'd	Forest	Other	Unkn'n	TOTAL
Filled-in	No.	-	2.8	-	0.4	1.5	1.1	-	5.8
	SE	-	*(1.4)*	-	*(0.4)*	*(1.1)*	*(0.8)*	-	*(1.9)*
Built-over	No.	-	1.5	-	-	-	0.6	-	2.1
	SE	-	*(0.9)*	-	-	-	*(0.6)*	-	*(1.1)*
Drained	No.	1.8	2.3	-	0.7	1.1	-	-	5.9
	SE	*(1.1)*	*(1.2)*	-	*(0.7)*	*(0.8)*	-	-	*(2.0)*
Other loss	No.	0.5	1.2	-	-	-	1.5	-	3.2
	SE	*(0.5)*	*(1.1)*	-	-	-	*(1.0)*	-	*(1.5)*
TOTAL	**No.**	**2.3**	**7.9**	-	**1.1**	**2.6**	**3.2**	-	**17.0**
	SE	*(1.2)*	*(2.3)*	-	*(0.8)*	*(1.5)*	*(1.3)*	-	*(3.9)*

***note high standard errors associated with many numbers**

- = no ponds

Table 3.9a (1990-1996 NET CHANGE). ***Numbers and Standard Errors ('000)* of net change in lowland ponds in GB between 1990 and 1996, by land use context, by country and by landscape type.***

		England	Scotland	Wales	Arable landscape	Pastural landscape	GB
Crops	No.	-1.7	-	-	-1.2	-0.5	-1.7
	SE	*(1.3)*	-	-	*(1.2)*	*(0.5)*	*(1.3)*
Grass	No.	-1.7	-1.0	-0.5	-1.8	-1.4	-3.2
	SE	*(2.3)*	*(0.9)*	*(0.5)*	*(1.6)*	*(2.4)*	*(2.9)*
Mixed crops/grass	No.	-	-	-	-	-	-
	SE	-	-	-	-	-	-
Unenclosed	No.	-0.9	-0.1	-	-0.7	-0.4	-1.1
	SE	*(0.8)*	*(0.1)*	-	*(0.7)*	*(0.4)*	*(0.8)*
Woodland	No.	-1.4	-	-0.2	-1.7	0.1	-1.6
	SE	*(1.7)*	-	*(0.3)*	*(1.3)*	*(1.3)*	*(1.8)*
Other land	No.	3.1	-	1.4	-0.4	4.9	4.5
	SE	*(4.7)*	-	*(1.5)*	*(1.9)*	*(4.5)*	*(6.2)*
No information	No.	1.0	-	0.1	0.7	0.4	1.1
	SE	*(0.8)*	-	*(0.1)*	*(0.7)*	*(0.5)*	*(0.8)*
TOTAL	**No.**	**-1.7**	**-1.2**	**0.8**	**-5.1**	**3.1**	**-2.1**
	SE	*(6.0)*	*(0.9)*	*(1.6)*	*(3.4)*	*(6.6)*	*(7.5)*

***note high standard errors associated with many numbers**

- = no ponds

Table 3.9b (1990-1996 NET CHANGE). ***Numbers and Standard Errors ('000)* of net change in lowland ponds in GB, by land use context, and by size class, in 1996***

	Size class									
	A	*(SE)*	**B**	*(SE)*	**C**	*(SE)*	**D**	*(SE)*	**TOTAL**	*(SE)*
Crops	-2.3	*(1.2)*	0.6	*(0.6)*	-	-	-	-	-1.7	*(1.3)*
Grass	-5.0	*(2.5)*	1.2	*(0.9)*	0.6	*(0.6)*	-	-	-3.2	*(2.9)*
Mixed crops/grass	-	-	-	-	-	-	-	-	-	-
Unenclosed	-1.1	*(0.8)*	-	-	-	-	-	-	-1.1	*(0.8)*
Woodland	-2.6	*(1.5)*	-	-	1.0	*(1.0)*	-	-	-1.6	*(1.8)*
Other land	3.7	*(6.1)*	-	-	0.8	*(0.9)*	-	-	4.5	*(6.2)*
No information	0.4	*(0.5)*	0.7	*(0.7)*	-	-	-	-	1.1	*(0.8)*
Total	**-6.9**	*(7.1)*	**2.5**	*(1.3)*	**2.3**	*(1.4)*	-	-	**-2.1**	*(7.5)*

***note high standard errors associated with many numbers**

A = 0.0025 - 0.04 ha; B = 0.04 - 0.2 ha; C = 0.2 - 1.0 ha; D = 1.0 - 2.0 ha

- = no ponds

Table 3.10 (SUMMARY). ***Numbers and Standard Errors ('000) of 1996 Stock and 1990-96 Net change in lowland pond numbers in GB, by size class, by land use context, by country and by landscape type.***

	1996 Stock			Net change 1990-1996	
	No.	*SE.*	%	No.	*SE.*
Size Class					
A (0.0025 - 0.04 ha)	142.2	*(19.8)*	62%	-6.9	*(7.1)*
B (0.04 - 0.2 ha)	65.5	*(10.3)*	29%	2.5	*(1.3)*
C (0.2 - 1.0 ha)	17.0	*(3.6)*	7%	2.3	*(1.4)*
D (1.0 - 2.0 ha)	4.1	*(1.5)*	2%	-	-
Land use context					
Crops	38.8	*(7.8)*	17%	-1.7	*(1.3)*
Grass	90.2	*(13.3)*	39%	-3.2	*(2.9)*
Mixed crops/grass	2.1	*(1.3)*	1%	-	-
Unenclosed	2.2	*(1.2)*	1%	-1.1	*(0.8)*
Forest/Woodland	44.5	*(10.1)*	19%	-1.6	*(1.8)*
Other	32.3	*(7.9)*	14%	4.5	*(6.2)*
No information	18.8	*(4.2)*	8%	1.1	*(0.8)*
Country					
England	203.1	*(23.9)*	89%	-1.7	*(6.0)*
Scotland	10.1	*(2.7)*	4%	-1.2	*(0.9)*
Wales	15.7	*(3.5)*	7%	0.8	*(1.6)*
Landscape type					
Arable	125.4	*(20.7)*	55%	-5.1	*(3.4)*
Pastural	103.5	*(15.5)*	45%	3.1	*(6.6)*
GB Total	228.9	*(25.9)*	100%	-2.1	*(7.5)*

ANNEXE 4. ENVIRONMENTAL DATA

Table 4.1 Water depth: national estimates of the number of lowland ponds in six water depth categories in 1996

Water depth category		Arable		Pastural		Britain	
		Numbers (in '000)	Percent	Numbers (in '000)	Percent	Numbers (in '000)	Percent
0 m - 0.01m	Number	42.77	42%	33.13	41%	75.90	41%
	(Standard error)	*(9.85)*	*(10%)*	*(8.16)*	*(10%)*	*(12.79)*	*(7%)*
0.02 - 0.25m	Number	19.53	19%	21.23	26%	40.76	22%
	(Standard error)	*(5.43)*	*(5%)*	*(6.13)*	*(8%)*	*(8.19)*	*(4%)*
0.26 - 0.50m	Number	14.51	14%	14.07	17%	28.57	16%
	(Standard error)	*(3.36)*	*(3%)*	*(6.35)*	*(8%)*	*(7.18)*	*(4%)*
0.51 - 1.00m	Number	16.50	16%	4.58	6%	21.08	11%
	(Standard error)	*(4.09)*	*(4%)*	*(1.44)*	*(2%)*	*(4.34)*	*(2%)*
1.00 - 2.00m	Number	8.00	8%	5.44	7%	13.45	7%
	(Standard error)	*(2.51)*	*(2%)*	*(1.73)*	*(2%)*	*(3.05)*	*(2%)*
2.00 - 4.00m	Number	1.67	2%	2.12	3%	3.79	2%
	(Standard error)	*(1.15)*	*(1%)*	*(1.26)*	*(2%)*	*(1.71)*	*(1%)*

Table 4.2 Sediment depth: national estimates of the number of Britain's lowland ponds in six sediment depth categories in 1996

Sediment depth category		Great Britain		Arable		Pastural	
		Numbers (in '000)	Percent	Numbers (in '000)	Percent	Numbers (in '000)	Percent
0 - 0.01m	Number	17.481	10%	11.28	11%	6.199	8%
	(Standard error)	*(4.75)*	*(3%)*	*(4.25)*	*(4%)*	*(2.10)*	*(3%)*
0.01 - 0.25m	Number	65.767	36%	30.70	30%	35.059	44%
	(Standard error)	*(10.03)*	*(5%)*	*(5.80)*	*(6%)*	*(8.18)*	*(10%)*
0.26 - 0.50m	Number	50.789	28%	27.08	26%	23.705	29%
	(Standard error)	*(9.10)*	*(5%)*	*(5.32)*	*(5%)*	*(7.38)*	*(9%)*
0.51 - 1.00m	Number	39	21%	26.81	26%	12.189	15%
	(Standard error)	*(6.88)*	*(4%)*	*(6.20)*	*(6%)*	*(2.98)*	*(4%)*
1.00- 2.00m	Number	9.359	5%	6.70	7%	2.653	3%
	(Standard error)	*(3.07)*	*(2%)*	*(2.77)*	*(3%)*	*(1.34)*	*(2%)*
2.00 - 4.00m	Number	1.158	1%	0.38	0.4%	0.769	1%
	(Standard error)	*(0.77)*	*(0.5%)*	*(0.54)*	*(0.5%)*	*(0.54)*	*(1%)*

Annexe Table 4.3 Average sediment composition from LPS96 ponds

	Landscape type		All
	Arable	Pastural	Ponds
Pebbles/rocks	2%	1%	1%
Gravel/sand	8%	10%	9%
Fine mud	54%	57%	55%
Coarse organic matter	36%	32%	34%

Annexe Table 4.4 Typical water source

	Landscape type		All ponds
	Pastural	Arable	
Runoff	41%	52%	47%
Stream, ditch, flood	29%	19%	23%
Groundwater	16%	22%	19%
Spring/flush	8%	4%	6%
Direct precipitation	6%	4%	5%
Inflow present	62%	50%	55%
Wet inflow present	27%	15%	21%

Table 4.5 Number of lowland ponds containing extensive amounts of rubbish or rubble in 1996

		Arable		Pastural		Britain	
		Numbers (in '000)	Percent	Numbers (in '000)	Percent	Numbers (in '000)	Percent
Little or no rubbish	Number	97.94	95%	77.24	96%	175.18	95%
	(Standard error)	*(16.02)*	*(16%)*	*(12.65)*	*(16%)*	*(20.41)*	*(11%)*
Extensive rubbish	Number	5.04	5%	3.34	4%	8.38	5%
	(Standard error)	*(1.71)*	*(2%)*	*(1.76)*	*(2%)*	*(2.46)*	*(1%)*

Table 4.6 Shade: percentage of overhanging tree cover in Britain's lowland ponds in four categories in 1996

% of pond overhung		Arable		Pastural		Britain	
		Numbers (in '000)	Percent	Numbers (in '000)	Percent	Numbers (in '000)	Percent
0 - 25%	Number	45.32	47%	35.25	48%	80.57	47%
	(Standard error)	*(7.63)*	*(8%)*	*(6.86)*	*(9%)*	*(10.26)*	*(6%)*
26 - 50%	Number	15.45	16%	9.00	12%	24.45	14%
	(Standard error)	*(3.88)*	*(4%)*	*(3.09)*	*(4%)*	*(4.96)*	*(3%)*
51 - 75%	Number	14.63	15%	16.26	22%	30.89	18%
	(Standard error)	*(4.76)*	*(5%)*	*(6.56)*	*(9%)*	*(8.11)*	*(5%)*
76 - 100%	Number	20.85	22%	13.18	18%	34.03	20%
	(Standard error)	*(6.21)*	*(6%)*	*(3.28)*	*(4%)*	*(7.02)*	*(4%)*

Table 4.7 Management: national estimates of the number of lowland ponds managed between 1990 and 1996

		Arable		Pastural		Britain	
		Numbers (in '000)	Percent	Numbers (in '000)	Percent	Numbers (in '000)	Percent
No management	Number	81.77	84%	72.23	89%	154.00	86%
	(Standard error)	*(15.02)*	*(15%)*	*(12.83)*	*(16%)*	*(19.76)*	*(11%)*
Managed	Number	15.45	16%	9.00	11%	24.45	14%
	(Standard error)	*(3.88)*	*(4%)*	*(3.09)*	*(4%)*	*(4.96)*	*(3%)*
Managed by dredging only	Number	8.9	9%	2.94	4%	11.81	6%
	(Standard error)	*(2.8)*	*(3%)*	*(1.63)*	*(2%)*	*(3.06)*	*(2%)*

Annexe 4.1 Correlations between physical and chemical variables

4.1.1 Intercorrelations in the data set

The relationship between the major physical, chemical and landuse variables measured in the study was investigated using correlation analyses.

The LPS96 data set shows strong intercorrelations between four major physical variables: pond area, water depth, shade and sediment type.

Physico-chemical correlates not directly associated with these interrelationships are discussed further below. This includes interrelationships between the following environmental factors: pond drawdown, sediment depth and composition, water chemistry, water source, shading, grazing and land cover.

4.1.2 Pond drawdown

The strongest correlate of pond drawdown was water source. Thus there was a significant tendency for ponds fed by more permanent inflows to have a lower summer drawdown height. Ponds fed by surface water run-off only were, in contrast, likely to have greater summer drawdown.

Perhaps surprisingly, there were few significant correlations between permanence and land use or landscape type. The exception was a negative association between drawdown height and the presence of marginal fen or marsh in the surrounds. This relationship is itself likely to be associated with the relationship between permanence and spring water source. Thus ponds with water levels which varied little in summer tended to be spring fed and to be associated with marginal fen or marsh development.

4.1.3 Sediment

Sediment depth showed positive correlations with total pond depth, and to a lesser extent tree cover (Annexe 7). There was, however, no relationship between sediment depth and either water depth or pond area. Strong negative correlations were evident between sediment depth and the presence of gravel or sand, suggesting that the ponds mainly filled in through accumulation of fine or organic rich deposits rather than inflow-borne sands or gravels.

In terms of sediment composition, the data showed strong positive correlations between the percentage of coarse organic matter and both the extent of the pond overhung and presence of woodland and scrub in the surrounds. Seasonal ponds were particularly likely to have coarse organic sediments

Both sand/gravel and mud sediments were characteristic of deeper and more permanent ponds. Finer muddy sediments were particularly associated with the presence of improved grassland in areas adjacent to the pond.

4.1.4 Water chemistry

Conductivity and calcium levels were strongly positively correlated and both showed negative correlations with (i) the occurrence of fen/marsh and (ii) the presence of rock or stone lithologies in the surrounds. Both were also significantly lower in ponds located in pastural landscapes, and higher in arable landscape types.

Although calcium and conductivity readings generally showed similar trends this was not always the case. Conductivity alone was higher in ponds surrounded by arable land, and the association occurred for both the 5-25 m and 25-100 m land use zones. Calcium and conductivity readings also showed different trends in silty and shaded ponds: only calcium was significantly higher in ponds with deep silt, whereas conductivity was elevated in ponds with a high percentage of tree cover.

The data set showed few associations between pH and other environmental variables. The most significant trend was a tendency for smaller and shallower ponds with organic-rich sediments to have a lower pH.

4.1.5 Water source

Surface runoff and stream inflow water sources were most strongly correlated with depth, permanence, area and tree shade variables. Additional associations were evident between (i) inflow volume and proximity to urban areas and (ii) spring-fed ponds and the occurrence of adjacent fen or marsh. Ponds fed largely by runoff were associated with arable landscape types, though not with arable areas in the immediate (<5m) surrounds.

4.1.6 Pond shade and grazing

As might be expected smaller ponds had significantly greater tree shade than larger sites. Shaded ponds were also more likely to be located in wooded areas, to have deeper organic-rich silt, and to be seasonal, than open unshaded ponds.

The data set showed significant associations between land use, grazing and shade. Ponds which were grazed and associated with improved grassland typically had a lower percentage of tree cover. In contrast, ponds located in arable landscapes were more likely to be overhung by trees than those in pastural landscape types.

4.1.7 Land cover

Land cover intercorrelations largely suggest predictable relationships: urban landuse types (roads, buildings, parks and gardens) were positively intercorrelated with each other. Woodland, scrub and hedge showed similar positive associations.

Negative correlations were found between the presence of (i) arable land and woodland (ii) pasture and woodland and (iii) between unimproved and improved grassland.

As expected, there were positive relationships between the occurrence of grassland in the pond surrounds and the location of the pond in ITE pastural landscapes. There were similar relationships between arable pond surrounds and arable landscape types. The corollary, a negative relationship between arable and pasture landuse/landscapes, also held true.

ANNEX 5. RAINFALL DATA FOR 1984, 1990 AND 1996

Rainfall in the six months and twelve months before the Countryside Surveys 1984 and 1990 and Lowland Pond Survey 1996

Key:
LTA = Long-term (1961-1990) average

		Previous 12 months			Previous 6 months		
		ITE 1984	CS 1990	LPS96	ITE 1984	CS 1990	LPS96
England & Wales	mm	815	860	703	313	269	289
	LTA	896	896	896	404	404	404
	%	0.91	0.96	0.78	0.77	0.67	0.72
North West	mm	1106	1186	799	392	422	382
	LTA	1203	1203	1203	534	534	534
	%	0.92	0.99	0.66	0.73	0.79	0.72
Northumbrian	mm	786	751	716	294	291	296
	LTA	853	853	853	397	397	397
	%	0.92	0.88	0.84	0.74	0.73	0.75
Severn Trent	mm	703	724	586	297	222	249
	LTA	754	754	754	357	357	357
	%	0.93	0.96	0.78	0.83	0.62	0.70
Yorkshire	mm	824	729	593	297	256	274
	LTA	821	821	821	380	380	380
	%	1.00	0.89	0.72	0.78	0.67	0.72
Anglian	mm	583	496	417	284	179	188
	LTA	596	596	596	298	298	298
	%	0.98	0.83	0.70	0.95	0.60	0.63
Thames	mm	638	636	548	273	175	205
	LTA	689	689	689	327	327	327
	%	0.93	0.92	0.80	0.83	0.54	0.63
Southern	mm	700	737	600	243	203	232
	LTA	779	779	779	335	335	335
	%	0.90	0.95	0.77	0.73	0.61	0.69
Wessex	mm	757	850	816	276	230	291
	LTA	838	838	838	361	361	361
	%	0.90	1.01	0.97	0.76	0.64	0.81
South West	mm	1073	1261	1101	335	359	390
	LTA	1174	1174	1174	456	456	456
	%	0.91	1.07	0.94	0.73	0.79	0.86
Welsh	mm	1130	1362	1097	385	382	444
	LTA	1313	1313	1313	534	534	534
	%	0.86	1.04	0.84	0.72	0.72	0.83

ANNEXE 6. PLANTS RECORDED IN LPS96

Species	English name	Number of ponds	Status
Achillea ptarmica	Sneezewort	2	Common
Acorus calamus	Sweet-flag	1	Common
Agrostis stolonifera	Creeping Bent	219	Common
Alisma lanceolatum	Narrow-leaved Water-plantain	5	Local
Alisma plantago-aquatica	Water-plantain	102	Common
Alopecurus geniculatus	Marsh Foxtail	59	Common
Anagallis tenella	Bog Pimpernel	1	Local
Angelica sylvestris	Wild Angelica	27	Common
Apium inundatum	Lesser Marshwort	2	Local
Apium nodiflorum	Fool's Water-cress	35	Common
Aponogeton distachyos	Cape Pondweed	1	Common
Azolla filiculoides	Water Fern	2	Common
Barbarea vulgaris	Winter-cress	5	Common
Berula erecta	Lesser Water-parsnip	8	Common
Bidens cernua	Nodding Bur-marigold	15	Local
Bidens tripartita	Trifid Bur-marigold	17	Local
Butomus umbellatus	Flowering-rush	2	Local
Calamagrostis epigejos	Wood Small-reed	3	Local
Callitriche brutia	Pedunculate Water-starwort	1	Local[1]
Callitriche hamulata	Intermediate Water-starwort	15	Local
Callitriche obtusangula	Blunt-fruited Water-starwort	3	Local
Callitriche platycarpa	Various-leaved Water-starwort	6	Local
Callitriche stagnalis	Common Water-starwort	21	Common
Caltha palustris	Bog Arum	12	Common
Cardamine amara	Large Bitter-cress	8	Common
Cardamine pratensis	Cuckooflower	41	Common
Carex acutiformis	Lesser Pond-sedge	8	Common
Carex diandra	Lesser Tussock-sedge	1	Local
Carex echinata	Star Sedge	1	Common
Carex flacca	Glaucous Sedge	1	Common
Carex lasiocarpa	Sleder Sedge	1	Local
Carex nigra	Common Sedge	6	Common
Carex otrubae	False Fox-sedge	29	Common
Carex paniculata	Greater Tussock-sedge	2	Common
Carex pendula	Pendulous Sedge	26	Common
Carex pseudocyperus	Cyperus Sedge	12	Local
Carex riparia	Greater Pond-sedge	9	Common
Carex rostrata	Bottle Sedge	7	Common
Carex vesicaria	Bladder Sedge	1	Local
Carex vulpina	Fox Sedge	1	RDB2 (Vulnerable)
Ceratophyllum submersum	Soft Hornwort	1	Nationally Scarce B
Ceratophyllum demersum	Rigid Hornwort	19	Local
Chara globularis	A charophyte	2	Local
Chara hispida	A charophyte	1	Local
Chara vulgaris var. longibracta	A charophyte	1	Local
Chara vulgaris var. papillata	A charophyte	2	Local
Cirsium palustre	Marsh Thistle	12	Common
Conium maculatum	Hemlock	2	Common
Crassula helmsii	New Zealand Stonecrop	6	Common
Cyperus longus	Galingale	2	Common
Deschampsia caespitosa	Tufted Hair-grass	29	Common
Eleocharis palustris	Common Spike-rush	38	Common

[1] Note:*Callitriche brutia* has been recorded from fewer than 100 10 km squares, but is not currently listed as Nationally Scarce because the species may be under recorded.

ANNEXE 6. PLANTS RECORDED IN LPS96 (CONTINUED)

Species	English name	Number of ponds	Status
Elodea canadensis	Canadian Waterweed	20	Common
Elodea nuttallii	Nuttal's Waterweed	9	Common
Epilobium hirsutum	Great Willow-herb	125	Common
Epilobium lanceolatum	Spear-leaved Willow-herb	1	Local
Epilobium obscurum	Short-fruited Willow-herb	45	Common
Epilobium palustre	Marsh Willow-herb	9	Common
Epilobium parviflorum	Hoary Willow-herb	26	Common
Epilobium tetragonum	Square-stalked Willow-herb	22	Local
Epipactis palustris	Marsh Helleborine	1	Local
Equisetum fluviatile	Water Horsetail	18	Common
Equisetum palustre	Marsh Horsetail	13	Common
Eupatorium cannabinum	Hemp-agrimony	6	Common
Filipendula ulmaria	Meadowsweet	31	Common
Fontinalis antipyretica	Willow moss	6	Common
Galium palustre	Common Marsh-bedstraw	93	Common
Glyceria declinata	Small Sweet-grass	7	Common
Glyceria fluitans	Floating Sweet-grass	115	Common
Glyceria maxima	Reed Sweet-grass	18	Common
Glyceria notata	Plicata Sweet-grass	3	Common
Gunnera tinctoria	Giant Rhubarb	1	Common
Hippuris vulgaris	Mare's Tail	6	Local
Hottonia palustris	Water-violet	5	Local
Hydrocharis morsus-ranae	Frogbit	2	Local
Hydrocotyle vulgaris	Marsh Pennywort	11	Common
Hypericum tetrapterum	Square-stalked St Johns Wort	7	Common
Impatiens glandulifera	Indian Balsam	4	Common
Impatiens noli-tangere	Touch-me-not Balsam	1	Nationally Scarce A
Iris pseudacorus	Yellow Iris	63	Common
Isolepis setacea	Bristle Club-rush	1	Common
Juncus acutiflorus	Sharp-flowered Rush	26	Common
Juncus articulatus	Jointed-rush	51	Common
Juncus bufonius	Toad Rush	51	Common
Juncus bulbosus	Bulbous Rush	3	Common
Juncus compressus	Round-fruited Rush	3	Local
Juncus conglomeratus	Compact Rush	37	Common
Juncus effusus	Soft-Rush	155	Common
Juncus inflexus	Hard Rush	64	Common
Lagarosiphon major	Curly Waterweed	8	Common
Lemna gibba	Fat Duckweed	6	Local
Lemna minor	Common Duckweed	135	Common
Lemna minuta	Least Duckweed	4	Common
Lemna polyrhiza	Greater Duckweed	8	Local
Lemna trisulca	Ivy-leaved Duckweed	13	Common
Littorella uniflora	Shoreweed	1	Common
Lotus pedunculatus	Greater Bird's-foot Trefoil	24	Common
Lychnis flos-cuculi	Ragged-robin	3	Common
Lycopus europaeus	Gipsywort	59	Common
Lysimachia nemorum	Yellow Pimpernel	4	Common
Lysimachia nummularia	Creeping Jenny	5	Common
Lysimachia vulgaris	Yellow Loosestrife	5	Local
Lythrum portula	Water-purslane	10	Local
Lythrum salicaria	Purple-loosestrife	19	Common

ANNEXE 6. PLANTS RECORDED IN LPS96 (CONTINUED)

Species	English name	Number of ponds	Status
Mentha aquatica	Water Mint	72	Common
Menyanthes trifoliata	Bogbean	6	Common
Mimulus guttatus	Monkeyflower	1	Common
Molinia caerulea	Purple Moor-grass	3	Common
Myosotis laxa	Tufted Forget-me-not	49	Common
Myosotis scorpioides	Water Forget-me-not	28	Common
Myosotis secunda	Creeping Forget-me-not	3	Common
Myosoton aquaticum	Water Chickweed	2	Local
Myrica gale	Bog Myrtle	1	Common
Myriophyllum alterniflorum	Alternate Water-milfoil	2	Local
Myriophyllum aquaticum	Parrot's Feathers	3	Common
Myriophyllum spicatum	Spiked Water-milfoil	8	Local
Rorippa mirophylla	Narrow-fruited Water-Cress	1	Local
Rorippa nasturtium-aquaticum	Water-cress	27	Common
Nitella flexilis agg.	A stonewort	2	Local
Nitella mucronata var. gracillina	A stonewort	1	Nationally Scarce B
Nuphar lutea	Yellow Water-lily	15	Common
Nymphaea alba	White Water-lily	18	Common
Oenanthe aquatica	Fine-leaved Water-dropwort	9	Local
Oenanthe crocata	Hemlock Water-dropwort	40	Common
Oenanthe lachenalii	Parsley Water-dropwort	1	Local
Petasites hybridus	Butterbur	4	Common
Phalaris arundinacea	Reed Canary-grass	32	Common
Phragmites australis	Common Reed	12	Common
Polygonum amphibia	Amphibious Bistort	16	Common
Polygonum hydropiper	Water-pepper	31	Common
Polygonum lapathifolia	Pale Persicaria	14	Common
Polygonum maculosa	Redshank	63	Common
Potamogeton alpinus	Red Pondweed	1	Local
Potamogeton berchtoldii	Small Pondweed	13	Local
Potamogeton crispus	Curled Pondweed	22	Common
Potamogeton natans	Broad-leaved Pondweed	69	Common
Potamogeton obtusifolius	Blunt-leaved Pondweed	2	Local
Potamogeton pectinatus	Fennel Pondweed	7	Local
Potamogeton perfoliatus	Perfoliate Pondweed	1	Local
Potamogeton polygonifolius	Bog Pondweed	2	Local
Potamogeton pusillus	Lesser Pondweed	10	Local
Potentilla palustris	Marsh Cinquefoil	3	Common
Pulicaria dysenterica	Common Fleabane	13	Common
Ranunculus aquatilis	Common Water-crowfoot	2	Common
Ranunculus circinatus	Fan-leaved Water-Crowfoot	1	Local
Ranunculus flammula	Lesser Spearwort	25	Common
Ranunculus hederaceus	Ivy-leaved Crowfoot	7	Common
Ranunculus lingua	Greater Spearwort	1	Common
Ranunculus omiophyllus	Round-leaved Crowfoot	4	Local
Ranunculus peltatus	Pond Water-crowfoot	10	Local
Ranunculus sceleratus	Celery-leaved Buttercup	75	Common
Ranunculus trichophyllus	Thread-leaved Water-crowfoot	6	Local
Riccia fluitans	A liverwort	2	Local
Rorippa amphibia	Great Yellow-cress	5	Local

ANNEXE 6. PLANTS RECORDED IN LPS96 (CONTINUED)

Species	English name	Number of ponds	Status
Rorippa palustris	Marsh Yellow-cress	17	Common
Rorippa sylvestris	Creeping Yellow-cress	1	Local
Rumex hydrolapathum	Water Dock	3	Local
Rumex maritimus	Golden Dock	2	Nationally Scarce B
Sagittaria sagittifolia	Arrowhead	2	Local
Sagina procumbens	Procumbent Pearlwort	13	Common
Schoenoplectus lacustris ssp lacustris	Common Club-rush	14	Local
Schoenoplectus lacustris ssp tabernaemontani	Grey Club-rush	7	Local
Scirpus maritimus	Sea Club-rush	3	Local
Scrophularia auriculata	Water Figwort	32	Common
Scutellaria galericulata	Skullcap	9	Common
Senecio aquaticus	Marsh Ragwort	6	Common
Solanum dulcamara	Bittersweet	193	Common
Sparganium emersum	Unbranched Bur-weed	5	Local
Sparganium erectum	Branched Bur-weed	81	Common
Stachys palustris	Marsh Woundwort	15	Common
Stellaria uliginosa	Bog Stitchwort	16	Common
Stratiotes aloides	Water Soldier	2	Common
Symphytum officinale	Common Comfrey	1	Common
Thalictrum flavum	Common Meadow-rue	1	Local
Typha angustifolia	Lesser Bulrush	5	Local
Typha latifolia	Bulrush	74	Common
Valeriana dioica	Marsh Valeria	1	Local
Veronica anagallis aquatica	Blue Water-speedwell	3	Common
Veronica beccabunga	Brooklime	51	Common
Veronica catenata	Pink Water-speedwell	14	Local
Veronica scutellata	Marsh Speedwell	4	Common
Viola palustris	Marsh Violet	1	Common
Wolffia arrhiza	Rootless Duckweed	1	Nationally Scarce A
Zannichellia palustris	Horned Pondweed	5	Local
Hybrids			
Potamogeton x zizii		1	
Typha x glauca		1	

ANNEXE 7. SIGNIFICANT DATA SET CORRELATIONS

TABLE 7.1 SPEARMAN RANK CORRELATION COEFFICIENTS BETWEEN VARIABLES

(••• $P < 0.001$; •••• $P < 0.0001$. FOR EXPLANATION OF ABBREVIATIONS SEE ANNEXE 7.2).

	ITE SQ	POND NO	ITE LC	POND AREA	WATER %	TEMPO-RARY	DRAW-DOWN	MEAN WD	MEAN SD	SED OM	SED G&S	SED OOZE	pH
ITE SQ	1												
POND NO	-0.3076 ••••	1											
ITE LC	0.7392 ••••	-0.2504 ••••	1										
POND AREA	0.2147 ••••	-0.2739 ••••	0.2172 ••••	1									
WATER %	0.2462 ••••		0.2996 ••••	0.4681 ••••	1								
TEMPORARY			-0.1689 •••	-0.3608 ••••	-0.7981 ••••	1							
DRAWDOWN			-0.1866 •••		-0.3794 ••••	0.1788 •••	1						
MEAN WD	0.1718 •••		0.215 ••••	0.5148 ••••	0.8796 ••••	-0.7775 ••••	-0.1914 •••	1					
MEAN SD						-0.2256 ••••			1				
SED OM	-0.1985 •••		-0.207 ••••	-0.2427 ••••	-0.5107 ••••	0.4086 ••••		-0.4867 ••••		1			
SED G&S					0.2495 ••••			0.2379 ••••	-0.2674 ••••	-0.2529 ••••	1		
SED OOZE					0.3178 ••••	-0.3404 ••••		0.3 ••••		-0.7349 ••••	-0.2962 ••••	1	
pH	0.2369 •••			0.3046 ••••				0.2396 •••		-0.2484 ••••			1
CALCIUM									0.2801 ••••				
COND			-0.342 ••••										
CLARITY													
INFL VOL				0.2287 ••••	0.359 ••••	-0.2379 ••••	-0.2355 ••••	0.2977 ••••					
WS GROUND	0.3738 ••••	-0.2176 ••••	0.2301 ••••	0.1752 •••							0.2139 ••••		
WS SPRING													
WS STREAM				0.2365 ••••	0.2715 ••••		-0.1947 •••	0.2234 ••••					
WS RUNOFF	-0.2038 ••••	0.3088 ••••	-0.2194 ••••	-0.2788 ••••	-0.348 ••••	0.2575 ••••	0.2101 ••••	-0.3097 ••••			-0.2574 ••••		

(Continued)	ITE SQ	POND NO	ITE LC	POND AREA	WATER %	TEMPO-RARY	DRAW-DOWN	MEAN WD	MEAN SD	SED OM	SED G&S	SED OOZE	pH
WS DIRECT													0.213 •••
TOT EMERG					-0.2099 ••••	0.2181 ••••		-0.2531 ••••					
TOT FLOAT			0.2326 ••••	0.2629 ••••	0.4667 ••••	-0.4257 ••••		0.5183 ••••		-0.1845 •••			
TOT SUBMG	0.2578 ••••		0.3208 ••••	0.2948 ••••	0.4393 ••••	-0.3486 ••••		0.4448 ••••		-0.265 ••••		0.1883 •••	
TOT COVER			0.1802 •••										
NO. EMERG	0.2057 ••••		0.3103 ••••	0.4368 ••••	0.3871 ••••	-0.3019 ••••		0.3749 ••••		-0.2656 ••••		0.22 ••••	
NO. AQUAT	0.2262 ••••		0.3325 ••••	0.346 ••••	0.5319 ••••	-0.4768 ••••		0.5544 ••••		-0.2662 ••••		0.1884 •••	
TOT NO.	0.2256 ••••		0.3363 ••••	0.4568 ••••	0.4551 ••••	-0.3661 ••••		0.4479 ••••		-0.2991 ••••		0.2361 ••••	
SUB/FLOAT	0.2224 ••••		0.3136 ••••	0.333 ••••	0.4669 ••••	-0.3882 ••••		0.5031 ••••		-0.2554 ••••			
SP/AREA				-0.6897 ••••	-0.1748 •••			-0.2182 ••••					-0.2132 •••
RARE SCOR			0.2108 ••••	0.4332 ••••	0.3132 ••••	-0.3116 ••••		0.3619 ••••					
ALIEN SP			0.2249 ••••	0.1878 •••	0.2751 ••••	-0.2132 ••••		0.3145 ••••		-0.1989 •••			
OVERHUNG%	-0.2109 ••••	0.2451 ••••	-0.238 ••••	-0.2631 ••••	-0.4051 ••••	0.2553 ••••		-0.3808 ••••	0.2111 ••••	0.4851 ••••	-0.2684 ••••	-0.2614 ••••	
5M WOODS	-0.1957 ••••	0.2688 ••••			-0.1688 •••					0.3613 ••••	-0.2185 ••••	-0.1798 •••	
5M SCRUB													
5M HEATH													
5M MARSH			0.206 ••••		0.1955 ••••		-0.2078 ••••						
5M RANK					0.2149 ••••	-0.1823 •••		0.1734 •••		-0.2531 ••••		0.1824 •••	
5M UNIMP				0.1943 ••••									
5M IMPRV	0.1772 •••		0.1817 •••							-0.2772 ••••		0.2225 ••••	
5M ARABL													
5M URBAN					0.1951 ••••								
5M ROADS	0.1827 •••			0.1845 •••									0.2185 •••
5M ROCK													
5M LAKES													

(Continued)	ITE SQ	POND NO	ITE LC	POND AREA	WATER %	TEMPO-RARY	DRAW-DOWN	MEAN WD	MEAN SD	SED OM	SED G&S	SED OOZE	pH
5M RIVER													
5M SEMI		-0.1758 •••		0.1793 •••	0.3131 ••••	-0.2501 ••••	-0.1876 •••	0.2216 ••••		-0.309 ••••		0.2085 ••••	
25M WOODS		0.2114 ••••								0.1815 •••			
25M SCRUB			-0.2055 ••••										
25M HEATH	0.1735 •••		0.1829 •••										
25M MARSH					0.1955 ••••		-0.1918 •••						
25M RANK													
25M UNIMP													
25M IMPRV			0.1835 •••										
25M ARABL			-0.224 ••••										
25M URBAN													
25M ROADS	0.1796 •••												
25M ROCK			0.2192 ••••										
25M LAKES		0.2048 ••••											
25M RIVER													
25M SEMI					0.1844 •••		-0.1855 •••						
100MWOODS													
100MSCRUB													
100MHEATH	0.1886 •••		0.1906 •••										
100MMARSH					0.1786 •••								
100MRANK													
100MUNIMP													
100MIMPRV			0.1913 •••										
100MARABL			-0.2598 ••••										
100MURBAN					0.2219 ••••	-0.1901 •••		0.1854 •••					

(Continued)	ITE SQ	POND NO	ITE LC	POND AREA	WATER %	TEMPO-RARY	DRAW-DOWN	MEAN WD	MEAN SD	SED OM	SED G&S	SED OOZE	pH
100MROADS													
100MROCK	0.1711 •••		0.1768 •••										
100MLAKES													
100MRIVER													
100MSEMI													
PAST\ARAB		-0.2366 ••••											
NEW POND					0.1788 •••			0.2028 ••••	-0.1863 •••	-0.2058 ••••			
MANAGEMNT					0.2177 ••••	-0.2061 ••••		0.2869 ••••		-0.2117 ••••			
GRAZED										-0.1952 •••			
VISIBLE													
FISHING				0.3244 ••••	0.3109 ••••	-0.1783 •••		0.3557 ••••		-0.2578 ••••		0.2049 ••••	
SHOOTING				0.1836 •••									
ORMTL FSH				0.173 •••				0.172 •••		-0.1826 •••			
BOATING													
AMENITY				0.3751 ••••	0.3748 ••••	-0.2592 ••••		0.3671 ••••		-0.3088 ••••		0.2187 ••••	0.2138 •••
DEC EMRG1	-0.3284 ••••	0.2956 ••••	-0.3748 ••••						0.2693 ••••	0.2355 ••••	-0.2489 ••••		
DEC EMRG2					0.211 ••••	-0.18 •••	-0.2116 ••••						

(Continued)	CAL	COND	CLAR-ITY	INFL VOL	WS GR.WTR	WS SPRING	WS STREAM	WS RUNOFF	WS DIRECT	TOT EMERG	TOT FLOAT	TOT SUBMG	TOT COVER
CALCIUM	1												
COND	0.5956 ••••	1											
CLARITY			1										
INFL VOL				1									
WS GROUND					1								
WS SPRING						1							
WS STREAM				0.8107 ••••	-0.1859 •••		1						
WS RUNOFF				-0.5292 ••••	-0.3862 ••••	-0.3396 ••••	-0.4867 ••••	1					
WS DIRECT						-0.1986 ••••		0.2312 ••••	1				
TOT EMERG			0.2065 •••							1			
TOT FLOAT					0.2158 ••••			-0.1745 •••			1		
TOT SUBMG		-0.2797 ••••	0.2372 ••••		0.2004 ••••			-0.2177 ••••			0.4367 ••••	1	
TOT COVER			0.3376 ••••							0.7872 ••••	0.4656 ••••	0.3517 ••••	1
NO. EMERG		-0.2872 ••••		0.2127 ••••				-0.2143 ••••		0.4178 ••••	0.4422 ••••	0.4396 ••••	0.4864 ••••
NO. AQUAT	-0.2313 •••	-0.3136 ••••	0.2086 •••		0.2301 ••••			-0.2179 ••••			0.7601 ••••	0.7957 ••••	0.4064 ••••
TOT NO.		-0.3048 ••••		0.2169 ••••	0.2035 ••••			-0.2409 ••••		0.3699 ••••	0.5502 ••••	0.5653 ••••	0.5145 ••••
SUB/FLOAT		-0.2381 •••			0.2052 ••••			-0.1826 •••			0.6464 ••••	0.7239 ••••	0.2972 ••••
SP/AREA										0.4449 ••••			0.4243 ••••
RARE SCOR					0.184 •••					0.1937 •••	0.4252 ••••	0.5334 ••••	0.3544 ••••
ALIEN SP					0.1693 •••			-0.1922 •••			0.2961 ••••	0.4785 ••••	0.2156 ••••
OVERHUNG%		0.2405 •••		-0.2101 ••••			-0.1741 •••	0.2497 ••••		-0.2991 ••••	-0.2444 ••••	-0.3181 ••••	-0.3827 ••••
5M WOODS										-0.3005 ••••		-0.1686 •••	-0.2862 ••••
5M SCRUB		0.2751 ••••											
5M HEATH													
5M MARSH						0.2137 ••••							0.177 •••
5M RANK													
5M UNIMP											0.1945 ••••		

(Continued)	CAL	COND	CLAR-ITY	INFL VOL	WS GR.WTR	WS SPRING	WS STREAM	WS RUNOFF	WS DIRECT	TOT EMERG	TOT FLOAT	TOT SUBMG	TOT COVER
5M IMPRV													
5M ARABL		0.269 ••••											
5M URBAN				0.2741 ••••									
5M ROADS													
5M ROCK													
5M LAKES													
5M RIVER				0.5546 ••••			0.5349 ••••	-0.3536 ••••					
5M SEMI				0.1817 •••				-0.2749 ••••					
25M WOODS									-0.1794 •••	-0.234 ••••			-0.177 •••
25M SCRUB													
25M HEATH													
25M MARSH	-0.2382 •••			0.1708 •••		0.2632 ••••		-0.2551 ••••					
25M RANK													
25M UNIMP													
25M IMPRV													
25M ARABL		0.2638 ••••											
25M URBAN				0.2037 ••••									
25M ROADS													
25M ROCK	-0.2241 •••	-0.2226 •••											
25M LAKES													
25M RIVER				0.4321 ••••			0.444 ••••	-0.3854 ••••					
25M SEMI				0.1839 •••			0.1826 •••	-0.2356 ••••					
100MWOODS										-0.1868 •••			
100MSCRUB									0.1802 •••				
100MHEATH													
100MMARSH	-0.2881 ••••	-0.297 ••••				0.2137 ••••		-0.2006 ••••					
100MRANK													
100MUNIMP													
100MIMPRV													

(Continued)	CAL	COND	CLAR-ITY	INFL VOL	WS GR.WTR	WS SPRING	WS STREAM	WS RUNOFF	WS DIRECT	TOT EMERG	TOT FLOAT	TOT SUBMG	TOT COVER
100MARABL		0.2884 ••••					-0.185 •••	0.1769 •••					
100MURBAN				0.2124 ••••		0.1697 •••							
100MROADS													
100MROCK	-0.2086 •••												
100MLAKES							0.2086 ••••						
100MRIVER				0.2601 ••••			0.2887 ••••	-0.2755 ••••					
100MSEMI							0.2014 ••••	-0.1876 •••					
PAST\ARAB	-0.2604 ••••	-0.2992 ••••						-0.1725 •••				0.1708 •••	
NEW POND													
MANAGEMNT												0.1735 •••	
GRAZED													0.1763 •••
VISIBLE								-0.1898 •••					
FISHING											0.1949 ••••	0.24 ••••	
SHOOTING													
ORMTL FSH				0.1805 •••			0.1832 •••						
BOATING													
AMENITY											0.1709 •••	0.3111 ••••	
DEC EMRG1	0.293 ••••	0.3358 ••••								-0.261 ••••		-0.2602 ••••	-0.2808 ••••
DEC EMRG2											0.1745 •••		

(Continued)	NO. EMERG	NO. AQUAT	TOT NO.	SUB/ FLOAT	SP/AREA	RARE SCOR	ALIEN SP	OVER-HUNG%	5M WOODS	5M SCRUB	5M HEATH	5M MARSH	5M RANK
NO. EMERG	1												
NO. AQUAT	0.5857 ****	1											
TOT NO.	0.9767 ****	0.7309 ****	1										
SUB/FLOAT	0.4533 ****	0.7847 ****	0.5778 ****	1									
SP/AREA	0.2293 ****		0.2202 ****		1								
RARE SCOR	0.6429 ****	0.6324 ****	0.6973 ****	0.5093 ****		1							
ALIEN SP	0.3348 ****	0.4589 ****	0.4 ****	0.4373 ****		0.2979 ****	1						
OVERHUNG%	-0.4895 ****	-0.3485 ****	-0.4971 ****	-0.2768 ****		-0.3027 ****	-0.2307 ****	1					
5M WOODS	-0.2719 ****		-0.256 ****			-0.1816 ***		0.6068 ****	1				
5M SCRUB									-0.4011 ****	1			
5M HEATH								-0.1801 ***			1		
5M MARSH			0.1697 ***									1	
5M RANK								-0.1906 ***	-0.2342 ****				1
5M UNIMP	0.2262 ****		0.2255 ****										
5M IMPRV	0.1939 ***		0.1959 ****		0.2133 ****			-0.409 ****	-0.3454 ****				
5M ARABL													
5M URBAN													
5M ROADS													
5M ROCK													
5M LAKES													
5M RIVER													
5M SEMI	0.28 ****		0.2694 ****					-0.3114 ****	-0.3489 ****		0.1737 ***	0.3254 ****	0.7059 ****
25M WOODS								0.3765 ****	0.7525 ****	-0.3153 ****			
25M SCRUB									-0.2281 ****	0.584 ****			
25M HEATH											0.776 ****		
25M MARSH			0.1693 ***									0.595 ****	
25M RANK													0.5675 ****

(Continued)	NO. EMERG	NO. AQUAT	TOT NO.	SUB/ FLOAT	SP/AREA	RARE SCOR	ALIEN SP	OVER-HUNG%	5M WOODS	5M SCRUB	5M HEATH	5M MARSH	5M RANK
25M UNIMP													
25M IMPRV					0.1722 ***			-0.2132 ****	-0.1939 ***				
25M ARABL	-0.1991 ****		-0.212 ****										0.1725 ***
25M URBAN													
25M ROADS													
25M ROCK													
25M LAKES													
25M RIVER													
25M SEMI	0.2113 ****		0.2022 ****								0.1815 ***		0.2859 ****
100MWOODS								0.2467 ****	0.5826 ****	-0.2845 ****			
100MSCRUB									-0.2081 ****	0.4269 ****			
100MHEATH											0.6815 ****		
100MMARSH	0.1863 ***		0.1823 ***									0.4274 ****	
100MRANK													0.3686 ****
100MUNIMP													
100MIMPRV					0.1701 ***								
100MARABL	-0.1921 ***		-0.1974 ****					0.1848 ***					0.1765 ***
100MURBAN													
100MROADS													
100MROCK													
100MLAKES													
100MRIVER	0.187 ***		0.2 ****			0.1733 ***							
100MSEMI	0.2292 ****		0.2198 ****			0.1921 ***					0.184 ***		
PAST\ARAB	0.2136 ****		0.2239 ****					-0.2139 ****		-0.203 ****			
NEW POND								-0.196 ****					
MANAGEMNT								-0.2163 ****					
GRAZED					0.2245 ****			-0.2574 ****	-0.1878 ***				
VISIBLE													

(continued)	NO. EMERG	NO. AQUAT	TOT NO.	SUB/FLOAT	SP/AREA	RARE SCOR	ALIEN SP	OVER-HUNG%	5M WOODS	5M SCRUB	5M HEATH	5M MARSH	5M RANK
FISHING	0.2668 ****	0.2707 ****	0.2881 ****	0.2659 ****	-0.1922 ***	0.2091 ****	0.1736 ***	-0.1794 ***					
SHOOTING	0.1766 ***		0.1727 ***				0.221 ****						
ORMTL FSH													
BOATING							0.1744 ***						
AMENITY	0.3237 ****	0.2882 ****	0.3451 ****	0.2564 ****		0.2717 ****	0.3004 ****	-0.2591 ****					
DEC EMRG1	-0.3635 ****	-0.2818 ****	-0.3811 ****	-0.2073 ****	-0.2222 ****	-0.2576 ****	-0.1865 ***	0.5189 ****	0.3845 ****		-0.1757 ***		
DEC EMRG2	0.2293 ****	0.1879 ***	0.2481 ****						0.1895 ***			0.1969 ***	

(Continued)	5M UNIMP	5M IMPRV	5M ARABL	5M URBAN	5M ROADS	5M ROCK	5M LAKES	5M RIVER	5M SEMI	25M WOODS	25M SCRUB	25M HEATH	25M MARSI
5M UNIMP	1												
5M IMPRV		1											
5M ARABL		-0.1768 ***	1										
5M URBAN				1									
5M ROADS					1								
5M ROCK						1							
5M LAKES							1						
5M RIVER								1					
5M SEMI	0.2885 ****	-0.1789 ***				0.1982 ****		0.2443 ****	1				
25M WOODS		-0.3133 ****	-0.2002 ****						-0.196 ****	1			
25M SCRUB										-0.2425 ****	1		
25M HEATH						0.1753 ***			0.1789 ***			1	
25M MARSH									0.2766 ****				1
25M RANK									0.3814 ****				
25M UNIMP	0.5852 ****	-0.1744 ***							0.1774 ***				
25M IMPRV		0.731 ****	-0.326 ****							-0.3059 ****			
25M ARABL		-0.2655 ****	0.6252 ****							-0.1694 ***			
25M URBAN				0.4573 ****									
25M ROADS					0.5734 ****								
25M ROCK						0.547 ****							
25M LAKES							0.2812 ****			0.2043 ****			
25M RIVER								0.648 ****	0.2187 ****				
25M SEMI	0.2417 ****	-0.276 ****						0.2016 ****	0.5025 ****			0.2217 ****	0.339 ****
100MWOODS		-0.2236 ****	-0.2328 ****							0.8533 ****	-0.2417 ****		
100MSCRUB										-0.2238 ****	0.6855 ****		
100MHEATH									0.1869 ***			0.8756 ****	
100MMARSH						0.1756 ***			0.2048 ****				0.7143 ****

(continued)	5M UNIMP	5M IMPRV	5M ARABL	5M URBAN	5M ROADS	5M ROCK	5M LAKES	5M RIVER	5M SEMI	25M WOODS	25M SCRUB	25M HEATH	25M MARSH
100MRANK									0.2372 ****				
100MUNIMP	0.4107 ****	-0.1791 ***											
100MIMPRV		0.6007 ****	-0.3291 ****							-0.2224 ****			
100MARABL		-0.3154 ****	0.542 ****										
100MURBAN				0.2986 ****									
100MROADS					0.3971 ****								
100MROCK						0.4105 ****							
100MLAKES										0.2 ****			
100MRIVER								0.4719 ****	0.1987 ****				
100MSEMI	0.2211 ****	-0.1853 ***							0.2743 ****			0.2371 ****	0.2308 ****
PAST\ARAB		0.2191 ****	-0.2258 ****										
NEW POND													
MANAGEMNT													
GRAZED		0.4157 ****				0.1711 ***				-0.2083 ****			
VISIBLE													
FISHING													
SHOOTING	0.2041 ****												
ORMTL FSH				0.2627 ****									
BOATING													
AMENITY													
DEC EMRG1		-0.3498 ****				-0.1926 ***				0.2694 ****			
DEC EMRG2		-0.2698 ****								0.3022 ****			0.2347 ****

(Continued)	25M RANK	25M UNIMP	25M IMPRV	25M ARABL	25M URBAN	25M ROADS	25M ROCK	25M LAKES	25M RIVER	25M SEMI	100M WOODS	100M SCRUB	100M HEAT
25M RANK	1												
25M UNIMP		1											
25M IMPRV		-0.2041 ****	1										
25M ARABL			-0.4769 ****	1									
25M URBAN					1								
25M ROADS					0.198 ****	1							
25M ROCK							1						
25M LAKES								1					
25M RIVER									1				
25M SEMI	0.5113 ****	0.3883 ****	-0.2769 ****				0.1758 ***	0.3784 ****	0.3538 ****	1			
100MWOODS			-0.2112 ****	-0.2511 ****				0.1706 ***			1		
100MSCRUB											-0.2293 ****	1	
100MHEATH										0.2351 ****			1
100MMARSH							0.1821 ***		0.1707 ***	0.3117 ****			
100MRANK	0.6084 ****									0.3639 ****			
100MUNIMP		0.748 ****	-0.2437 ****							0.3063 ****			
100MIMPRV		-0.1819 ***	0.8976 ****	-0.5312 ****		-0.1782 ***				-0.2119 ****	-0.1843 ***		
100MARABL			-0.5233 ****	0.8895 ****							-0.1996 ****		
100MURBAN				-0.1696 ***	0.6635 ****	0.2305 ****							
100MROADS					0.2337 ****	0.6977 ****							
100MROCK							0.6272 ****						
100MLAKES								0.6021 ****		0.2873 ****	0.1859 ***		
100MRIVER									0.739 ****	0.2384 ****			
100MSEMI	0.3053 ****	0.3453 ****	-0.2186 ****				0.1855 ***	0.2444 ****	0.2922 ****	0.6939 ****			0.270 ****
PAST\ARAB			0.2303 ****	-0.3505 ****									
NEW POND													
MANAGEMNT					0.1952 ****								

(Continued)	25M RANK	25M UNIMP	25M IMPRV	25M ARABL	25M URBAN	25M ROADS	25M ROCK	25M LAKES	25M RIVER	25M SEMI	100M WOODS	100M SCRUB	100M HEATH
GRAZED			0.4214 ****	-0.196 ****									
VISIBLE						0.2601 ****							
FISHING													
SHOOTING													
ORMTL FSH					0.2224 ****								
BOATING													
AMENITY													
DEC EMRG1			-0.2539 ****	0.2916 ****									
DEC EMRG2			-0.2024 ****							0.2801 ****	0.3282 ****		

(Continued)	100M MARSH	100M RANK	100M UNIMP	100M IMPRV	100M ARABL	100M URBAN	100M ROADS	100M ROCK	100M LAKES	100M RIVER	100M SEMI	PAST\ ARAB	NEW POND
100MMARSH	1												
100MRANK		1											
100MUNIMP			1										
100MIMPRV			-0.2531 ****	1									
100MARABL	-0.1797 ***			-0.6233 ****	1								
100MURBAN						1							
100MROADS						0.3617 ****	1						
100MROCK								1					
100MLAKES		0.1762 ***							1				
100MRIVER	0.1843 ***									1			
100MSEMI	0.2909 ****	0.4631 ****	0.4169 ****	-0.1822 ***				0.2309 ****	0.4894 ****	0.3487 ****	1		
PAST\ARAB				0.2137 ****	-0.3806 ****							1	
NEW POND													1
MANAGEMNT						0.2227 ****							
GRAZED				0.4076 ****	-0.2234 ****								
VISIBLE							0.2864 ****						
FISHING												0.184 ***	
SHOOTING													
ORMTL FSH												0.1708 ***	
BOATING													
AMENITY												0.1891 ***	0.199 ****
DEC EMRG1				-0.2196 ****	0.316 ****			-0.1797 ***				-0.3324 ****	
DEC EMRG2	0.1975 ***										0.2353 ****		

(Continued)	MANAG EMNT	GRAZ-ED	VISIBLE	FISHING	SHOOT-ING	ORMT FSH	BOAT-ING	AMEN-ITY	DEC EMRG1	DEC EMRG2
MANAGEMNT	1									
GRAZED		1								
VISIBLE			1							
FISHING				1						
SHOOTING					1					
ORMTL FSH				0.2426 ****		1				
BOATING				0.172 ***			1			
AMENITY	0.314 ****			0.6142 ****				1		
DEC EMRG1		-0.3363 ****							1	
DEC EMRG2										1

ANNEXE 7.2. ABBREVIATIONS USED FOR VARIABLES.

Abbreviation	Variable Description
ITE SQ	ITE number SQ
POND NO	Code number
ITE LC	ITE number LC
POND AREA	Pond area
WATER %	% water left in the pond
TEMPORARY	Temporary pond
DRAWDOWN	Drawdown height
MEAN WD	Mean water depth
MEAN SD	Mean silt depth
SED OM	Sediment: coarse organic matter
SED G&S	Sediment: gravel/sand
SED OOZE	Sediment: ooze
pH	Water quality: pH
CAL	Water quality: calcium
COND	Water quality: conductivity
CLARITY	Water quality clarity
INFL VOL	Inflows volume (ranked on a 1-10 scale)
WS GR.WTR	Water source: groundwater
WS SPRING	Water source: spring/flush
WS STREAM	Water source: stream, ditch or flood inflow
WS RUNOFF	Water source: runoff
WS DIRECT	Water source: direct precipitation
TOT EMERG	Total cover emergents
TOT FLOAT	Total cover floating
TOT SUBMG	Total cover submerged
TOT COVER	Total cover
NO. EMERG	Number of emergent plants
NO. AQUAT	Number of aquatic plants
TOT NO.	Total number of plants
SUB/FLOAT	No. submerged/no. floating species
SP/AREA	No. species/pond area
RARE SCOR	Rare Species Score: Total plants
ALIEN SP	Total no of alien species
OVERHUNG%	Pond % overhung
5M WOODS	Landuse 0-5m: trees and deciduous/mixed woodland
5M SCRUB	Landuse 0-5m: Scrub and hedge
5M HEATH	Landuse 0- 5m: Moorland and heath
5M MARSH	Landuse 0-5m: Fen, marsh, bog
5M RANK	Landuse 0-5m: Rank vegetation
5M UNIMP	Landuse 0-5m Unimproved grassland
5M IMPRV	Landuse 0-5m: Improved grassland
5M ARABL	Landuse 0-5m: Arable
5M URBAN	Landuse 0-5m: Urban
5M ROADS	Landuse 0-5m: Roads and tracks
5M ROCK	Landuse 0-5m: Rock and stone
5M LAKES	Landuse 0-5m: Ponds and lakes
5M RIVER	Landuse 0-5m: rivers, streams and ditches
5M SEMI	Landuse 0-5m: semi-natural (no woodland)
25M WOODS	Landuse 5-25m: trees and deciduous/mixed woodland
25M SCRUB	Landuse 5-25m: Scrub and hedge
25M HEATH	Landuse 5-25m: Moorland and heath

Abbreviation	Variable Description (continued)
25M MARSH	Landuse 5-25m: Fen, marsh, bog
25M RANK	Landuse 5-25m: Rank vegetation
25M UNIMP	Landuse 5-25m Unimproved grassland
25M IMPRV	Landuse 5-25m: Improved grassland
25M ARABL	Landuse 5-25m: Arable
25M URBAN	Landuse 5-25m: Urban
25M ROADS	Landuse 5-25m: Roads and tracks
25M ROCK	Landuse 5-25m: Rock and stone
25M LAKES	Landuse 5-25m: Ponds and lakes
25M RIVER	Landuse 5-25m: rivers, streams and ditches
25M SEMI	Landuse 5-25m: semi-natural (no woodland)
100MWOODS	Landuse 25-100m: trees and decidouos/mixed woodland
100MSCRUB	Landuse 25-100m: Scrub and hedge
100MHEATH	Landuse 25-100m: Moorland and heath
100MMARSH	Landuse 25-100m: Fen, marsh, bog
100MRANK	Landuse 25-100m: Rank vegetation
100MUNIMP	Landuse 25-100m Unimproved grassland
100MIMPRV	Landuse 25-100m: Improved grassland
100MARABL	Landuse 25-100m: Arable
100MURBAN	Landuse 25-100m: Urban
100MROADS	Landuse 25-100m: Roads and tracks
100MROCK	Landuse 25-100m: Rock and stone
100MLAKES	Landuse 25-100m: Ponds and lakes
100MRIVER	Landuse 25-100m: rivers, streams and ditches
100MSEMI	Landuse 25-100m: semi-natural (no woodland)
PAST/ARAB	ITE Pastural(1) arable(0) landscape
NEW POND	New pond (1=yes)
MANAGEMNT	Pond management
GRAZED	Grazed
VISIBLE	Visibility from a public right of way
FISHING	Amenity use: Fishing
SHOOTING	Amenity use: Shooting
ORMTL FSH	Amenity use: Ornamental fish
BOATING	Amenity use: Boating
AMENITY	Amenity use: all
DEC EMRG1	DECORANA Axis 1 - Emergents
DEC EMRG2	DECORANA Axis 2 - Emergents

ANNEXE 8. MESO-LANDSCAPE CHARACTERISTICS OF PONDS

(a) High numbers of uncommon species

Square/ pond	Area	Semi-natural				Intensive		
		SSSI	Flood-plain	Others (e.g. National Park)	>50% Semi-natural	>50% Improved grass	>50% Arable	Other intensive
423/2	Ouse Washes	✔						
129/2	Somerset Levels		✔					
335/2	R. Great Ouse floodplain		✔					
116/4	750 m from R. Arun floodplain						✔	
179/1	Cotswold scarp, Kingswood, Bristol					✔		
205/1	Old canal system, nr Newport		✔					
273/2	Vale of Aylesbury, R. Thame		✔					
295/2	Wormbridge, W of Hereford						✔	
482/2	Headwater of R. Wensum, Norfolk						✔	
558/4	500m from sea in Anglesea				✔			
761/1	Floodplain of R. Blyth/Pont		✔					
61/7	Edge of New Forest			✔				
116/7	Floodplain of R. Arun		✔					
129/1	Somerset Levels		✔					
129/5	Somerset Levels		✔					
146/1	Frittenden, Kent; R. Beult catchment						✔	
205/2	Old canal system, nr Newport		✔					
307/1	Letchworth					✔		
366/2	Near Stow-cum-Quay Fen (1000 m)				✔			
366/2	Near Stow-cum-Quay Fen (200 m)		✔					
384/3	Wyre Forest (near SSSI)				✔			
761/3	Floodplain of R. Blyth/Pont		✔					
75/3	Beside valley fen SSSI, Tiverton			✔				
129/3	Somerset Levels		✔					
146/3	Frittenden, Kent; R. Beult catchment					✔		
146/14	Frittenden, Kent; R. Beult catchment					✔		
224/4	250 m from sea at Milford Haven		✔					
269/2	R. Windrush, arable in meander bend		✔					
279/2	N. of Chelmsford							✔
305/1	Woodland: prob. ancient semi-natural				✔			
324/2	Wormsley, W. of Hereford					✔		
328/2	Near R. Avon (above floodplain)				✔			
328/3	Near R. Avon (above floodplain).				✔			
369/2	Woolpit, Stowmarket. Moat in arable area;						✔	
402/2	Blyford, nr Southwold.						✔	
402/7	Blyford, nr Southwold.						✔	
418/1	R. Welland meander cutoff by channelisation		✔					
436/1	SW Shrewsbury						✔	
589/2	Edge of Peak District NP					✔		
735/1	Upland Galloway					✔		
735/1	Upland Galloway				✔			
893/2	Queen Elisabeth Forest Park					✔		
	Number of sites	1	15	2	7	8	8	1
	Total number of sites				25			17

ANNEXE 8. MESO-LANDSCAPE CHARACTERISTICS OF PONDS (CONTINUED)

(b) No uncommon species

Square/ pond	Area	Semi-natural: SSSI	Semi-natural: Flood-plain	Semi-natural: Others (e.g. National Park)	Semi-natural: >50% Semi-natural	Intensive: >50% Improved grass	Intensive: >50% Arable	Intensive: Other intensive
013/1	Headwaters of R. Fal						✔	
53/7	S. of Honiton					✔		
75/1	Near Tiverton						✔	
76/3	E. of Tiverton					✔		
86/2	N. of Fareham				✔			
108/1	Nr. E. Knoyle					✔		
108/6	Nr. E. Knoyle					✔		
116/2	Nr R. Arun					✔		
120/2	S. of Bewl Bridge Reservoir						✔	
120/7	S. of Bewl Bridge Reservoir						✔	
120/12	S. of Bewl Bridge Reservoir						✔	
120/17	S. of Bewl Bridge Reservoir				✔			
120/22	S. of Bewl Bridge Reservoir					✔		
120/27	S. of Bewl Bridge Reservoir							✔
121/6	Above R. Rother Levels, Kent							✔
121/11	Above R. Rother Levels, Kent				✔			
127/1	Nr Dunster Castle, Somerset					✔		
146/7	Frittenden, Kent; R. Beult catchment				✔			
146/17	Frittenden, Kent; R. Beult catchment					✔		
184/3	Near Newbury, Berks					✔		
189/2	Wimbledon Common, Surrey				✔			
212/2	Nr Kingston Lyle, Oxon					✔		
241/1	Henwood (Boars Hill) Oxon				✔			
244/2	Nr Chesham, Bucks					✔		
244/6	Nr Chesham, Bucks					✔		
273/1	Fleet Marston, Bucks					✔		
279/1	N. of Chelmsford						✔	
296/1	Nr R. Wye					✔		
305/4	Nr Little Brickhill, Beds							✔
317/1	W. Wales							✔
341/3	R. Brett, edge of village					✔		
358/1	Golf course, edge of Leamington Spa					✔		
359/1	E. of Leamington Spa							✔
359/7	E. of Leamington Spa					✔		
369/1	Woolpit nr. Stowupland							✔
396/1	NO DATA						✔	
400/9	S. of Diss					✔		
402/10	Blyford, nr Southwold.				✔			
428/4	Nr Bungay, Norfolk						✔	
443/2	W. of Leicester					✔		
472/1	Around the M1, NE Loughborough						✔	
482/6	Headwater of R. Wensum, Norfolk				✔			
510/4	NW Fakenham					✔		
546/5	Nr Macclesfield, Pennine edge					✔		
558/1	Nr Holyhead					✔		
561/1	Anglesey, Nr Menai Strait							✔
565/2	The Wirral					✔		
573/1	Bisected by M1, Wales in Yorkshire				✔			
594/1	Holton le Moor, nr Caistor Lincs						✔	
656/1	Meathop, nr Grange over Sands					✔		
761/2	Floodplain of R. Blyth/Pont		✔					
	Number of sites	0	1	0	9	24	10	7
	Total number of sites				10			41

ANNEXE 9. PROTECTED SPECIES FOUND IN PONDS

Table A9.1 Pond associated species in the English Nature Species Recovery Programme

Species continuing as Phase 1 projects
Fen Raft Spider
Fen Orchid
Fen Violet
Atlantic Stream Crayfish

New species for Phase 1 projects
Spangled Water Beetle
Tadpole Shrimp
Water Vole

Species continuing as Phase 2 projects
Ribbon-leaved Water-Plantain
Starfruit
Strapwort

New species for Phase 2 projects
Natterjack Toad

Species continuing as pre-recovery projects
Pool Frog

New species for pre-recovery projects
Adder's-tongue Spearwort
Brown Galingale
Floating Water-plantain
Glutinous Snail
Lesser Silver Water Beetle
Medicinal Leech
Stoneworts

Scientific names are given in Table 7.1.

Table A9.2 Freshwater plants and animals for which Biodiversity Action Plans have been prepared

Great crested newt (*Triturus cristatus*)	✔
Natterjack Toad (*Bufo calamita*)	✔
Atlantic Stream Crayfish (*Austropotamobius pallipes*)	✔
Glutinous Snail (*Myxas glutinosa*)	✔
Medicinal Leech (*Hirudo medicinalis*)	✔
Shining Ramshorn Snail (*Segmentina nitida*)	✔
Anisus vorticulus (a ramshorn snail)	✔
Margaritifera margaritifera (a pearl mussel)	Rivers
Depressed River Mussel (*Pseudanodonta complanata*)	Rivers,canals
Pisidium tenuilineatum (a pea mussel)	Rivers,canals
Southern Damselfly (*Coenagrion mercuriale*)	Flushes
Mossy Stonewort (*Chara muscosa*)	Lakes
Creeping marshwort (*Apium repens*)	Wet grassland
Floating Water-plantain (*Luronium natans*)	✔
Holly-leaved Naiad (*Najas marina*)	Upton Broad
Three-lobed Water-crowfoot (*Ranunculus tripartitus*)	✔
Ribbon-leaved Water-plantain (*Alisma graminuem*)	✔
Shetland pondweed (*Potamogeton rutilus*)	Lakes
Slender Naiad	Lakes
Starfruit (*Damasonium alisma*)	✔
Other species which may benefit from pond conservation	
Water vole	✔
Otter	✔

Key:
✔ species occuring in, or associated with, ponds