Countryside Survey

Countryside Survey:
Ponds Report from 2007

CS Technical Report No. 7/07

Ponds Report from 2007

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Executive Summary

This Countryside Survey technical report describes the current state of ponds[1] in Britain and assesses how they have changed over the last decade.

Ponds in the Countryside Survey

Countryside Survey (CS) is a representative sample-based study that assesses state and change in the rural environment. Full surveys have been run in 1978, 1984, 1990, 1998 and 2007. In 2007 the survey covered a total of 591 1 km x 1 km sample squares spread across England, Scotland and Wales.

Pond numbers have been counted in Countryside Survey since 1984 with the last count in 1998. However, Countryside Survey 2007 is the first Countryside Survey to assess the physico-chemical condition and biological quality of ponds across all of Great Britain. Pond condition and quality has previously only been assessed in Countryside Survey lowland ponds in the 1996 thematic Lowland Pond Survey (LPS96).

In the current report, CS data are used to provide information on change in pond numbers in Great Britain between 1998 and 2007, and change in the quality of lowland ponds between 1996 and 2007.

Pond numbers

In 2007, the number of ponds in Great Britain was estimated to be 478,000, with mean densities of 1.8, 2.5 and 2.2 ponds per km^2 in England, Scotland and Wales, respectively.

There was a high turnover of ponds between 1998 and 2007, with an estimated 18,000 ponds lost and 70,600 new ponds created.

Overall, the number of ponds in Britain is estimated to have increased by 1.4% per annum between 1998 and 2007. This extends a gain of 0.8% per annum made between 1990 and 1998 and reverses pond losses in the 1980s of around 1% per annum.

Value of ponds

Pond biodiversity

Pond biodiversity value and ecological quality were assessed using plant community measures. Temporal trends were evaluated for lowland areas only, by comparing plant data gathered in 2007 with plant data collected from the same ponds in the 1996 Lowland Pond Survey.

In total, 205 plant species were recorded from 259 ponds surveyed in detail in 2007. This is around half of all Britain's wetland plant species. The species found included five uncommon species of national conservation importance and over 40 species that are locally uncommon.

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[1] A pond is defined as a body of standing water 0.0025 ha to 2 ha, in area, which usually holds water for at least four months of the year.

Invasive non-native wetland plant species, such as New Zealand Pigmyweed (*Crassula helmsii*), were recorded in 10% of ponds. There was no evidence of a significant increase in the occurrence of invasive species in the lowlands of Britain between 1996 and 2007.

Other pond services

Almost two-thirds (63%) of ponds were directly linked to the stream network. A third of these ponds had an inflow but no outflow suggesting that many ponds intercept and retain drainage water and may play a role in flood amelioration.

Pond quality

Pond quality in 2007

Countryside Survey 2007 data provided consistent evidence that ponds in England and Wales were widely degraded, with around 80% of ponds Poor or Very Poor quality. On average, ponds supported 38% of the expected number of wetland plant species and 21% of the expected number of uncommon plants. Mean Trophic Ranking Scores were 13% above predicted levels suggesting ponds were commonly polluted by nutrients. Pond quality in Scotland was more difficult to assess but provisional analysis suggests, on average, Scottish ponds were less degraded than English or Welsh ponds.

Ponds were poorer in quality or had fewer plant species where: (i) they had elevated nutrients levels, (ii) were located in areas of arable land, or (iii) had inflows. There was also a strong relationship between poorer pond quality and greater tree shade.

Change in pond quality between 1996 and 2007

Despite a low baseline, there was evidence that pond quality declined significantly in the lowlands of England and Wales between 1996 and 2007. Mean plant species richness decreased by 20% during this period from 10.2 to 8.2 species per pond. The proportion of Poor or Very Poor quality ponds increased by 17%. This decline was broadly related to land use intensity and pollution risk and specifically linked to:

- high nitrogen levels in pond water
- presence of road-runoff
- presence of stream inflows, and
- increasing tree shade.

At a national level there was no evidence that pond quality declines were linked to commonly cited degradation factors such as over-stocking of ducks, or the occurrence of invasive alien plant species.

Ameliorating factors

There was evidence that pond quality was greater where ponds were located close to other waterbodies and wetlands. In the English and Welsh lowlands, ponds were also more likely to have degraded between 1996 and 2007 where there was a lower proportion of waterbodies or wetlands in their surrounds. This suggests that isolation may play a role in pond degradation and, conversely, that freshwater networks may confer biodiversity benefits, helping to maintain pond quality in the countryside.

The quality of new ponds

New ponds were typically of better quality and supported more plant species than older ponds. The mean plant richness for 0-9 year-old ponds was 10.2 species per pond compared to 7.9 for older sites. Overall, creation of new ponds increased the mean plant richness of Britain's ponds from 7.9 in older ponds to 8.2 species per pond for all sites.

24% of the new ponds were of Good Quality and qualify as Biodiversity Action Plan (BAP) Priority Ponds on this basis. Approximately 6% of older sites were Good Quality.

Ponds and climate change

Comparison of the number of lowland ponds which dried out in 1996 and 2007 shows that between-year differences in rainfall had a considerable influence on pond seasonality. One in 20 ponds dried out in the seasonally wet year of 2007, compared to 1 in 4 ponds in the dry year of 1996. The results suggest that at least a quarter of Britain's lowland ponds are shallow bowls of variable seasonality. It is likely that these sites will be particularly susceptible to impacts from climate change.

Conclusions and implications

The results of the first assessment of pond quality change in Great Britain provide evidence, based on plant assemblage measures, that pond quality is poor and declining across much of Britain. Assessments of other biotic assemblages, made over longer time-periods, are now required to provide a more complete picture of pond quality and quality trends.

Set against evidence of declining quality, is a substantial increase in the number of new ponds, and in pond density. New ponds are known to colonise quickly, and as the CS data have shown, this can help to maintain the diversity of pond biota in the countryside. Some evidence from Countryside Survey and elsewhere suggests that new pond quality is unlikely to be maintained in the long-term unless ponds have semi-natural catchments with few pollutant inputs. There is no evidence from the 2007 that this was the case: of the new ponds studied in detail, only 6% had semi-natural surrounds, and all these were in Scotland. The quality of most new CS ponds may therefore decline as the waterbodies age.

There is still very little information describing the quality of lost ponds so it remains difficult to assess how far new pond creation is currently compensating for pond loss.

Contents

1 Introduction

This report describes the results of pond surveys undertaken across Great Britain as part of Countryside Survey in 2007 and the previous national Lowland Pond Survey undertaken in 1996 using Countryside Survey methodology. Summary results from the pond surveys are described in the Countryside Survey UK Results from 2007 report (Carey *et al*. 2008 a,b) and the country Reports published for England, Scotland and Wales in 2009 (http://www.countrysidesurvey.org.uk/reports2007.html). Data for the Countryside Survey in 2007 and earlier years have previously been released via the project web site (http://www.countrysidesurvey.org.uk/data.html).

1.1 Report Aims

This report presents information about the extent and quality of the pond resource in Great Britain.

Specific aims are to describe:

- The number of ponds in Britain
- Changes in pond numbers since 1998
- The physico-chemical condition of Britain's ponds
- The biological quality of ponds, assessed using plant assemblage measures
- Changes in lowland pond quality since 1996, including possible causes of change
- Pond attributes of particular relevance to policy including the quality of new ponds and occurrence of alien plant species.

1.2 The Countryside Survey

The Countryside Survey (CS) is a sample-based study which assesses state and change in the rural environment. Surveys have been undertaken every 6-8 years: 1978, 1984, 1990, 1998 (reported in 2000) and 2007. In 2007 the Countryside Survey covered a total of 591 1 km x 1 km sample squares spread across England, Scotland and Wales.

The area covered by CS is statistically representative of the wider countryside, including variations in climate and geology. The survey area includes cultivated land and grassland, areas around towns and more remote areas including moorlands, mountains and islands. It excludes only urban areas and the sea (see Countryside Survey UK report at http://www.countrysidesurvey.org.uk for details of general survey principles and methodology).

1.3 Ponds and the Countryside Survey

Ponds have been mapped as part of Countryside Survey since 1984, providing data that systematically describe the number and area of small waterbodies in Britain.

The first survey of pond quality was undertaken in 1996 as part of the Lowland Pond Survey (LPS96). This was a thematic pond-only study using Countryside Survey methodology and it was restricted to the lowlands of Britain. It assessed the physico-chemical attributes and plant assemblages of ponds for the first time, and included the first formal definition of a pond within Countryside Survey.

The current Countryside Survey (CS) has been the first to assess both pond numbers and pond quality across the whole of the British countryside including upland areas. It is also the first survey that can be used to investigate change in pond quality and condition by comparison with compatible data from lowland areas surveyed in LPS96.

1.4 Policy context

Pond data from the Countryside Survey can be used to inform government, non-governmental organisations and others with information relevant to current policy frameworks. Some of the main policy drivers are outlined below.

Habitats Directive

Annex 1 of the Habitats Directive (92/43/EEC) lists eight “habitats of high conservation importance” that either partly or wholly include ponds (see Appendix 1). The UK also has international obligations for a range of Annex II species found in ponds. The UK aims to protect Habitats Directive listed species and habitats through designation of Special Areas for Conservation (SACs). However, with a few notable exceptions, such as the New Forest SAC, and SACs designated for Great Crested Newt (*Triturus cristatus*), most standing water SACs are currently designated for larger waterbodies. Ponds receive some incidental protection through designation of SAC areas for other wetland and terrestrial habitat types.

Water Framework Directive

The Water Framework Directive (WFD) (2000/60/EC) aims to protect the ecological quality of all surface and groundwater in a catchment context. The UK, like most other national administrations, has adopted the 50 ha size limit of WFD System A for the identification of standing waterbodies to which WFD monitoring and assessment will apply. Waterbodies in protected areas above 1 ha in area will also be included although this will only affect about 250 sites across the whole of England and Wales.

Priority Habitats

In 2007, high quality ponds became a Priority Habitat identified under the UK Biodiversity Action Plan. Five criteria are used to define whether a pond meets priority status. These criteria are wide-ranging and include plant, invertebrate, amphibian and pond-type measures (see Appendix 2). A pond can qualify as a Priority Habitat Pond on the basis of one or more of the criteria.

If a pond has priority status this confers on it some protection in policy and law and ensures its greater consideration by public bodies through the ‘biodiversity duty’ under the Natural Environment and Rural Communities Act 2006. National targets and actions are currently in the process of development to ensure that the number of Priority Ponds is maintained and increased.

1.5 The value of ponds

Biodiversity

Ponds are a significant wildlife habitat, supporting populations of at least two-thirds of Britain's freshwater plant and animal species. For many species, ponds are also their main refuge and they are uncommon in other waterbody types. Individual ponds can differ widely in their biodiversity value. When they are located in semi-natural habitats they can be amongst the richest freshwater habitats, but when they are degraded they can be amongst the most impoverished (Williams *et al*. 2004).

The biodiversity value of ponds is particularly significant when considered collectively. Ponds are physically and biologically heterogeneous habitats with high gamma diversity[2]. Thus, at regional level they have been shown to support more plant and invertebrate species and more uncommon species than other freshwater habitat types including streams, rivers, ditches and lakes (Williams *et al*. 2004).

At national level ponds support around 80 Biodiversity Action Plan priority species. Analysis undertaken by Natural England shows that ponds support twice as many BAP species as lakes, and about 15% more than rivers and streams (Webb 2008a,b).

Ecosystem services

In addition to their role as freshwater habitats supporting a diverse range of flora and fauna, ponds also provide a variety of ecosystem services such as flood attenuation, water storage, and carbon sequestration.

Ponds are widely used in traditional flood amelioration schemes and are increasingly implemented as part of Sustainable Urban Drainage Systems (SUDS) contributing to the attenuation of flows and trapping pollutants (Woods-Ballard *et al*. 2007). In the rural environment modelling studies have suggested that ponds could trap 50% of phosphorus and 20% of nitrogen without any additional measures added (Hawkins and Schofield 2003). Ponds are also widely used for on-farm water storage for irrigation, although the number of farm reservoirs has not recently been estimated.

Research in North America suggests that ponds may be making a large contribution to carbon sequestration globally. Downing *et al.* (2008) estimated that North American farm ponds could, on average, trap over 1000 g C m^2 per annum. Pilot studies undertaken by Pond Conservation in 2008 show that similar rates of carbon trapping can occur under UK conditions. However, the potentially damaging release of atmospheric gases such as methane or nitrous oxide from ponds, has been little studied.

Other pond services

Ponds contribute to national heritage, with at least 20 pond types protected as Scheduled Monuments (e.g. moats, mill ponds, hammer ponds). Many ponds have local, and sometimes regional, scenic importance and are they are often noted as features of value within regional Landscape Character Areas.

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[2] Gamma diversity is the total number of species recorded from a habitat type within an area (e.g. the collective number of species recorded from all ponds in a county). This contrasts with alpha diversity, which is the number of species recorded from a single site (e.g. a single pond).

Although many traditional uses of ponds have declined or disappeared over recent centuries (e.g. flax retting, swelling wooden wheels and barrels), some uses have remained. Ponds are still used for watering cattle in some areas. Their uses for wildfowl hunting and fishing continue, although now with an emphasis on leisure rather than providing food for the table. New uses have also arisen, including their role as golf hazards and in education.

1.6 Trends in pond number and quality

Pond numbers

At a national level it is estimated that pond numbers in England and Wales decreased by around three-quarters during the 20th Century from a maximum of about 800,000 estimated from map counts in the late 19th century to around 200,000 by the 1980s (Rackham 1986, Barr *et al.* 1994, Biggs *et al.* 2005). The historic numbers of ponds and rate of pond loss in Scotland are not known, but rates of loss are probably lower with maximum estimated losses of only 7% between the 1950's and the 1980's (Swan and Oldham 1993 and Swan *et al*. 1994).

Swan and Oldham (1993), reporting the results of the National Amphibian Survey, estimated that overall pond loss in Britain since the Second World War was of the order of 38%, a loss of just under 1% per annum. Numbers probably reached an all time low by the 1980s, although the data are somewhat contradictory. Analysis of Countryside Survey results in 1990 suggested losses of around 1% per annum for 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 (MAFF 1985).

Countryside Survey data suggest that from the 1990's pond numbers began to rise with an increase of around 6% (0.8% per annum) between 1990 and 1998 (Haines-Young *et al.* 2000).

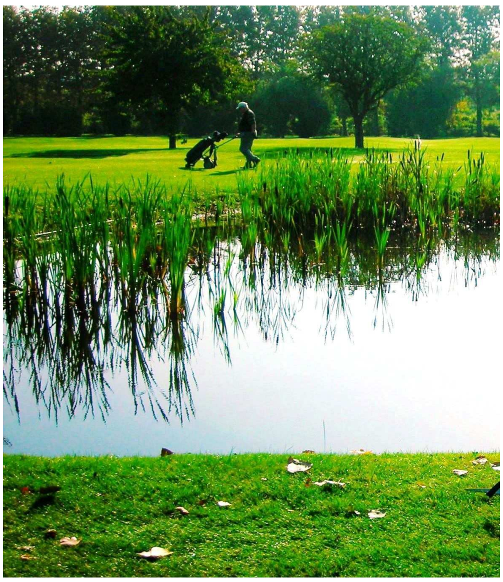

Photo 1.1 Although some of the traditional uses for ponds have declined over the last century, new uses for ponds have arisen, including their role as golf hazards

Trends in pond quality

There are few studies documenting trends in pond quality. However, pond quality is likely to have declined in the 20th Century, coincident with the rise in agricultural intensification and the development of modern urban networks.

Lowland Pond Survey 1996 provided the first systematic estimate of pond quality in Britain. This survey found that ponds were widely degraded: supporting, on average, half the expected number of wetland plants compared to minimally impaired ponds. At the time there was no system for objectively assessing pond quality (now possible using PSYM, see Box 5.1, p49) but in terms of conservation value based on the plant richness and the occurrence of species of conservation concern, 50% of the 377 survey ponds were of low value, 30% of moderate value and the remaining 20% of high, or very high, value (Williams *et al.* 1998).

Only one study provides some evidence of change in pond quality in the UK. Nicolet (2000) repeated a botanical survey of the ponds of the parish of Christleton in Cheshire in 1973, after a period of 25 years. She found that by 1998, 25% of the ponds had disappeared with no compensatory pond creation. Mean species richness increased slightly between the two surveys although this may have been influenced by more comprehensive survey techniques. Significantly, several species of conservation concern declined, most notably the water quality sensitive Frogbit (*Hydrocharis morsus-ranae*) which had been present in 18 sites and declined to two. There was also a significant loss of the common aquatic species such as Broad-leaved Pondweed (*Potamogeton natans*) which was only present in half as many ponds as in the previous survey. Taken together the results suggested that there had been a decline in water quality principally affecting aquatic species, probably explained by a creeping intensification of the landscape resulting from conversion of pasture to arable and intensification of the remaining grasslands.

1.7 Threats to ponds

Ponds are typically small in area and volume, and are therefore potentially vulnerable to degradation caused by a wide range of factors including urban runoff, nutrient enrichment, acidification, agricultural biocides, abstraction and land drainage. Because of their small size, they can also be strongly impacted by biological stresses which have less impact on larger waters, such as high densities of waterfowl and fish, and even regular dog swimming.

Lowland Pond Survey 1996 indicated that ponds associated with intensive urban and rural land management were likely to be impaired, particularly ponds associated with the broadly arable landscape (Williams *et al.* 1998). There is also evidence that isolation played a role in degradation.

More positively, recent changes to the Common Agricultural Policy and the introduction of environmental land management schemes such as Countryside Stewardship (replaced by Environmental Stewardship in 2005), may have brought some benefits to ponds, particularly through reduced chemical inputs, buffering and possibly through raising of water levels. The effects of these schemes on ponds have been little studied.

Loss of ponds may well remain a threat. Previous Countryside Survey data (Haines-Young *et al.* 2000) indicated that net loss of ponds may have halted during the 1990s. However, considerable numbers of ponds were still being filled-in at this time, and there is little knowledge of the value of these lost ponds. In the Lowland Pond Survey there was evidence that many new ponds were stream filled, which is probably undesirable in the medium term as these waterbodies will normally be exposed to stream borne pollutants (Williams *et al.* 1998).

Although succession has long been perceived to be a threat to ponds, the transition from permanent deeper water, to shallow water with periods of intermittent drought is a natural process to which many species are adapted. There is no evidence that succession is inherently harmful to pond quality, and once ponds become seasonal, many are very long lived and they may be retained for centuries or longer before they become dry ground. There is no doubt that successional processes cause profound changes in pond community type (Nicolet *et al.* 2004, Collinson *et al.* 1995). Factors such as lack of pond management and, increasingly, climate change, are therefore potentially important influences on the proportion of permanent and seasonal ponds and the communities they support.

2 Methods

This chapter outlines the rationale and methods used to collect pond data for Countryside Survey in 2007.

2.1 Definition of terms

What is a pond?

The definition of a pond used in Countryside Survey in 2007 and previous CS surveys after 1996 is *'a body of standing water between 25 m^2 and 2 ha in area which usually holds water for at least 4 months of the year'.* This definition specifically includes seasonal ponds i.e. ponds which typically dry out in the summer months.

The CS pond definition broadly follows the standard UK definition of a pond developed in the 1990s (Pond Conservation 1993), and subsequently used as part of criteria for defining Priority Habitat Ponds (Appendix 2). The main difference between the CS and standard definition is that CS has a lower size limit of 25 m^2 rather than 1 m^2. This change was made in order to maximise compatibility with Countryside Survey data collected prior to the Lowland Pond Survey in 1996.

Lowland and upland

In the current report, estimates of change in pond quality are made by comparing 2007 data with data collected in the lowlands for the Lowland Pond Survey 1996 (LPS96). The term *lowland* in this context refers to the areas of Britain included within Countryside Survey Environmental Zones 1, 2, 4 and 8. This contrasts with upland areas (including upland and marginal uplands) defined as Environmental Zones 3, 5, 6 and 9. Figure 2.1 shows a map of the areas of Britain included as lowland and upland within Countryside Survey. Environmental Zones are themselves aggregates of the 32 land classes used to divide England, Wales and Scotland according to the major environmental gradients found at national scales (Bunce *et al*. 1996, Carey *et al*. 2008), see: http://www.countrysidesurvey.org.uk/pdf/reports 2007/CS-UK-Results2007 Chapter01.pdf.

2.2 Countryside Survey

Countryside Survey is a sample-based study of the rural environment, which includes countryside around towns, cultivated land and grassland, and more remote areas including moorlands, mountains and islands. The sample is statistically representative of conditions in the wider countryside, excluding only urban and sea areas.

The survey comprises of a set of ‘sample squares’ measuring 1 km x 1 km, spread across England, Scotland and Wales, representative of the environmental conditions of the three countries.

Squares containing more than 75% of developed land or more than 90% of sea are not included in the field survey. Similarly, within survey squares, urban areas including curtilage directly associated with buildings are not surveyed. Garden and farmyard ponds were not, therefore, recorded as part of CS in 2007.

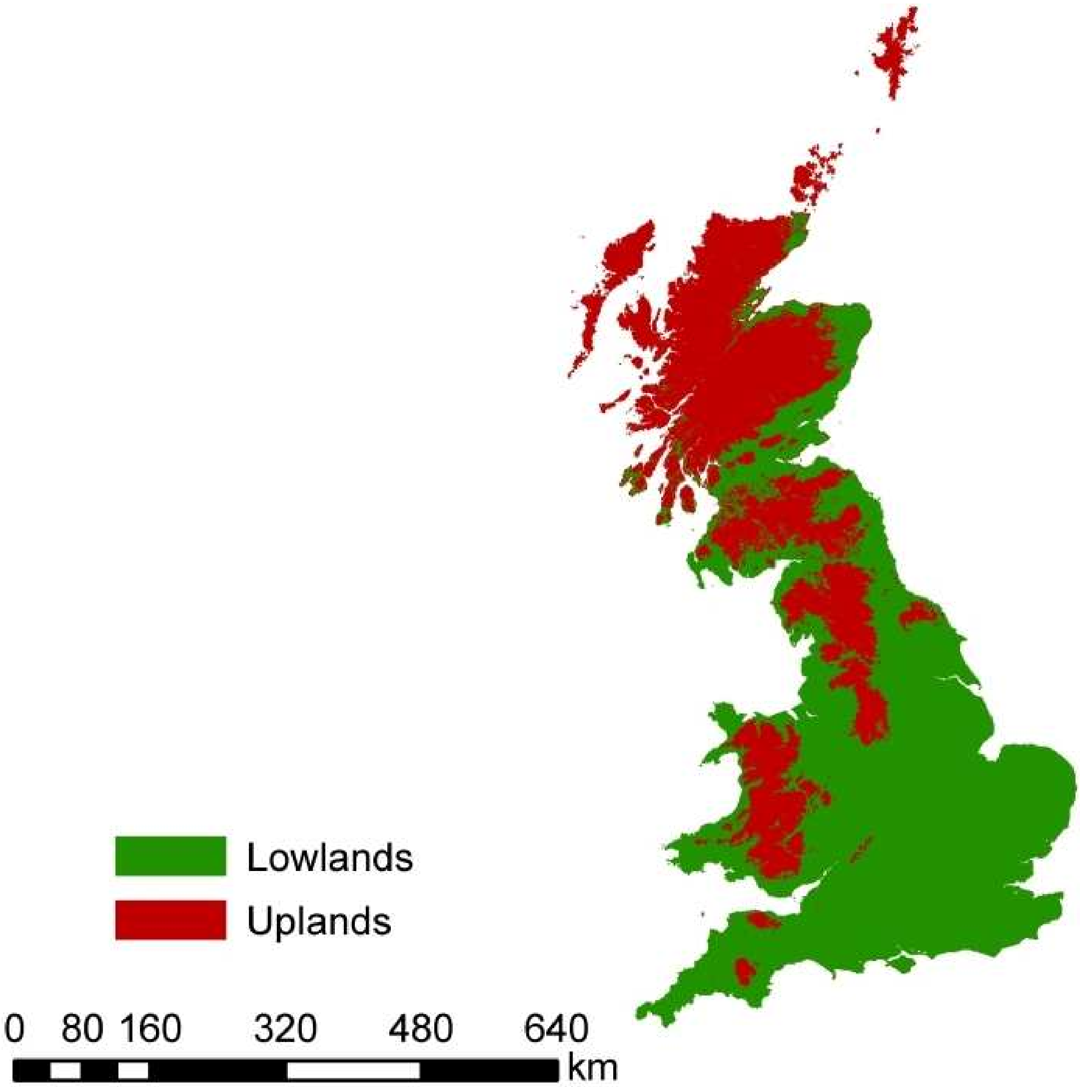

Figure 2.1 Delineation of lowland and upland areas within Countryside Survey.

2.3 Previous Surveys

Previous Countryside Surveys relevant to the current report include: Countryside Surveys run by the Centre for Ecology & Hydrology (CEH) in 1984, 1990 and 1998, the National Pond Survey (NPS) run by Pond Conservation in the early 1990's and the Lowland Pond Survey run jointly by CEH and Pond Conservation in 1996. These are described briefly below.

Previous Countryside Surveys

Survey of Rural Britain in 1984. This survey of 384 1 km squares was the first CS to count standing waterbodies. A combination of attributes to define size and associated vegetation cover were also recorded.

Countryside Survey in 1990. CS in 1990 increased the number of 1 km squares surveyed to 507. Waterbody numbers were recorded as part of the standard field survey (Barr *et al*. 1993).

Lowland Pond Survey 1996. LPS96 was a thematic Countryside Survey which was the first to record both pond numbers and ecological quality. The survey was restricted to lowland areas of England, Scotland and Wales (see Section 2.1). Its remit was to:

- describe the number, condition and quality of Britain's lowland countryside ponds
- review current policies which directly affect the maintenance and protection of ponds
- make policy recommendations based on the results of the study.

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.

(i) LPS96 was the first survey to introduce a definition of CS ponds (see Section 2.1), and to specifically 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'.

(ii) The search area for ponds within each 1 km sample square was extended to include woodlands and recreational areas such as golf courses. These areas were not always included in previous Countryside Surveys (see Barr *et al.* 1994).

(iii) Pond condition was described for the first time in terms of the ponds' physical and chemical attributes. Wetland plants were also recorded to provide biological data. Pond quality was assessed relative to high quality National Pond Survey reference sites.

In total, surveys were undertaken at 150 1 km x 1 km lowland squares; this included 136 squares which contained ponds and 14 "non-pond" squares. In each square, all ponds that were present (n=377) were surveyed in detail to provide ecological data.

Countryside Survey in 1998. Carried out in 1998, but reported in 2000, this survey included 569 1 km squares across Great Britain. The number and size of standing waters was counted in all squares. Ponds were defined using the standard definition developed in LPS96. Additional areas, such as golf courses and woodlands, were only surveyed for ponds in lowland squares that had also been surveyed in LPS96. Countryside Survey in 1998 did not include assessments of pond condition or quality (see Table 2.1).

The National Pond Survey

The National Pond Survey (NPS) was carried out between 1990 and 1994. It included a data set of approximately 200 ponds located in areas of semi-natural land use throughout Britain. Data gathered from each site included physico-chemical information together with records from both macroinvertebrate and plant surveys. These sites provided the minimally-impaired "reference baseline" used for the development of PSYM in England and Wales (see Box 5.1, p49).

PSYM has not yet been developed for Scotland, and in the current report NPS data are used as a baseline against which the quality of Scottish CS ponds in 2007 can be assessed in the absence of PSYM.

Table 2.1. Summary of the approach taken for counting ponds and assessing condition in previous Countryside Surveys.

Survey	Number of 1 km squares surveyed	CS squares included	Minimum size limit defined?	Counted dry ponds at time of survey?	Counted ponds in woodland / golf courses?	Surveyed environmental variables and wetland plants
CS in 1984	381	All CS squares	No	No	No	No
CS in 1990	507	All CS squares	No	No	No	No
Lowland Pond Survey 1996	150	Lowland squares only (Environmental Zones 1, 2, 4 and 8)	Yes, 25 m^2	Yes	Yes	Yes, for all ponds in each 1 km square
CS in 1998: (a) LPS Squares "lowland pond count"	150	Lowland squares only (Environmental Zones 1, 2, 4 and 8)	Yes, 25 m^2	Yes	Yes	No
CS in 1998 : (b) All squares "inland water body count"	569	All CS squares	Yes, 25 m^2	Yes	No	No
CS in 2007	591	All CS squares	Yes, 25 m^2	Yes	Yes	Yes, for one pond in each 1 km square

2.4 Countryside Survey data collection in 2007

The 2007 Countryside Survey covered a total of 591 1 km x 1 km sample squares spread across England, Scotland and Wales.

Counts were made of all ponds present in the sample squares. The definition of a pond conformed to the standard definition of a pond used in LPS96 and CS in 1998. Ponds located in woodlands and in amenity areas such as golf courses were counted in all squares (see Section 2.3, Table 2.1, Table 2.2).

In addition, a more detailed assessment of pond condition was made for one randomly selected pond in each square containing a pond (see Table 2.2). The condition assessment survey of one pond per square in CS in 2007 contrasts with LPS96, where all ponds present in lowland squares were assessed for condition.

Recording the presence of ponds

Field surveys of the 1 km squares were undertaken over a 10-week period between May and November 2007.

All ponds within each 1 km sample square were mapped in the field on a Geographical Information System (GIS), using a portable tablet PC. Physical changes from previous surveys were also logged, including presence of new ponds, lost ponds and changes in pond shape or size. Additional information was gathered on paper-based fieldsheets recording the likely reasons for pond loss or creation and whether ponds contained water at the time of survey.

A more detailed description of methods used to map Countryside Survey ponds can be found in the CS Field Mapping Handbook (CS Technical Report No.1/07)[3].

Pond condition assessments

If more than one pond was present in a square, the condition survey pond was selected using a random number table.

Detailed condition assessments were made for a total of 259 ponds across Britain. Of these 149 were in England, 81 in Scotland and 29 in Wales (see Table 2.2). Pond attribute comparisons between 1996 and 2007 were made for a subset of 77 lowland ponds which were surveyed in both years. These lowland ponds were predominantly located in England (n=64), with only seven Scottish and six Welsh ponds included.

The selection of environmental attributes measured at each pond conformed, as far as possible, to attributes measured in LPS96. Where appropriate, modifications were made to selected variables to maximise compatibility with standard National Pond Monitoring Network (NPMN) surveys[4]. The final selection of parameters was also influenced by Countryside Survey logistics. In particular, in LPS96 a boat was used to survey deeper ponds, but this was not possible in CS in 2007. This meant that analysis of changes in pond water and sediment depth was not possible in 2007.

Photo 2.1. In each 1 km survey square a single pond was selected at random and surveyed in detail to provide information about its plant communities and physico-chemical characteristics

[3] See Murphy and Weatherby (2007) http://www.countrysidesurvey.org.uk/pdf/reports2007/CS_UK_2007_TR1.pdf

[4] See http://www.pondconservation.org.uk/Data/aboutnpmn

Table 2.2 Number of Countryside Survey ponds used for condition assessments in Great Britain in 2007, and for comparison of ponds between 1996 and 2007 in the lowlands.

	GB	England	Scotland	Wales	Lowland comparison	
					LP96	CS in 2007
Number of sites	259	149	81	29	77	77

A summary of the main physical and chemical attributes measured and analysed by CS in 2007 is given in Table 2.3. A more detailed description of the survey methods is given in the 2007 Freshwater Manual (Murphy & Weatherby 2007[5]).

All physical, chemical and biological data collected from the ponds were recorded with reference to the pond's outer pond boundary. This is defined as the area of the pond flooded in winter, and is typically identified using a range of physical and biological markers (see Freshwater Manual[5]).

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 (see Freshwater Manual[5]). 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.

Quality assurance

Quality assurance (QA) measures undertaken in CS in 2007 are documented in the CS technical report "Quality Assurance Report: surveying condition of headwater streams and ponds" (Murphy *et al.* 2008[6]). In summary, consistent collection of high quality field data was ensured through a range of measures including the following:

- pre-survey training for all field survey staff
- provision of a field survey booklet and field survey form
- help line available for field survey staff
- desk-checks of recording sheets as they were returned, with follow-up of anomalies
- confirmation of uncommon and taxonomically difficult plant species by a national expert.

Quality assurance checks were undertaken on 7% of ponds by an experienced CS surveyor.

Analysis of the botanical data indicates there was no significant bias evident in the data, with the main survey tending to find 0.6 (± 1.03 95% CI) more species than the QA. Species richness assessments can therefore be considered robust. The mean percentage agreement of specific plant species was lower at 59%, with 100% agreement at five of the ponds. This difference is likely to be, in part, due to seasonal differences in the species recorded due to the time lag between the original and QA surveys.
The findings are discussed in detail in the CS freshwater Quality Assurance Report[6].

[5] See http://www.countrysidesurvey.org.uk/pdf/reports2007/CS_UK_2007_TR5.pdf
[6] See http://www.countrysidesurvey.org.uk/pdf/QA_FRESHWATER.pdf

Table 2.3 Summary of the main physical, chemical and biotic attributes recorded and analysed for ponds in CS in 2007.

Attributes	Variable measured and analysed
Pond area	Surface area of the pond lying within pond's outer boundary defined as the maximum standing winter water level.
Water depth	Water depth was measured at five points along perpendicular transects. However these data were not analysed because, without use of a boat, the data were skewed towards shallow ponds which could be easily waded.
Sediment depth	Sediment depth was measured at five points along perpendicular transects. However, like water depth measurements, the data were not analysed because they were skewed towards shallow ponds which could be waded.
Drawdown and permanence	Drawdown was measured as the difference between maximum and current water levels in terms of (a) vertical height (cm), and (b) % of water area remaining in the pond. Permanence was analysed using categorical variables (1 = water, 0 = no water).
Pond base	Assessed in terms of three categories based on percentage of different substrate types. Data used as a variable in PSYM predictions.
Water quality	(i) pH and conductivity: measured in the field with a portable meter. (iii) TON, soluble reactive phosphorus, alkalinity: filtered samples collected in the field and laboratory-analysed.
Turbidity	Estimated in one of four categories (clear, moderately clear, moderately turbid, turbid). Analysed using ranked variables (1=turbid, 4 = clear).
Evidence of pollutants	(i) visual evidence of rubbish (% of pond filled). (ii) road runoff (ranked 1 = minimal input, 5 = major input). (iii) other physical evidence listed.
Inflow/outflow	(i) Inflow or outflow present: recorded as a categorical variable (1/0). (ii) Wet inflow or outflow present: recorded as a categorical variable (1/0). (iii) Inflow or outflow volume: mean water width x mean water depth x flow (seconds / metre).
Surrounding land-use	Measured as the percentage cover of each of 12 land cover types around pond (including waterbody and wetland types), within two concentric zones around the pond (0-5m, 0-100m). Analysed in terms of 12 land use types, and aggregate land use categories. The two main aggregate categories were: (i) Semi-natural = Wood and trees, heathland, moorland, mountain, unimproved grassland, rank grassland, marshes, bogs, standing and running waters (ii) Intensive = arable, intensive grassland, buildings, gardens, roads and tracks.
Shade	Percentage of pond area overhung by trees or woody vegetation.
Occurrence of grazing	Presence, or evidence, of grazing analysed as a categorical variable (1/0), and percentage of the pond perimeter grazed. Data used as a variable in PSYM predictions.
Pond management	Evidence of all pond management: analysed as a categorical variable (1/0). Tick boxes for pond management in prescribed categories (e.g. dredging, trees planted). This replaced a free text box on LPS96 forms.
Water birds and fish	Evidence of presence analysed as a categorical variable (1/0), intensity of impact ranked 1-5, species information where known.

Macrophytes	Wetland plants were recorded as: (i) species present recorded on a prescribed wetland plant list (ii) percentage cover of each species recorded on a DAFOR scale (Dominant, Abundant, Frequent, Occasional, Rare) (iii) total % cover recorded for three aggregate groups: (a) emergent plants, (b) floating-leaved plants, (c) submerged plants Plant data were analysed in terms of: (i) the total number of wetland plant species and species richness of three morphological groups: (a) emergent, (b) floating-leaved, (c) submerged (ii) change in the frequency of occurrence of species between surveys (iii) the presence of uncommon plant species assessed as: (a) nationally uncommon species (Nationally Scarce, Red Data Book, IUCN Threatened or Near Threatened categories) (b) “locally uncommon” species is are defined here as species recorded from less than a quarter of all 10 x 10 km squares in Britain, but more common than Nationally Scarce species, i.e. species recorded from between 101-705 10 x 10 km squares (iv) occurrence of invasive alien species (v) PSYM metrics: (a) number of submerged and emergent plant species (b) the number of uncommon plant species (including locally uncommon and nationally uncommon species) (c) Trophic Ranking Score: a measure of nutrient enrichment based on scoring plant species according to their nutrient preferences (high score means nutrient-loving). The TRS is calculated as the mean score for plants from a site (Palmer *et al*. 1992) (vi) Ellenberg moisture and light scores: these are based on the mean shade and moisture tolerance of plant species at a site. High scores reflect species that prefer full sun or aquatic conditions respectively. Values used were based on modified Ellenberg scores (Hill *et a*l. 1999)

2.5 Data entry and analysis

Data entry

Mapping data and associated information from the field tablet PCs was uploaded to a central geodatabase held by CEH. Paper records were entered manually and checked for accuracy and logic. Geodatabase and paper records describing the occurrence of new ponds and lost ponds were cross-checked and a single, definitive version derived.

Estimating numbers of ponds

The total number of ponds present in Britain in 2007 was estimated using standard methods developed for the Countryside Survey. These are described briefly here but further detail is given in the Statistical Report (CS Technical Report No.4/07[7]).

The mean number of ponds per square was calculated separately for each Land Class. These means were multiplied by the total area of the respective land class in GB to give national estimates for the number of ponds in each Land Class. The estimated Land Class totals were added together to produce a national estimate of the number of ponds. Estimates of the numbers of ponds broken down by size class were derived using the same techniques.

Estimates of net change in pond numbers were calculated using all squares sampled in one or both of the 2007 and 1998 surveys. In contrast, gains and losses were calculated using only the subset of squares sampled in both surveys. These differences in calculation methods explain minor differences in the estimates of net change derived using the different techniques.

Analysis of condition measures

Since the dataset contained a large amount of categorical data, statistical analyses were mainly performed using non-parametric methods.

For analysis of ranked measures (e.g. PSYM Trophic Ranking Score metric and Ellenberg light scores), zero values were excluded where they occurred because no species were present in a pond, rather than because the site scored the lowest possible value.

Comparisons of change between lowland ponds in 1996 and 2007 were made using data from ponds surveyed in both years. Most analyses were performed using the Wilcoxon matched-pairs test. A sign test was used where the data were categorical, for example the presence/absence species data used in Figure 5.4 . The Mann-Whitney *U* test was used to look at differences between attributes measured in CS ponds in 2007.

Partial Least Squares (PLS) regression was used to identify factors that best explain the biological quality of ponds. PLS effectively combines Principal Components Analysis (PCA) and multiple regression and is specifically designed to handle large numbers of inter-correlated variables as, for example, typically influence pond quality. PLS was implemented using SIMCA P+ 12.0 (Umetrics AB, Umeå Sweden).

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[7] See http://www.countrysidesurvey.org.uk/pdf/reports2007/CS_UK_2007_TR4.pdf

PLS combines sets of inter-correlated predictor variables into one or several independent components. The overall relevance of each predictor variable is described by the score 'variable importance in the projection' (VIP), with VIP values over 1.0 the most relevant in explaining the response variable, and values ≥ 0.7 also important. The loading of each predictor variable within the component indicates the direction of the relationship between the environmental variable and the response variable i.e. environmental predictors with a positive sign were associated with increased plant richness measures or higher PSYM scores.

The VIP score allows the different environmental variables to be ranked in order of importance, and is therefore particularly valuable in identifying the key environmental factors, from a large pool of factors all of which probably have some influence.

Mean variable importance (i.e. mean VIP rank order) was assessed for each group of plant measures and metrics: numbers of species, PSYM score and component metrics and change in PSYM score between 1996 and 2007 sites common to both LPS96 and CS in 2007.

The significance of components extracted by PLS was assessed using a cross validation test. Variables with skewed distributions were transformed prior to analysis, using log or arc sin transformations.

Relationships between potentially causative environmental variables and biological quality were investigated for three groups of measures:

- number of submerged and number of emergent plant species. Note that the number of floating-leaved plants was not assessed, because it is often inversely related to pond quality (see Section 5.3)
- metrics contributing to PSYM, and overall PSYM score (see Box 5.1, p49)
- change in PSYM score in Lowland Pond Survey sites between 1996 and 2007.

Models were constructed using PLS to identify the most important environmental and biological factors potentially explaining plant metric and PSYM and scores. These included factors known to cause natural variation in pond communities (e.g. pond area, pH, grazing) and those often causing pond degradation e.g. nutrients (nitrogen and phosphorus), occurrence of road runoff, high densities of waterbirds and fish, presence of inflows and intensive land use around the pond in two zones (0-5 m and 0-100 m from the pond).

In addition, the potentially mitigating effects of wetlands in the surrounding landscape was also examined through two land-use factors:

- land around ponds occupied by bog, fen, marsh or flushes, in two zones (0-5 m and 0-100 m)
- land around ponds occupied by ponds, streams and ditches in two zones (0-5 m and 0-100 m).

In analyses of pond quality change between 1996 and 2007, PLS models were based on environmental variables (e.g nitrogen levels, presence of a stream inflow) measured in 2007. The exception was the tree shade variable which measured change in tree shade between 1996 and 2007.

In practice, PLS fitted one significant component to the PSYM change data. PLS relationships between environmental variables and plant species richness measures alone were not undertaken (*c.f.* Table 5.7) because, given the small number of lowland Scottish sites, they added little to the analysis not encompassed by the number of submerged and emergent plant species PSYM score.

2.6 Meteorological data.

Temperature and rainfall data for Great Britain were obtained from the Meteorological Office for the period 1988-2007 and averaged to give a 20-year mean. These values were compared with country and seasonal means for 1996 and 2007.

Table 2.4 Annual rainfall data for 1996 and 2007 in England, Scotland and Wales, and seasonal means for GB, including comparison with the long term (1988-2007) mean.

		Country				Season			
		England	Scotland	Wales	GB	Winter	Spring	Summer	Autumn
Long term mean annual rainfall 1988-2007 (mm)		839	1529	1415	1261	340	231	230	325
1996	Mean annual rainfall (mm)	670	1232	1161	1021	245	183	172	324
	% long term mean	80	81	82	81	72	79	75	100
2007	Mean annual rainfall (mm)	935	1585	1484	1335	438	230	358	234
	% long term mean	111	104	105	106	129	99	155	106

Source: Meteorological Office

Table 2.5 Annual temperature data for 1996 and 2007 in England, Scotland and Wales, and seasonal means for GB, including comparison with the long term (1988-2007) mean.

		Country				Season			
		England	Scotland	Wales	GB	Winter	Spring	Summer	Autumn
Long term mean annual temperature 1988-2007 (°C)		9.9	7.7	9.9	9.1	4.2	8.0	14.5	9.6
1996	Mean annual Temp. (°C)	8.8	7.0	8.8	8.2	2.5	6.4	14.2	9.2
	% long term mean	89	91	89	89	60	79	98	95
2007	Mean annual Temp. (°C)	10.4	8.2	10.4	9.6	5.6	9.1	14.1	9.9
	% long term mean	104	107	104	105	131	113	97	103

Source: Meteorological Office

The results indicate there were considerable differences in rainfall between 1996 and 2007 (Table 2.4). 1996 was an unusually dry year with annual precipitation around 80% of the 20 year mean. Overall, rainfall in 2007 was close to average, however the summer of 2007 was exceptionally wet, with over 50% more rainfall than the seasonal mean (Table 2.4). In contrast, there was little difference in temperature between 1996 and 2007 with summer and autumn values for GB that were within 5% of the seasonal mean (Table 2.5).

3 Number of ponds

This chapter provides estimates of the number of ponds in Great Britain in 2007 and the rates of pond loss and creation over the last decade.

3.1 Methodological issues

The methods used to assess the number of ponds are described in Chapter 2 of this report. However, a number of issues relating to the pond-count methodology have a particular bearing on the 2007 pond stock estimates, and are therefore discussed here.

Countryside Survey's pond count methodology has evolved over the last decade. The most recent CS included ponds in areas such as woodlands, golf courses and bogs which were not always systematically surveyed in earlier surveys. The Countryside Survey 2007 training programme also clarified differences between ponds and other wetland habitat types, with particular emphasis on identifying difficult pond types such as temporary ponds.

These changes contributed to an increase in the number of ponds identified during CS in 2007. Some of these ponds were newly created, but a considerable proportion was ponds which existed but were not included in previous survey estimates. These "missed" ponds were added to the 1998 pond count during post-processing of the survey data, and do not contribute to the increase in pond numbers reported below. However, even for a trained surveyor, the decision of whether a pond was "created in the last nine years", or "previously missed" can be difficult, and this reduces the accuracy of new pond estimates in the 2007 dataset.

A more significant issue is the discrepancy between different 2007 recording methods. CS surveyors recorded new ponds in two ways: (i) through CS tablet PCs used for mapping the 1 km^2 survey squares, (ii) using a paper-based record to gather additional information about the ponds. Discrepancies were particularly evident for "new" ponds where, in around 25% of cases, there was a record of "real change" on the tablet PC (meaning a new pond was created), but the corresponding paper-based record showed the pond had been "previously missed" and was *not* new. In addition, there was no substantiating paper record for 10% of new ponds recorded on the tablet PC. In both these cases the information on the tablet PC was given preference because this is the standard data source for all Countryside Survey records in 2007. However, it is possible that this may lead to an over-estimate of the proportion of new ponds created between 1998 and 2007.

3.2 Change in the number of ponds from 1998

The number of ponds in Great Britain is estimated to have increased significantly by 12.5% from 425,000 to 478,000 ponds between 1998 and 2007. This equates to a change in pond density from 1.86 to 2.10 ponds per km^2 (Table 3.1). The number of ponds also increased in all three countries (Table 3.1). However, the percentage change in pond numbers was significantly higher in England and Wales (18% and 17% respectively) than in Scotland (5.5%), (Table 3.1).

The estimated rate of increase in pond numbers across Great Britain over the last decade was calculated as an average of 1.4% per annum and follows a 0.8% per annum increase in lowland pond numbers between 1990 and 1998 (Haines-Young *et al*. 2000). Prior to this, the number of lowland ponds was estimated to have declined between 1984 and 1990 (Barr *et al*. 1994) by around 1% per annum (see Section 1.6).

Table 3.1 Change in the estimated number of ponds ('000s) and pond density (per km^2) across Great Britain between 1998 and 2007. Arrows denote significant change (P<0.05) in the direction shown.

	Density (per km^2))		Number of ponds ('000s)		% Change	Direction of significant changes 1998-2007
	1998 (95% CIs)	2007 (95% CIs)	1998 (95% CIs)	2007 (95% CIs)		
GB	1.86 (1.41, 2.54)	2.1 (1.64, 2.78)	425 (321, 580)	478 (374, 634)	12.5	↑
England	1.55 (1.30, 1.81)	1.83 (1.53, 2.14)	197 (165, 230)	234 (195, 272)	18.3	↑
Scotland	2.35 (1.25, 4.14)	2.48 (1.37, 4.30)	187 (100, 330)	198 (110, 344)	5.5	↑
Wales	1.91 (0.85, 3.31)	2.24 (1.23, 3.70)	40 (18, 70)	47 (26, 78)	16.9	↑

3.3 Pond numbers in different size classes

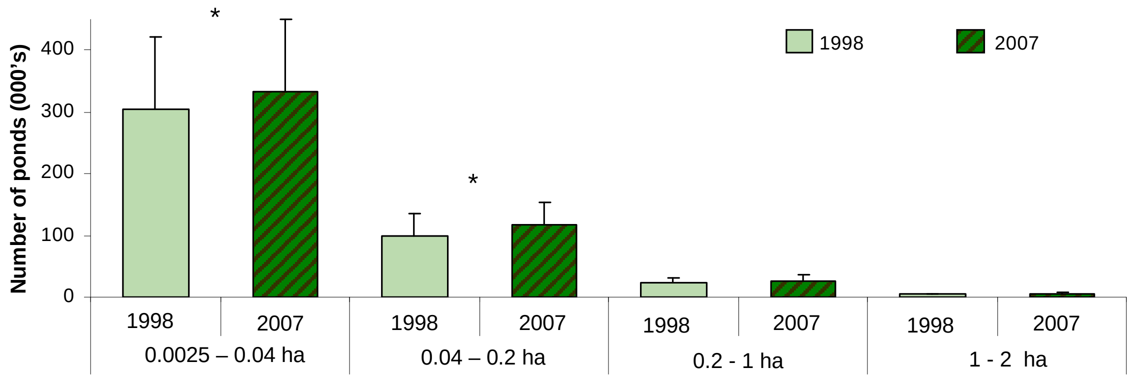
Most ponds in Britain were small, with around 70% of ponds falling into the smallest CS size category of 25 m^2 to 400 m^2. Fewer than 1% of ponds were one to two hectares in area (Table 3.2). Between 1998 and 2007 there was a significant increase in the number ponds in the two smaller size categories (25 m^2 to 400 m^2, 400 m^2 – 0.2 ha), but no difference in the number of larger ponds.

Table 3.2 Estimated number (000's) and proportion of ponds in four size classes across Great Britain in 2007.

	0.0025 - 0.04 ha			0.04 - 0.2 ha			0.2 – 1 ha			1 - 2 ha		
	No. of ponds (000's)	95% CI (000's)	%	No. of ponds (000's)	95% CI (000's)	%	No. of ponds (000's)	95% CI (000's)	%	No. of ponds (000's)	95% CI (000's)	%
GB	332.5	253.6, 450.9	69	117.8	89.4, 153.8	24	26.5	19.4, 36.4	6	4.1	1.7, 6.8	1
England	158.6	127.2, 193.3	68	59.1	48.2, 71.2	25	14.2	8.8, 21.8	6	2.2	0.4, 4.7	1
Scotland	146.3	79.5, 254.2	73	42.7	20.8, 75.5	21	9.1	4.7, 15.3	5	1.5	0.3, 2.7	1
Wales	27.6	13.7, 46.7	58	16.0	6.9, 28.1	34	3.2	1.3, 5.5	7	0.4	0, 0.8	1

Note: The national estimate for the total number of ponds calculated by summing over the size classes may be different from those calculated using a single count of all ponds. The difference is attributable to the internal mechanisms of the statistical processing that results in the production of the national estimates. These differences are small in comparison to the confidence intervals for the estimates.

Figure 3.1 Change in the estimated number of ponds in four size classes in Great Britain between 1998 and 2007. 95% confidence intervals are shown for each bar. Asterisks indicate a statistically significant change between surveys (P<0.05).



3.4 Pond turnover

The increase in pond numbers seen between 1998 and 2007 represents the net difference between pond loss and pond gain in this period. Estimates of actual loss and gain were made based on the subset of 544 squares which were surveyed in both 1998 and 2007; loss was estimated based on those ponds recorded in 1998 but not in 2007, and new pond estimates were based on ponds recorded in 2007 which were not present in 1998.

Pond loss between 1998 and 2007

An estimated 18,000 ponds were lost in Great Britain between 1998 and 2007, representing 4% of the 1998 total pond stock (see Table 3.1 and Table 3.3). Pond loss was greatest in England (7.5%) and Wales (5.5%). There was no significant loss of ponds in Scotland.

Table 3.3 Estimated number of ponds created and lost across Great Britain between 1998 and 2007. Asterisks denotes significant change (P<0.05).

	1998-2007 Number of new ponds				1998-2007 Number of lost ponds			
	Number gained ('000s)	95% CI	% change	Significant change 1998-2007	Number lost ('000s)	95% CI	% change	Significant change 1998-2007
GB	70.6	55.2, 87.3	16.5	*	18.0	11.9, 23.9	4.2	*
England	48.3	36.7, 60.7	24.1	*	14.9	9.5, 20.0	7.5	*
Scotland	11.0	5.7, 16.7	5.9	*	0.8	0, 2.1	0.4	
Wales	11.3	3.5, 22.9	27.7	*	2.2	0.4, 4.6	5.5	*

Note: new and lost ponds in this table were calculated using the subset of squares sampled in both surveys. Estimates of net change in pond numbers in Table 3.1 were calculated using all squares sampled in one or both surveys. These differences in calculation methods explain minor differences in the estimates of net change derived using the different techniques.

Ponds created between 1998 and 2007

In Britain as a whole, an estimated 70,600 new ponds were created between 1998 and 2007 (Table 3.3). This represents a 16.5% increase on the 1998 stock of ponds (Table 3.1). As a proportion of the existing pond stock, the rate of creation was greatest in Wales (27.7 %) and England (24.1%), and more limited, although still significant, in Scotland (5.9%).

3.5 Conclusions

The number of ponds

2007 data suggest that there were an estimated 478,000 ponds in Great Britain in 2007. This is substantially higher than the previous estimate made in 1998 of 397,700 *for all* standing waters (including lakes) (Haines-Young *et al*. 2000). This increase is due to both (a) change in methodology as evidenced by the revised estimate for 1998 of 425,000 ponds (hindcast using the 2007 methodology), and (b) substantial creation of new ponds.

After removing the affects of methodological change, the current survey showed a real gain in the number of ponds between 1998 and 2007 of around 53,000 ponds. This is an average increase of c.1.4% of the pond stock per annum across Great Britain. These gains consolidate and extend an increase of 0.8 % per annum estimated for lowland ponds between 1990 and 1996, and suggest a reversal of losses observed by Countryside Survey in the 1980s (see Section 1.6).

Pond turnover

CS survey results show that considerable numbers of ponds are still being lost in Britain, with around 18,000 ponds lost from the countryside between 1998-2007. However, pond loss was substantially outweighed by a gain of c.70,600 ponds during this period.

Photo 3.1 It is estimated that over 70,000 new ponds were created between 1998 and 2007

4 Physical and chemical condition of ponds

This chapter describes the physical and chemical characteristics of the 259 ponds surveyed in detail in 2007 and assesses differences between lowland ponds (n=77) surveyed in 1996 and 2007.

4.1 Seasonal ponds

In Countryside Survey the term “seasonal” refers to a pond that does not contain water at the time of survey. CS estimates of seasonal pond numbers are always minimum figures. This is because field surveys are typically carried out between April and November, so if a normally late-drying temporary pond is surveyed early in the year, it would be recorded as containing water at the time of survey.

Seasonal ponds were a barely-recognised pond type in Britain until the 1990’s. The 1996 Lowland Pond Survey showed for the first time that seasonal ponds were not only present in Britain, but a common habitat type in the lowland countryside. The current CS provides a first opportunity to (i) look at the prevalence of this pond type across all of Britain, and (ii) make an initial assessment of between-year variation in the number of lowland ponds which dry up.

2007 was a slightly wetter than average year (see Section 2.6), and only 4% of CS ponds were dry at the time of survey (Figure 4.1). The proportion of dry ponds was slightly, but not significantly, higher in England (5%) than in Scotland (2%). None of the 29 Welsh survey ponds were dry.

The number of seasonal ponds recorded in 2007 data contrasts strongly with results from the dry year of 1996 (Section 2.6), when 29% of Britain’s lowland ponds were dry at the time of survey (Figure 4.1).

Figure 4.1 Percentage of ponds which dried up across Great Britain in 2007 and comparison of the number of lowland ponds which dried in 1996 and 2007. Asterisks indicate a statistically significant change between surveys (P<0.05).

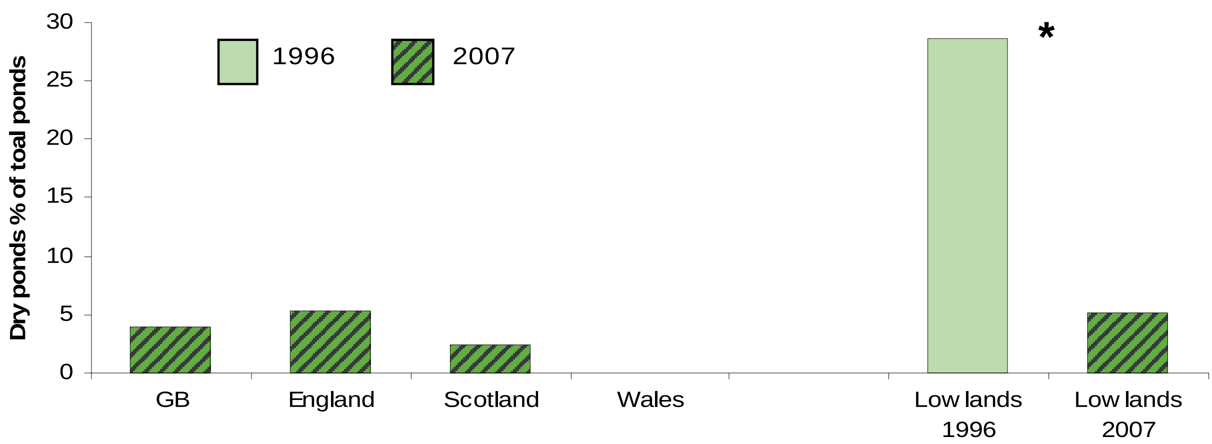
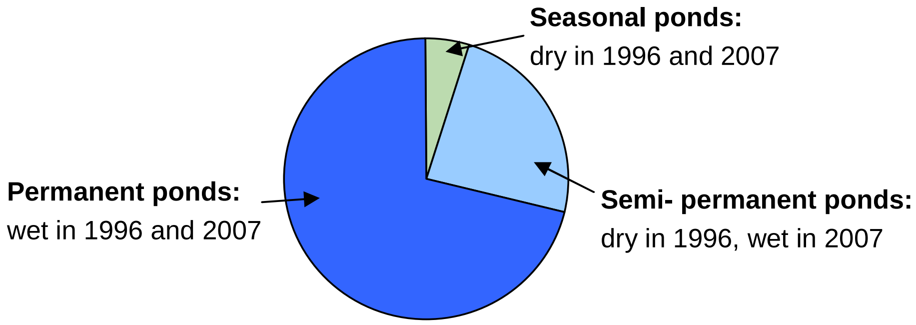


Figure 4.2. Proportion of lowland ponds across Great Britain which dried up in 1996 and 2007. The proportion of seasonal ponds is a minimum estimate because some ponds are likely to have dried after they were surveyed.



By comparing seasonal pond data from lowland Britain in the dry year of 1996 and the seasonally wet year of 2007, it is possible to make a first estimate of the number of Britain's ponds which are truly seasonal (drying every year), and those which are semi-permanent (i.e. only dry out in drought years). The results suggest that in lowland GB, at least 5% of ponds may be fully seasonal and around 25% of ponds may be semi-permanent, drying in drier years but retaining water in wet years. A maximum of 70% of ponds are likely to be permanent (see Figure 4.2).

Drawdown

The drawdown is a measure of how far water levels drop in summer compared to their bank-full winter standing water levels.

In 2007, pond water levels across GB dropped by a mean of 12 cm compared to bank-full. Drawdown height was greater in England (14 cm) than in Scotland (10 cm). Comparison of lowland ponds surveyed in both 1996 and 2007 shows that in the dry summer of 1996, mean drawdown was almost double the 2007 level, with water levels around 14 cm lower in 1996 (Figure 4.3, Table 4.1).

In terms of the area of the pond that this drop in water level represents: ponds were typically around three-quarters full at the time of the 2007 survey. In the lowlands in 1996, the water area covered was significantly less, with a mean of just under 60% of the ponds' bank-full area (Table 4.1).

Figure 4.3 Mean drawdown height in ponds across Great Britain in 2007 and in lowland ponds in 1996 and 2007. Asterisks indicate a statistically significant change between surveys (*P*<0.05). 95% confidence intervals are shown for each bar.

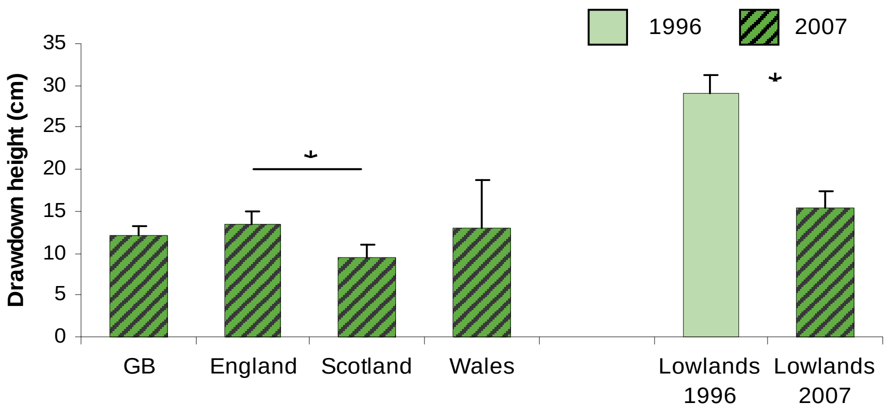


Table 4.1 Pond drawdown height and water area across Great Britain in 2007 and in lowland ponds in 1996 and 2007. Range values are given in parentheses.

	Drawdown height (range) (cm)	Mean surface area of water remaining in pond (% bank full area)
GB	12 (0-100)	76
England	14 (0-80)	76
Scotland	10 (0-70)	77
Wales	13 (0-100)	79
Lowlands 1996	29 (0-100)	57
Lowlands 2007	15 (0-80)	72

4.2 Water quality

Countryside Survey water chemistry data provide a single snap-shot of the chemical conditions prevailing at the time of survey. Levels of determinands such as nitrogen and phosphorus can vary considerably in freshwaters during the year, so although the general trends provided by these data can be informative, individual values for ponds are only indicative.

2007 results show that, for four of the five chemical variables measured (pH, alkalinity, conductivity and soluble reactive phosphorus), mean values were highest in England and lowest in Scotland. Mean values for total oxidised nitrogen (TON) were highest in England and lowest in Wales (Table 4.2).

Ponds with phosphorus levels greater than 0.12 mg/l PO_4-P and nitrogen levels greater than 2.0 mg/l TON are likely to be experiencing pollution impacts resulting from elevated nutrient concentrations[8]. In England 38% of ponds had soluble reactive phosphorus (SRP) concentrations above this level; in Wales and Scotland the proportions were lower (4% and 15% respectively). For the proportion of ponds with levels above 2.0 mg/l were: England 20%, Scotland 6%, Wales 11%. There was little overlap between the ponds that exceeded phosphorus and nitrogen limits. Thus, only 2% of GB ponds exceeded both limits, whilst 39% exceeded either one or the other limit (England 58%, Scotland 10%, Wales 26%).

In reality, the proportion of sites with elevated mean nutrient levels is likely to be higher still because the majority of CS water samples were taken in summer when dissolved nutrients are stripped from the water by actively growing aquatic plants.

Nutrient levels were not measured in the LPS96 so it is not possible to look at change in pond nutrient levels over the last decade. Of the three water chemistry attributes that were measured in both 1996 and 2007, conductivity and pH, were significantly higher, and alkalinity significantly lower, in 1996 than in 2007. The reason for these differences is not readily explicable without further data, but be related to differing climatic conditions prevailing in the two years.

[8] In the National Pond Survey minimally impaired ponds (i.e. ponds protected from the effects of surface water borne pollution) the 90%-ile value for SRP was 0.12 mg/l, the 90%-ile value forTON was 2.0 mg/l. (see Section 2.3).

Table 4.2 Mean levels of chemical determinands from ponds across GB in 2007 and lowland ponds in 1996 and 2007. Range values in parenthesis. Confidence intervals are indicated in Figure 4.4 and Figure 4.5.

	pH	Conductivity (µS cm^2)	Alkalinity (mg/l)	Total oxidised nitrogen (mg/l)	Soluble reactive phosphorus (mg/l PO_4-P)
GB	6.7 (3.6-10.1)	386 (5-2560)	119 (0.5-503)	2.1 (<0.02-160.0)	0.23 (<0.005-4.5)
England	7.2 (3.9-10.1)	502 (13-2560)	171 (0.5-503)	2.9 <0.02-160.0)	0.38 (<0.005-4.5)
Scotland	5.7 (3.6-9.1)	195 (5-997)	30 (0.5-348)	1.2 (<0.02-60.5)	0.02 (<0.005-0.44)
Wales	6.7 (4.3-9.0)	340 (38-1813)	108 (0.5-327)	0.6 (<0.02-3.6)	0.10 (<0.005-1.0)
Lowlands 1996	7.8 (6.7-9.9)	601 (80-1990)	84 (8-280)	No data	No data
Lowlands 2007	7.3 (5.6-10.0)	506 (90-1509)	183 (0.5-497)	2.7 (0.05-60.5)	0.35 (<0.005-3.9)

Figure 4.4 Soluble reactive phosphorus in ponds across Great Britain in 2007. Mean values are shown by the central point, green shaded bars show standard errors, lines show 95% CIs, open circles indicate outliers.

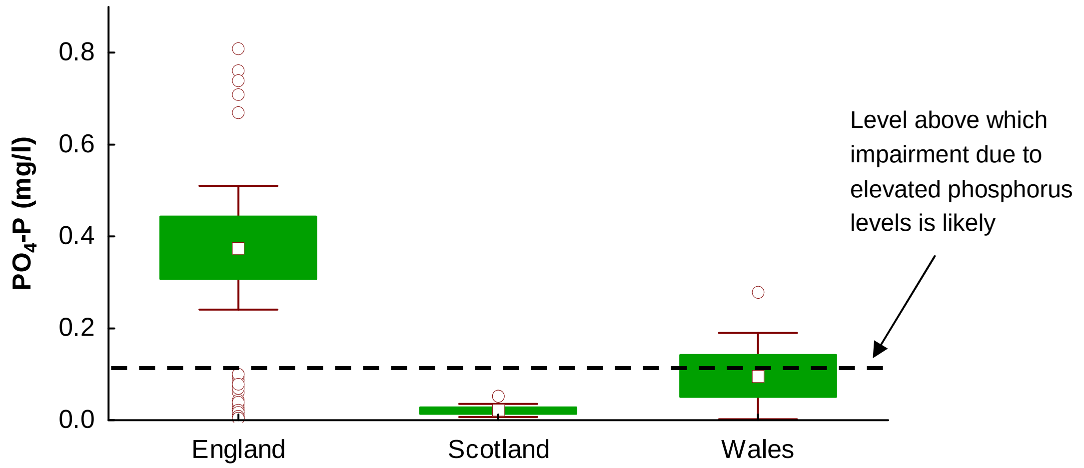
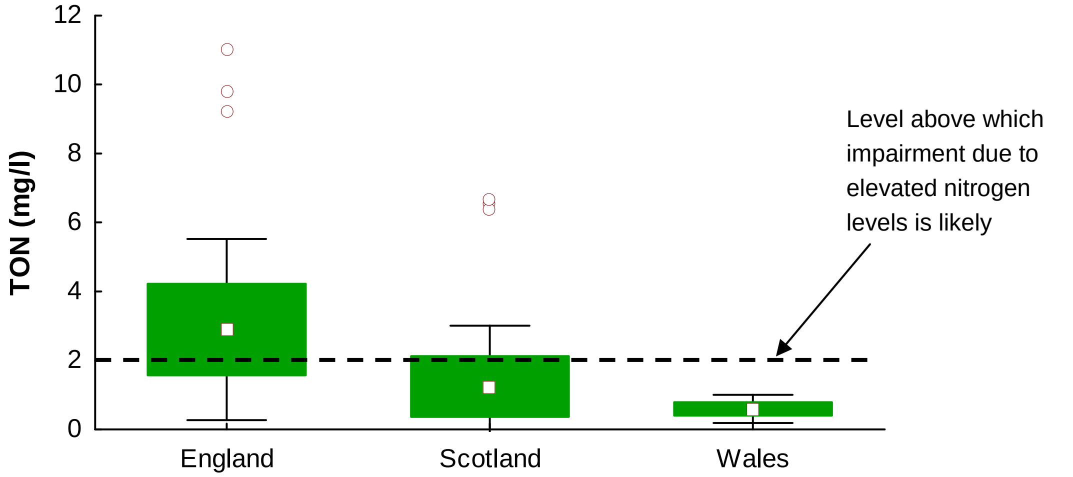


Figure 4.5 Total oxidised nitrogen in ponds across Great Britain in 2007. 95% Mean values are shown by the central point, green shaded bars show standard errors, lines show 95% CIs. Open circles indicate outliers.



Water clarity

Water clarity was ranked visually on a four point scale from turbid to clear. Water clarity was significantly lower in England where 49% of ponds were clear or moderately clear compared to around 70% in Wales and Scotland (Figure 4.6).

There was no significant difference in the number of lowland ponds with turbidity rating of clear/moderately clear or turbid/moderately turbid between 1996 and 2007.

Figure 4.6 Water clarity in ponds across Great Britain in 2007 and in Lowland ponds in 1996 and 2007. Bars show the percentage of ponds in two water clarity bands.

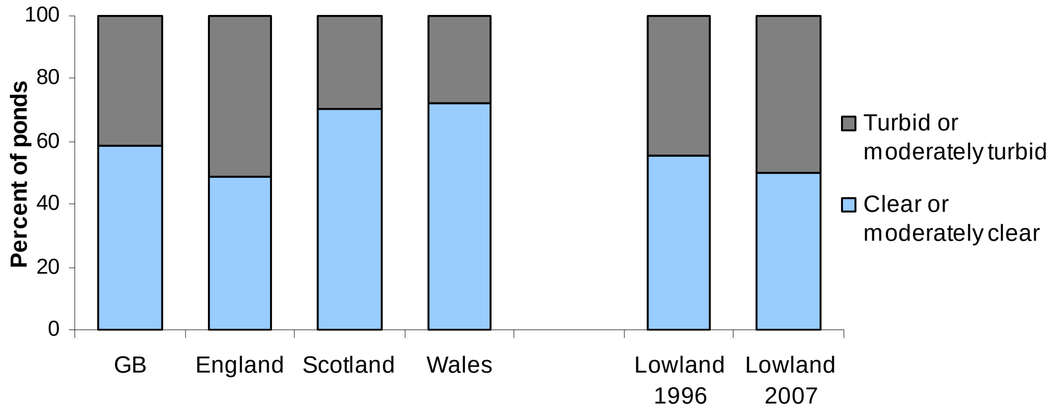


Photo 4.1 In England around half of Countryside Survey 2007 ponds had water that was turbid.

Rubbish and other sources of degradation

Ponds can be degraded by a wide range of pollutants and other impacts. Some sources of degradation are easy to spot on-site from physical evidence, such as a leaking oil drum or a drain bringing in road-runoff. Other potential pollutants are less immediately visible, such as diffuse surface run-off from agricultural fields.

Within Countryside Survey in 2007, overt evidence of pollution or likely sources of degradation were assessed in four categories:

- Rubbish and rubble
- Road drains and oil
- Agricultural field drains
- Other sources (e.g. adjacent manure heaps)

There was physical evidence of one or more of these potential pollutant sources at 23% of sites across Britain. English ponds were significantly more likely to have such evidence than were Scottish ponds. Road drains were the most frequently observed feature; they were present at 18% of sites (see Table 4.3). Significant amounts of rubbish (i.e. filling more than 1% of the pond area) were recorded at around 6% of ponds. Field drains were observed at 3% of sites. However, these drains are often buried, so this is likely to be a considerable underestimate of their true number.

Table 4.3 Percentage of Countryside Survey ponds in 2007 with physical indicators of pollution.

	Rubbish (fills >1% of pond)	Road drains and oil	Field drains	Other evidence of pollution	One or more sources of pollution
GB	6	18	3	2	23
England	8	19	3	3	27
Scotland	2	15	1	0	16
Wales	3	21	3	3	24

4.3 Inflows and outflows

Inflows

Stream and ditch inflows can have an important influence on pond hydrology and physico-chemistry. Even small streams will bring considerable amounts of silt into a pond, increasing the rate of in-filling and impacting water quality. Inflows are also a predictor of community type used in PSYM (see Section 5.3).

Across Britain as a whole, around half of the 2007 survey ponds had at least one inflow (see Table 4.4). The proportion of ponds with an outflow in Scotland was significantly higher than in England. At the time of survey around a third of inflows were dry.

Photo 4.2 Almost two thirds (63%) of CS ponds had either an inflow or an outflow.

Outflows

Across Britain, 46% of ponds had outflows (see Table 4.4). A significantly higher proportion of ponds in Scotland and Wales had outflows than in England.

Interestingly, around one third (35%) of the ponds with an inflow showed no signs of a wet or dry outflow. This suggests that ponds commonly intercept stream or ditch run-off. Since not even dry outflows were evident at these ponds, interception may occur even under high run-off/storm conditions.

In contrast, 33% of the ponds with an outflow had no obvious wet or dry inflow. In most cases these are likely to be ponds which are spring fed or lie at the top of stream headwaters.

Table 4.4 Percentage of all Countryside Survey 2007 ponds with inflow and outflow streams or ditches.

	Inflow present (wet or dry)	Outflow present (wet or dry)	Inflow but no outflow	Outflow but no inflow	Inflow or outflow	No inflow or outflow
GB	48	46	17	15	63	37
England	39	36	15	12	51	49
Scotland	63	58	20	15	78	22
Wales	52	62	17	28	80	20

4.4 Surrounding land use

Ponds are profoundly affected by the land that surrounds them, particularly the land use in their catchment (i.e. the area from which surface water drains into the pond). In common with other waterbody types, a pond's biological and chemical quality is often best where its catchment is semi-natural, and most impacted in areas where the catchment is dominated by intensive agriculture or urban land uses.

Within Countryside Survey in 2007, land use was assessed in two zones around the survey ponds:

- 0 m - 5 m: an area which typically covers the pond bank (i.e. the area between the pond's winter water level and the bank top), and in some cases a small area immediately adjacent to the pond
- 0 m - 100 m: which includes the pond's surrounds.

Within the 0 - 5 m zone the most common habitat types were trees, scrub or woodland. There were notable differences in the dominant habitat type between countries. Typically, trees dominated the pond edge and banks in England. Improved grassland was the most common habitat in Wales. Bog or marsh was the dominant edge habitat in Scotland.

Within the 100 m zone, no land cover type was dominant for around 60% of ponds. Where a single land cover was dominant (i.e. comprised more than 70% of the area), the most common land cover in England and Wales was improved grassland. In Scotland, bog and marsh or moorland and heath were the most typical surrounds (see Figure 4.7).

To investigate the intensity of land cover around ponds, land cover types were amalgamated into two groups: intensive (i.e. agricultural, urban) and semi-natural (woodland, heathland etc.) (see Table 2.3). The results showed that in England and Wales, around two thirds of ponds had more than 50% of their surrounds under intensive land uses (Figure 4.8). In Scotland, the proportion of intensive habitat around ponds was much lower: less than a quarter of ponds had more than 50% of their surrounds under intensive land use, and 60% of ponds were completely surrounded by semi-natural land use.

Figure 4.7 Dominant land use types within (a) 5 m and (b) 100 m of ponds in Great Britain in 2007. Bars show the percentage of ponds surrounded by a land cover type which covers more than 70% of the land area.

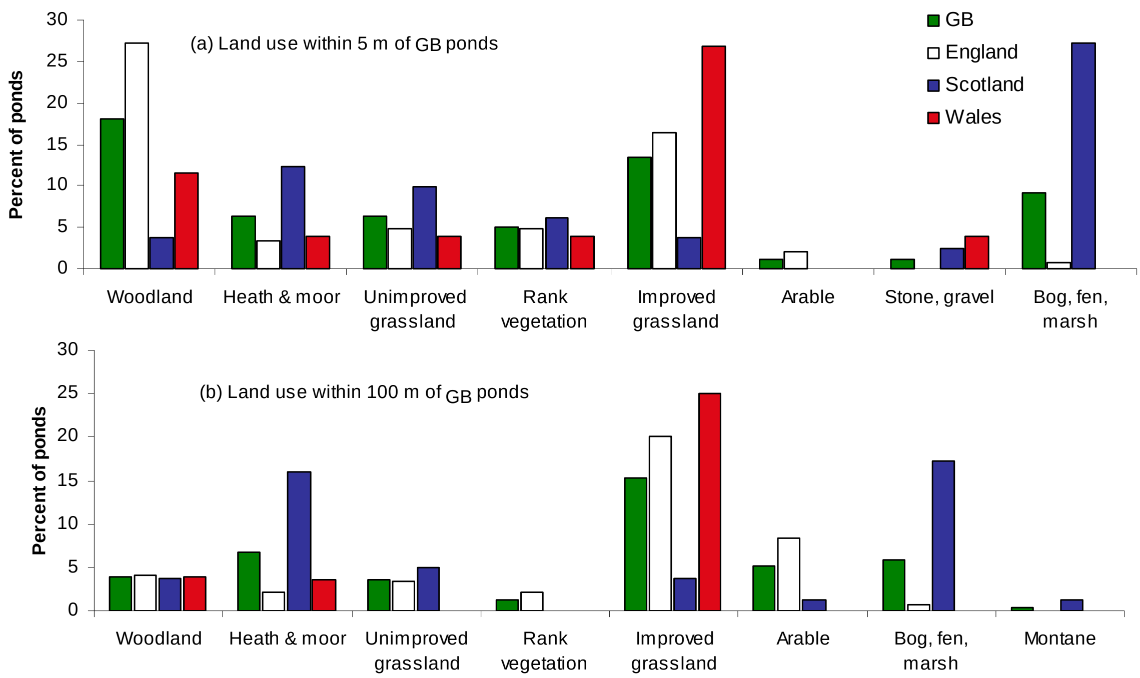


Photo 4.3 Ponds in Scotland were mainly surrounded by semi-natural habitats: predominantly bog, marsh and moorlands.

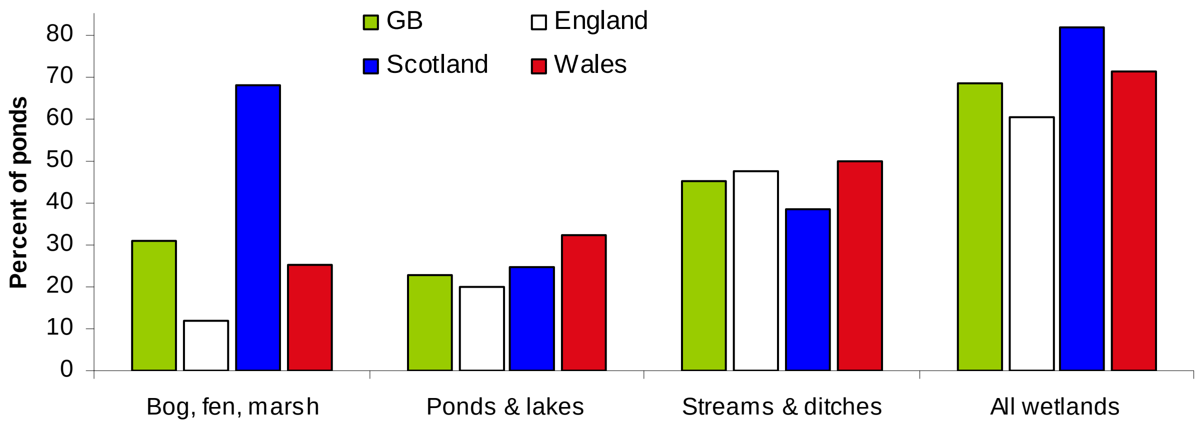
Figure 4.8 Percentage of intensive and semi-natural land use within 100 m of ponds across Great Britain.

4.5 Adjacent waterbodies

The proximity of ponds to waterbodies and wetlands (including ponds, streams, flushes, bogs, fens) is of particular interest because LPS96 (and other studies) have provided some evidence that a greater density of wetlands may have a beneficial effect on pond biological quality (see also Section 5.3).

Countryside Survey 2007 data show that 67% of GB ponds had one or more wetland type present within 100 m of the pond (Figure 4.9). Ponds in Scotland were significantly more likely to have wetlands in their vicinity than England, because of the high proportion of Scottish ponds located within bogs and marshland.

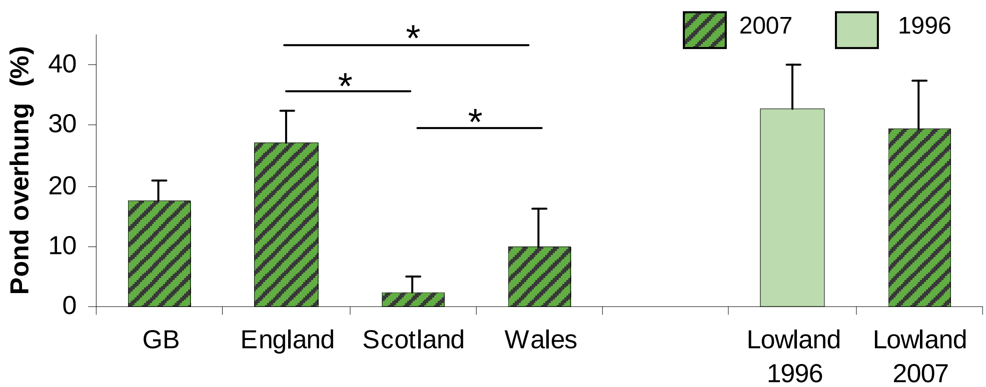
Figure 4.9 Percentage of ponds across Great Britain which have wetlands or waterbodies within 100 m of the pond.



4.6 Tree shade

In 2007 the mean tree overhang was 17% of pond area. However, this figure belies considerable country differences particularly in Scotland where, on average, only 2% of the pond area was shaded and England where the mean tree overhang was 27% (Figure 4.10), reflecting the respective adjacent land use types (Section 4.4). Comparison with lowland ponds surveyed in 1996 suggests that, overall, levels of shade did not change significantly during this period. However, individual sites showed considerable differences, either as a result of natural growth or of tree management, and there is some indication that this impacted plant assemblages (see Section 5.3).

Figure 4.10 Percentage of pond area overhung by trees in Great Britain in 2007 and 1996. Asterisks indicate a statistically significant change between surveys (* P<0.05). 95% confidence intervals are shown for each bar.



4.7 Pond management

There was evidence of pond management at around one in five ponds nationally (see Table 4.5). This figure represents a minimum however, since the data are based mainly on on-site evidence.

Statistically, there was no difference between the extent of management in English and Welsh and Scottish ponds. The types of management undertaken were varied (see Table 4.5) and no management type was dominant statistically.

There are differences between the management reported in the lowlands in 1996 and 2007. However, these data need to be interpreted with caution because of differences in reporting methodology between the two surveys (see Chapter 2).

The LPS96 showed that, not surprisingly, pond management was more likely to be undertaken when a pond was in close proximity to urban areas (such as buildings and roads). 2007 data showed a similar relationship with ponds more likely to be managed if they were close (within 5 m) to a path, track or road. Ponds used for fishing were also significantly more likely to be managed.

Table 4.5 Evidence of management undertaken in ponds across Britain in 2007. The table shows the percentage of ponds in each management category.

	2007 ponds (%)				Lowland 1996 (%)	Lowland 2007 (%)
	GB	England	Scotland	Wales		
Dredged	3	4	2	3	6	1
Vegetation removed	3	5	0	0	8	0
Plants introduced	6	7	1	17	1	6
Trees planted	7	9	2	7	0	5
Trees managed	5	6	4	0	0	6
Pond size or shape changed	5	4	5	10	0	6
Bank plants mown	7	6	2	21	0	6
Structural work	5	7	1	3	3	5
All management	22	26	9	34	18	23

4.8 Characteristics of new ponds and lost ponds

New Ponds

Of the 259 ponds surveyed in detail in 2007, 16 ponds had been created since the last Countryside Survey in 1998. Of these, 11 were located in England and five were in Scotland. The ponds selected for survey in Welsh survey squares did not include any new ponds. Information was also available from earlier surveys for five “new” ponds created in the lowlands between 1984 and 1996.

Overall, new ponds were similar to older ponds in terms of their physico-chemical characteristics, with no significant differences between the two groups in terms of major variables such as area, drawdown and water chemistry. The main statistically significant differences between the two pond types were:

Base type: new ponds were significantly more likely to have a sand or gravel base than older ponds

Management: new ponds were more likely to have trees planted in their near surrounds.

Access: new ponds were more likely to be created in areas *without* public access.

Land use: new ponds were more likely to be located in unimproved grassland landscapes.

Surrounding waterbodies: new ponds were significantly more likely to be created in areas adjacent to streams or rivers than older ponds. Around 50% of the new ponds were stream-fed, which is close to the national mean (Table 4.4). In LPS96, new ponds were significantly more likely to be stream-fed than older ponds (Williams *et al.* 1998). This tendency was not evident in the current assessment.

Shade: across GB new ponds were less likely to be shaded by overhanging trees than older ponds, this relationship was strongly significant for ponds in England.

Like older ponds, some new ponds showed evidence of enrichment. Of the 16 ponds, 18% had phosphorus levels which exceeded 0.12 mg/l PO_4-P compared to 26% of ponds across Britain as a whole (see Section 4.2). However, none of the new ponds showed elevated nitrogen levels (greater than 2.0 mg/l), whereas across CS ponds as a whole, 15% showed evidence of nitrogen pollution.

The phosphorus enrichment of some new ponds is likely to relate to their location. Only 6% of new sites were located in completely semi-natural landscapes (within 100 m of the pond), and all of these ponds were in Scotland. Only 27% of new ponds in England, but 40% of new ponds in Scotland, had more than 75% of their surrounds under semi-natural land use (see also Section 4.4).

Lost ponds

There are environmental survey data for only three ponds that were lost between 1998 and 2007: all were lowland sites surveyed for LPS96. Because these data are so limited it is not possible to make generalisations about the characteristics of lost ponds.

4.9 Conclusions

Seasonality and climate effects

Countryside Survey 2007 data have provided the first opportunity to look at the effects of differences in weather in different years on pond water levels and seasonality. The results suggest that weather has a considerable influence on pond seasonality, with five times as many ponds drying in the drought year of 1996, than in 2007 which was slightly wetter than mean values.

The implication of these findings is that at least a quarter of Britain's lowland ponds appear to be rather shallow bowls with the potential to dry out on an annual basis, depending on the prevalent weather that year. CS evidence suggests that as few as one in 20 ponds can dry in years with a wet summer. At least one in four may dry if the year is unusually dry. The mean difference in pond water level drawdown between these two very different scenarios can be as little as 14 cm.

Photo 4.3 At least a quarter of Britain's lowland ponds are shallow waterbodies which dry out completely in drier years.

Water chemistry

At a national scale, the chemical patterns observed in CS ponds were consistent with Britain's broad patterns of geology, altitude and land use. Thus, the highest mean values of all determinands were evident in English ponds; lower values were recorded in Wales and Scotland where geology, climate and altitude tend to give more acidic, base-poor waters.

Superimposed on these natural patterns was evidence of anthropogenic enrichment. 39% of GB ponds had elevated levels of phosphorus or nitrogen compared to baseline levels in ponds located in areas of semi-natural land cover. Evidence of enrichment was greatest in England, where 58% of sites had elevated levels of nitrogen or phosphorus. Similarly, in lowland areas, where anthropogenic impacts on land cover are generally most intensive, ponds with a greater proportion of semi-natural land in their surrounds had significantly lower levels of soluble reactive phosphorus and total oxidised nitrogen (TON) than ponds surrounded by more intensive land use.

Pond types

The 1996 Lowland Pond Survey included relatively few Scottish ponds because of the dominance of upland landscapes in Scotland. Countryside Survey 2007 has been the first study to look at the physico-chemistry of Scottish ponds in more detail. The results suggest that Scotland's ponds are relatively distinctive when compared to typical English and Welsh waterbodies. On average, the data showed that Scottish ponds were significantly less shaded. They were also more likely to be stream-fed and have lower levels of summer drawdown than more southerly ponds. A relatively high proportion of Scottish ponds were located in semi-natural areas, particularly heathlands, moorlands or wetlands, and relatively few showed obvious evidence of nutrient pollution.

New ponds

Understanding the physico-chemistry of new ponds is important because so many ponds have been created over the last decade. The limited physico-chemical data available (16 sites), suggests that new ponds are relatively similar to typical countryside ponds in terms of their size, intensity of surrounding land use and water sources. Except in Scotland, few new ponds had a high proportion of semi-natural land use in their surrounds. Perhaps linked to this is the finding that almost one in five new ponds had elevated levels of phosphorus.

Amelioration of runoff

Across Great Britain, the majority of ponds (63%) are directly linked to the stream drainage system either through inflows or outflows. The catchment-level impact that ponds have on surface water drainage pathways has been little considered. Around a third of 2007 stream or ditch-fed ponds had an inflow but no outflow. This is surprising, and suggests that these ponds intercept and retain stream drainage water, potentially recharging some or all to groundwater. Since even dry outflows were not observed at these ponds it is possible these ponds have the capacity to intercept and ameliorate stream runoff even during storm events. They may therefore play a more significant role than generally realised in catchment hydrology and flood amelioration.

5 Biodiversity and biological quality

This chapter describes the biological condition of ponds surveyed in Countryside Survey 2007 based on their plant assemblages, and assesses biodiversity differences between lowland ponds surveyed in 1996 and 2007. Likely reasons for the changes observed are evaluated.

5.1 Plant richness

Countryside Survey 2007 ponds supported a mean of 8.2 wetland plant species per pond. Ponds in England supported significantly fewer plant species than ponds in Scotland and Wales (Figure 5.1).

Comparison of plant data from CS in 2007 and LPS96 shows that in lowland areas the number of plant species declined significantly between 1996 and 2007 from a mean of 10.2 species to 8.2 species per pond (Figure 5.2).

When wetland plants are divided into groups based on their morphology, this decline in richness can be seen to have occurred in both emergent and submerged plant species (P<0.05), but not in floating-leaved plants.

Figure 5.1 Mean wetland plant richness in ponds across Great Britain in 2007. Asterisks indicate a statistically significant difference between countries (* *P*<0.05). 95% confidence intervals are shown for each bar.

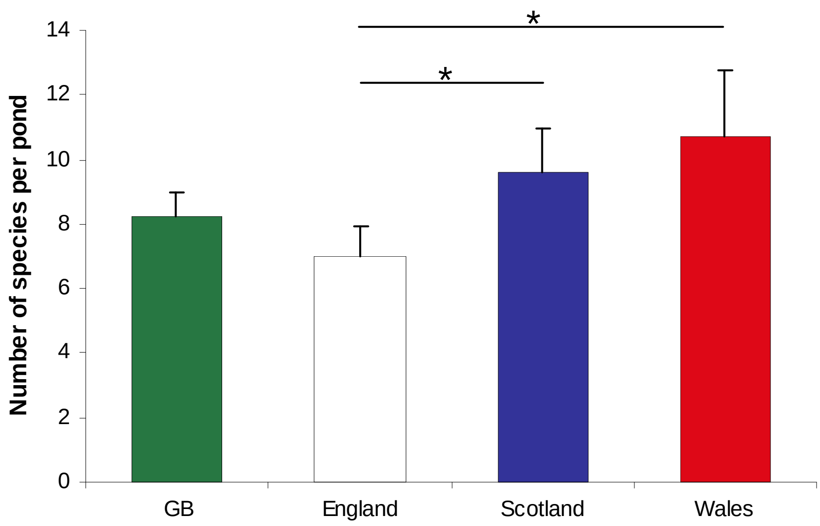


Figure 5.2 Change in wetland plant species richness in lowland ponds across Great Britain between 1996 and 2007, with a breakdown for emergent, floating-leaved and submerged plants. Asterisks indicate a statistically significant change between surveys (* P<0.05). 95% confidence intervals are shown for each bar.

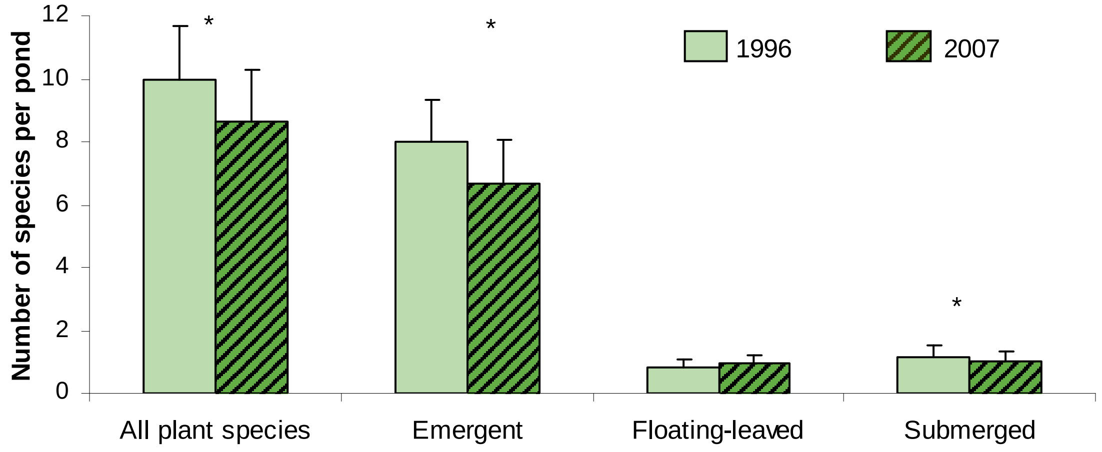


Table 5.1 Mean number of plant species recorded from ponds at country and GB spatial scale. Range values are given in parentheses.

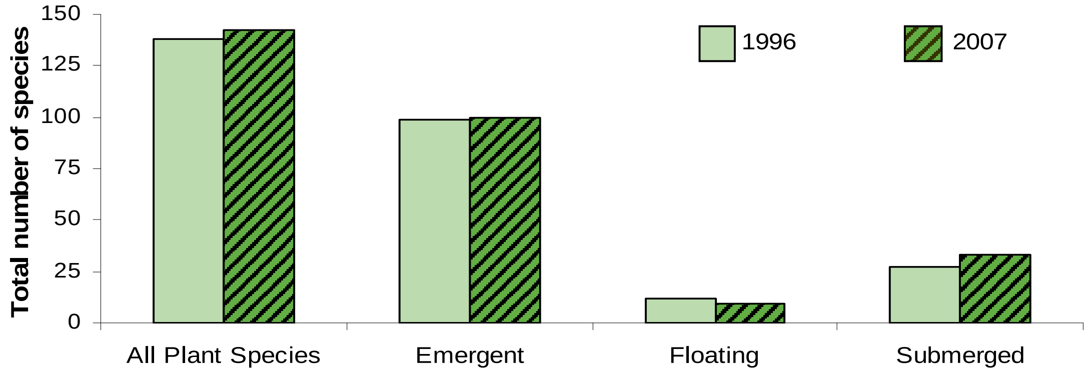
	Submerged species	Floating-leaved species	Emergent species	All wetland plant species
GB	1.1 (0-10)	0.8 (0-4)	6.3 (0-24)	8.2 (0-32)
England	0.7 (0-6)	0.9 (0-4)	5.4 (0-23)	7.0 (0-32)
Scotland	1.9 (0-10)	0.6 (0-3)	7.1 (0-23)	9.6 (0-27)
Wales	1.0 (0-3)	0.8 (0-4)	8.9 (0-24)	10.7 (1-29)
Lowland 1996	1.2 (0-8)	0.8 (0-4)	8.0 (0-25)	10.0 (0-30)
Lowland 2007	1.0 (0-5)	0.9 (0-4)	6.7 (0-23)	8.6 (0-32)

Pooled number of plant species recorded from ponds

In total, 205 wetland plant species were recorded from the 259 survey ponds. This represents around half (48%) of all wetland plants recorded in Britain (Murphy & Weatherby 2007).

In the lowlands, the total number of plant species recorded did not vary significantly between 1996 and 2007 (Figure 5.3). However, there was a high turnover of species between the two surveys. Of the 160 wetland plant species recorded in lowland ponds surveyed in 1996 and 2007, 106 (66%) were recorded in both years. There were 24 species recorded in 1996 that were not found in 2007 and 30 species newly-recorded in 2007.

Figure 5.3 Pooled wetland plant species richness in lowland ponds across Great Britain in 1996 and 2007, with a breakdown for emergent, floating-leaved and submerged plants. Difference between years was not statistically significant for any plant group.



Uncommon species recorded from Countryside Survey 2007 ponds

Five plant species with a national rarity or threat status were recorded during the survey (see Table 5.2).

In addition, there were records of 43 locally uncommon species which have a relatively restricted distribution in Britain (see Table 2.3 for definition of local). This included uncommon wetland plants such as: Bristly Stonewort (*Chara hispida*), Six-stamened Waterwort (*Elatine hexandra*), Fat Duckweed *(Lemna gibba*), White Beak-sedge (*Rhynchospora alba*), Various-leaved Pondweed (*Potamogeton gramineus*), Red Pondweed (*Potamogeton alpinus*) and the floating liverwort (*Ricciocarpos natans*).

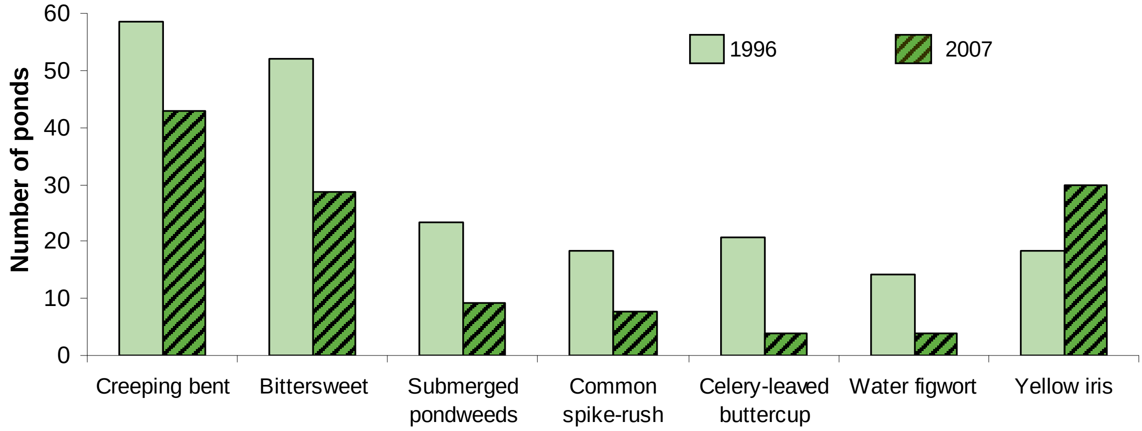
Table 5.2 Nationally uncommon and threatened species recorded from survey ponds in CS in 2007.

English name	Species	Status	Number of ponds (Total n=259)
Lesser Water-plantain	*Baldellia ranunculoides*	Near Threatened	1
Great Sundew	*Drosera anglica*	Near Threatened	5
Frog-bit	*Hydrocharis morsus-ranae*	Vulnerable	1
Pointed Stonewort	*Nitella mucronata*	Nationally Scarce	2
Slender-leaved Pondweed	*Potamogeton filiformis*	Nationally Scarce	1

Plant species change

Five plant species showed a significant decline in frequency between the two surveys: Creeping Bent (*Agrostis stolonifera*), Bittersweet (*Solanum dulcamara*), Common Spike-rush (*Eleocharis palustris*), Celery-leaved Buttercup (*Ranunculus sceleratus*) and Water Figwort (*Scrophularia auriculata*). Submerged pondweeds: an aggregate of all submerged *Potamogeton* species also declined significantly. One plant, Yellow Iris (*Iris pseudacorus*), increased its occurrence between 1996 and 2007 (Figure 5.4).

Figure 5.4 The wetland plant species which showed a significant change (P< 0.05) in frequency of occurrence between 1996 and 2007 in lowland ponds across Great Britain.



Alien invasive plants

Eight plant species regarded as invasive aliens were recorded from ponds (Table 5.3).

Across GB as a whole, around one in ten of the ponds supported at least one invasive species. However, English ponds were significantly more likely to support invasives and these species were correspondingly uncommon in Scotland (Table 5.3). The most frequently occurring species were: New Zealand Pigmyweed (*Crassula helmsii*), Least Duckweed (*Lemna minuta*) and Nuttall's Waterweed (*Elodea nuttallii*), each occurring in around 3% of ponds.

There was no significant difference in the occurrence of invasive species in the lowlands between 1996 and 2007.

Photo 5.1 The invasive alien plant Water Fern (*Azolla filiculoides*) covering a golf course pond.

Table 5.3 Percentage of ponds with invasive alien plant species across Great Britain in 2007, and in lowland ponds in 1996 and 2007.

		GB	England	Scotland	Wales	Lowlands	
						1996	2007
	Number of sites	(259)	(149)	(81)	(29)	(77)	(77)
Water fern	*Azolla filiculoides*	1.2	2.0	0.0	0.0	1.3	3.9
New Zealand Pigmyweed	*Crassula helmsii*	1.9	3.4	0.0	0.0	2.6	1.3
Canadian Waterweed	*Elodea canadensis*	3.1	2.7	3.7	3.4	6.5	3.9
Nuttall's Waterweed	*Elodea nuttallii*	2.7	3.4	0.0	6.9	0.0	2.6
Indian balsam	*Impatiens glandulifera*	1.2	2.0	0.0	0.0	2.6	0.0
Curly Waterweed	*Lagarosiphon major*	0.4	0.7	0.0	0.0	1.3	1.3
Parrot's-feather	*Myriophyllum aquaticum*	0.4	0.7	0.0	0.0	1.3	0.0
Least Duckweed	*Lemna minuta*	1.9	3.4	0.0	0.0	0.0	3.9
All invasive species		**10.8**	**14.8**	**3.7**	**10.3**	**14.3**	**11.7**

Non-parametric correlations (Spearman Rank Correlation) between the occurrence of invasive plant species and plant richness measures (number of submerged, number of floating-leaved and number of emergent plant species) all showed a positive significant relationship. Thus ponds with invasive species present generally supported richer communities of other plant species.

5.2 Plant cover

The extent to which ponds have a cover of wetland plants is of interest for a number of reasons. An increase in emergent plant species is likely to indicate that ponds are filling in and succeeding towards a seasonal pond stage or to damp ground. Lower submerged plant cover and higher cover of floating-leaved plants tends to be associated with poorer quality ponds (Biggs *et al*. 2000).

In Countryside Survey 2007, plant cover was assessed for three morphological groups: submerged, floating-leaved and emergent. There was no significant difference in total plant cover between countries. England had a significantly lower cover of submerged plants than Scotland and significantly higher floating-leaved plant cover than Scotland. Other between-country relationships were not significant.

There was no significant change in plant cover in lowland ponds between 1996 and 2007.

Table 5.4 Mean percentage plant cover in ponds across in Great Britain in 2007 and in the lowlands in 1996 and 2007. England had a statistically significantly lower cover of submerged plants, and significantly higher floating-leaved plant cover than Scotland at P<0.05.

	Submerged plants	Floating-leaved plants	Emergent plants	All wetland plants
GB	12	10	25	46
England	8	13	23	43
Scotland	20	5	25	48
Wales	14	10	35	58
Lowlands 1996	7	6	27	40
Lowlands 2007	7	11	27	45

5.3 Biological quality

Assessing biological quality using PSYM

The quality of Countryside Survey ponds, i.e. the extent of their degradation, was assessed using plant assemblage characteristics evaluated though the PSYM bioassessment tool (Box 5.1).

PSYM assesses pond quality using a range of biological measures (metrics), such as species richness, that are known to vary with human degradation (e.g. pollution, over-stocking with fish or wildfowl). PSYM scores are ideally calculated using both wetland plant and aquatic macroinvertebrate data. However, where invertebrate data are not available, a partial assessment can be made using plant data alone.

Plant PSYM uses three metrics, each of which has been shown to vary strongly with pond degradation (see Figure 5.5). These metrics are: (i) number of submerged and emergent plant species (ii) trophic ranking score (a measure of nutrient enrichment) and (iii) the number of uncommon plant species. The PSYM programme works by comparing the value of each metric observed at a pond, with the value that would be expected if the pond was pristine (i.e. in the "reference state"). Comparing the two scores provides an overall measure of how degraded each pond is relative to its expected pristine state.

Currently PSYM assessments can only be made for England and Wales.

Box 5.1 PSYM

PSYM, the Predictive SYstem for Multimetrics, is a Water Framework Directive compatible method for assessing pond quality (Biggs *et al*. 2000). PSYM uses a range of measures (metrics), each of which has been shown to vary predictably with degradation. The values from individual metrics are ultimately combined to give a single measure which aims to represent the overall ecological quality of the waterbody. Conceptually, the method is similar to the stream bioassessment tool RIVPACS, but PSYM assesses overall pond quality, rather than specifically water pollution status.

PSYM assessments should ideally be undertaken using both plant and aquatic invertebrate data, because, together, plants and animals span a complimentary range of sensitivities to potential degradation factors. Plants are, for example, particularly sensitive to waterbody nutrient status, whereas animals typically exhibit greater oxygen sensitivity. If necessary, however, PSYM assessments can be made using a single biotic group. In Countryside Survey in 2007, only plant data were recorded from ponds, so PSYM has been calculated using plant data alone.

PSYM was developed using data from plant surveys undertaken between June and September. CS data were collected over a longer period between May and November. Analysis showed that there were no significant differences between the number of plant species or PSYM metrics from ponds surveyed in and out of the "PSYM season". It was therefore deemed appropriate to assess all CS plant survey data using PSYM.

There are three plant metrics in PSYM:

(i) *Number of Submerged and Emergent Plant species (NSEP)*. Floating-leaved species are not included.

(ii) *Trophic Ranking Score (TRS):* which assigns scores to still-water plant species based on their known tolerance to nutrient enrichment (eutrophication).

(iii) *Number of Uncommon Plant species* (NUS): the number of locally uncommon, scarce or Red Data Book plant species recorded at each pond. "Locally uncommon" is defined here as species recorded from less than 25% of 10 x 10 km squares in GB.

Different pond types support different plant and animal communities depending on where the pond is located, how big it is, whether the pond is shaded by trees or grazed etc. The PSYM software programme takes geographic and environmental information gathered from surveys of each pond and uses this to predict the plant and animal metric values that would be expected for that type of pond, if the pond was pristine.

The true biological condition of a pond can be judged by comparing the observed value of each metric at a pond with the value expected if the pond was pristine. So, for example, if a CS pond is a small, shady, ungrazed pond in south west England, its metrics will be compared with those of a computer-predicted *pristine* small shady ungrazed pond from the south west. The difference between the metric values from the real (observed) pond, and PSYM-predicted pristine pond shows how degraded the real pond is by non-natural (anthropogenic) factors.

The observed metric values are expressed as an index (observed/expected), or percentage of the expected value. In high quality ponds the similarity with a pristine site is high (75%-100% similarity). As degradation increases, the percentage similarity between the observed and expected values falls. For reporting purposes percentage similarity is divided into four grades of ecological condition:

0%- 24%	Very Poor
25% - 49%	Poor
50% - 74%	Moderate
75% or above	Good

Pond quality results for England and Wales using PSYM

All three PSYM plant metrics showed significant differences between the mean observed and predicted values for Countryside Survey 2007 ponds (Figure 5.5).

Specifically, CS ponds in England and Wales had on average only 38% of the expected number of submerged and emergent plants. The mean number of uncommon plant taxa was 21% of the expected value. The observed Trophic Ranking Score was on average 13% above the predicted value: suggesting enrichment (Figure 5.5).

An overall assessment of pond quality in England and Wales can be made by placing sites into one of four PSYM quality categories. Most Countryside Survey 2007 ponds (80%) fell into the two lowest categories: Poor or Very Poor. Only 8% were Good quality (i.e. similar to the pristine state) (Figure 5.6).

Overall, these findings indicate that degradation was widespread amongst ponds in England and Wales, and that, typically, the extent of degradation at individual ponds was considerable.

Pond quality in Scotland

PSYM has not yet been developed for Scotland. However, some assessment of the quality of Scottish ponds can be made by comparing the number of plant species in CS ponds with Scottish waterbodies surveyed in the National Pond Survey (NPS) (see Section 2.3). The NPS survey, undertaken in the 1990's, includes biological and physico-chemical data from 39 pristine (i.e. reference state) Scottish ponds located in semi-natural landscapes . Comparison with NPS data provides some context for understanding the quality of Scottish ponds in 2007. The disadvantage of this comparison is that it is more open to sample bias than using PSYM. For example, NPS reference ponds might be larger than CS ponds, or located in different landscape types, and these natural factors could affect the mean number of plant species recorded.

Comparison of Scottish NPS and CS pond data showed that the CS ponds supported around 60% of the number of plant species found in pristine Scottish reference ponds. This is a considerably higher proportion than in England and Wales where CS ponds supported only a third of the expected number of plant species (Table 5.5).

Overall, these findings suggest that, although there is likely to be degradation of some Scottish ponds, overall, pond quality is likely to be higher than in England and Wales.

Figure 5.5 Comparison of the mean observed and expected (reference) values for the PSYM plant metrics used to assess the ecological quality of ponds in England and Wales in 2007. Asterisks indicate a statistically significant change between surveys (* P< 0.05).

<table>
<tr><th>Metric</th><th>What the metric measures</th><th>Results</th><th>Results</th></tr>
<tr><td>Number of submerged and emergent plant species (NSEP)</td><td>The number of plant species decreases at a pond as overall pollution levels increase.

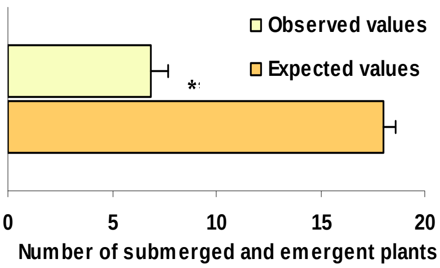
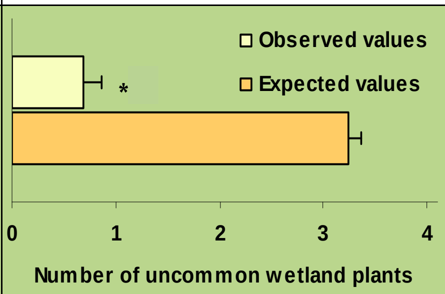
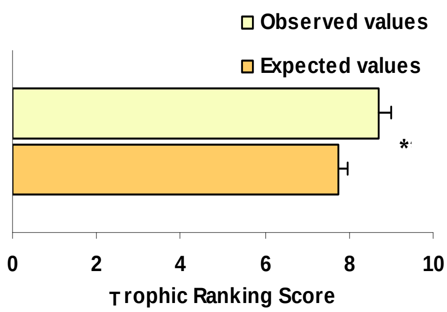
Note that floating-leaved species, like duckweeds, are not counted in the metric because they show the opposite relationship: i.e. ponds tend to have more floating-leaved species as degradation levels increase.</td><td>
</td><td>If all CS ponds were in good condition, they would be expected to have a mean of 18 species of plant per pond. The observed mean NSEP for CS ponds in 2007 was seven species per pond, which is significantly lower than that expected for a pond in good condition.</td></tr>
<tr><td>Number of uncommon species (NUS)</td><td>As ponds become more degraded and isolated they lose uncommon plant species. For the purposes of PSYM, uncommon means plants that are recorded in less than a quarter of all 10 x 10 km^2 in Britain.</td><td>
</td><td>A typical pristine ponds would be expect to have around three uncommon wetland plant species in each pond. The mean NUS in 2007 was less than one species (0.7) per pond suggesting considerable impairment.</td></tr>
<tr><td>Trophic Ranking Score (TRS)</td><td>Trophic Ranking Score is a measure of how enriched ponds are by nutrients. Plants are scored depending on their nutrient preferences. A TRS is calculated as the mean score for the plants at each pond. Higher values indicate a pond is more nutrient-rich.</td><td>
</td><td>A typical pristine pond would be expected to be moderately nutrient rich (mesotrophic) with a TRS of 7.7. The mean TRS for ponds across England and Wales in 2007 was 8.7, indicating that many countryside ponds were significantly enriched by nutrients and eutrophic.</td></tr>
</table>

Figure 5.6 Percentage of ponds falling into four PSYM quality categories in England and Wales. Left: comparison of lowland England and Wales in 1996 and 2007; Right: England and Wales in 2007.

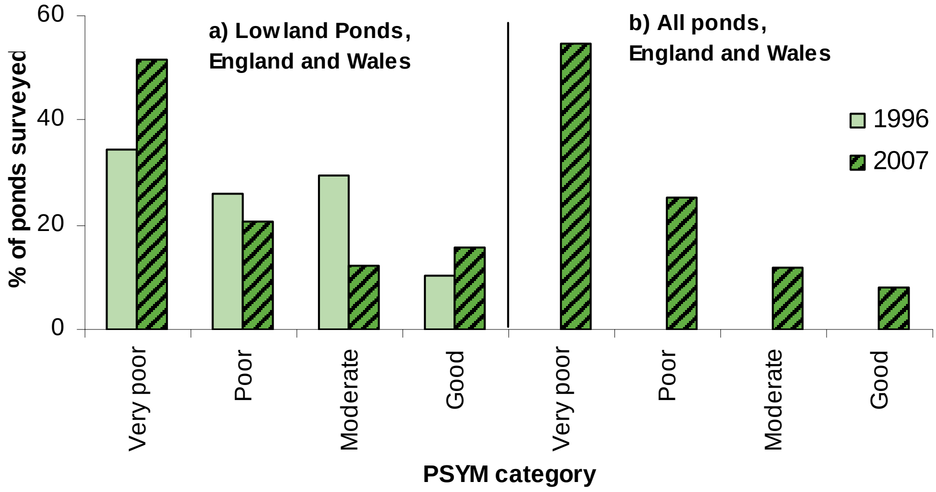


Table 5.5 Wetland plant richness (number of species) in Scotland, and in England and Wales, compared to plant richness of pristine (reference state) ponds in the National Pond Survey. Range values in parentheses.

	Countryside Survey	National Pond Survey reference sites
Scotland	9.6 (0-27)	15.6 (3-55)
England and Wales	7 (0-32)	22.8 (0-41)

Why are there so many poor quality ponds?

Countryside Survey 2007 findings suggest that, based on their plant assemblages, 80% of ponds in England and Wales are currently in Poor or Very Poor condition. Only 8% of ponds remain undegraded. Why is this?

Studies have suggested that a wide range of anthropogenic factors can potentially damage ponds including: diffuse agricultural pollutants such as nutrients and pesticides, road-runoff, excessive numbers of ducks or fish, alien plants and wetland destruction causing isolation (see Section 1.7).

Where feasible, potentially degrading factors were measured during 2007 field surveys to allow relationships with pond quality to be investigated.

Partial Least Squares (PLS) regression (see Section 2.5) was used to investigate the relationships between environmental factors and pond quality as assessed by two groups of plant measures. Environmental factors included both variables known to cause natural variation in pond communities (e.g. pond area, pH, grazing) and those often causing pond degradation (see Table 2.3). The two plant-based measures were:

- Plant richness measures i.e. number of plant species (submerged, floating-leaved, emergent and all wetland plants combined). Floating-leaved plants were not included because these species are more likely to be inversely associated with degradation (Biggs *et al.* 2000)

- PSYM metric scores contributing to PSYM, and overall PSYM score (England and Wales only).

Plant richness measures were used because these attributes were available for all ponds including those in Scotland. PSYM metrics were available only for England and Wales, but these were also analysed because (a) PSYM metrics are known to be specifically related to degradation and (b) using PSYM index values reduces the effects of natural variation (e.g. pond area, shade, pH) on plant measures. This means that significant relationships between PSYM and degradation factors are more likely to suggest that factors are causal.

Results

The measured environmental variables could generally explain a relatively low proportion of the differences in plant communities between ponds, with significant models accounting for between 11% and 38% of between-pond variation. This probably reflects the heterogeneity of pond environments (Table 5.6).

Plant species richness metrics

PLS fitted one significant component to the emergent plant richness data and two components to the submerged plant richness data.

Table 5.6 The proportion of variation (R^2Y) in plant and PSYM index metrics explained by each component extracted by PLS.

	Component 1 (R^2Y)	Component 2 (R^2Y)
Emergent plants	0.203	Not significant
Submerged plants	0.195	0.113
Number of Submerged & Emergent Plant Species	0.202	Not significant
Trophic Ranking Score	0.349	Not significant
PSYM Score	0.244	Not significant
PSYM Score change	0.375	Not significant

Variation between ponds in the number of submerged and emergent plant species was related to pond area, phosphorus concentration, pH, alkalinity, proportion of adjacent land in the 0-5 m zone occupied by ponds, streams and ditches, fish and tree shade (Table 5.7).

The well-known relationship between increased plant richness and increasing pond area (e.g. Moller & Rordam 1985) was the most important environmental factor for both measures.

Submerged and emergent richness declined with increasing phosphorus and to a lesser extent nitrogen concentrations: this a relationship is likely to be linked to excessive loading of nutrients from anthropogenic sources (see Section 4.2).

Amongst the ‘natural’ environmental variables, pH had positive relationships with both plant richness measures. Alkalinity and conductivity were also positively related to submerged plant richness. All are likely to reflect the commonly observed gradient of increasing plant richness from acid to base rich water (Defra 2003).

Photo 5.2 Shaded ponds often supported relatively few wetland plant species.

Amongst the land use variables there was a consistent trend for richer plant assemblages to be associated with the presence of adjacent wetlands. The strongest relationship was between increasing emergent plant richness and the presence of other ponds, ditches or streams within 5m of the pond.

Arable land generally showed negative relationships with plant richness. Urban land showed a weak trend for increased emergent plant richness associated with the 0-100 m zone.

Natural land uses often showed more complex relationships with plant richness variables. Extensive woodland (0-100 m zone) was associated with increased emergent richness, perhaps reflecting the protective effect of more natural catchments. However, there were negative relationships between woodland and submerged plants: possibly an effect of accumulating organic leaf litter which can limit the growth of submerged plant species (Barko and Smart 1986).

Relationships with heathland were often negative: probably because of the tendency for lower species richness in acid water sites (see above). Submerged plant species richness was greater when ponds were surrounded by extensive heathlands, perhaps reflecting the generally better water quality which would benefit the more pollution sensitive submerged plants.

Table 5.7 Summary of variable importance (VIP) for submerged and emergent wetland plants showing loading of environmental variables associated with each PLS component (Comp). All included metrics have VIP values ≥ 0.7.

Environmental variable	Emergent plants: number of species			Submerged plants: number of species			
	VIP rank	VIP loading	Comp 1	VIP rank	VIP loading	Comp 1	Comp 2
Pond area	1	2.24	0.38	1	2.39	0.23	0.69
pH	17	0.73	0.12	3	1.58	-0.10	0.38
Alkalinity	•	<0.7	•	4	1.54	-0.20	0.25
Conductivity	•	<0.7	•	13	1.09	-0.13	0.20
Soluble reactive phosphorus	5	1.42	-0.24	2	1.77	-0.33	-0.38
Total oxidised nitrogen	•	<0.7	•	11	1.27	-0.23	-0.29
Tree shade (% cover of pond)	4	1.50	-0.25	7	1.42	-0.30	-0.18
Grazing (% pond margin grazed)	•	<0.7	•	•	<0.7	•	•
Road runoff present	•	<0.7	•				
Heavy waterbird impact	•	<0.7	•	•	<0.7	•	•
Heavy fish impact (score 3+)	3	1.50	0.25	•	<0.7	•	•
Inflow present	12	0.99	-0.12	•	<0.7	•	•
Land use around the pond (% cover)*:*							
0-5 m Arable	13	0.98	-0.17	•	<0.7	•	•
0-5 m Improved grassland	•	<0.7	•	•	<0.7	•	•
0-5 m Building & gardens	7	1.34	0.23	•	<0.7	•	•
0-5 m Unimproved grassland	•	<0.7	•	•	<0.7	•	•
0-5 m Heathland	11	1.09	-0.19	16	0.70	0.12	-0.08
0-5 m Trees and woodland	•	<0.7	•	5	1.50	-0.31	-0.22
0-100 m Arable	8	1.30	-0.22	12	1.11	-0.23	-0.19
0-100 m Improved grassland	•	<0.7	•	•	<0.7	•	•
0-100 m Buildings & gardens	14	0.86	0.14	•	<0.7	•	•
0-100 m Unimproved grassland	•	<0.7	•	•	<0.7	•	•
0-100 m Heathland	15	0.80	-0.14	14	0.91	0.19	0.03
0-100 m Trees and woodland	6	1.34	0.23	15	0.87	-0.13	0.12
0-5 m Bog, fen, marsh	16	0.75	0.13	6	1.44	0.30	0.04
0-5 m Pond, stream, ditch	2	2.03	0.34	•	<0.7	•	•
0-5 m Water and wetland	10	1.12	0.19	8	1.40	0.29	0.02
0-100 m Bog, fen, marsh, flush	•	<0.7	•	9	1.38	0.28	0.02
0-100 m Pond, stream, ditch	9	1.20	0.20	•	<0.7	•	•
0-100 m Water and wetland	•	<0.7	•	10	1.31	0.26	-0.03

PSYM quality metrics

Partial Least Squares regression only fitted one significant component to each of the PSYM measures, probably because of the smaller number of sites (mainly from England, with a few in Wales) giving less clearly defined environmental gradients.

Relationships with PSYM could be created for two of the PSYM metrics (submerged and marginal plant richness and trophic ranking score) and also for the overall PSYM score. It was not possible to create a significant PLS model for the number of uncommon plant species metric.

Trees, woodland and shade were important variables explaining PSYM metric scores. The presence of trees and woodland in the broader catchment (0-100 m) was the strongest variable positively correlated with the overall PSYM score, suggesting a protective effect from woodland areas (i.e. land not under intensive management). However, increasing tree shade in the immediate surrounds showed complex relationships with PSYM scores; the number of emergent and submerged plants declined, and trophic ranking scores declined, suggesting lower levels of enrichment. Ponds on heathlands had metric scores that were generally lower than predicted by PSYM. The reason for this is not known.

After these variables, nitrogen and phosphorus were the next most important variables in the PLS analysis with higher nutrient concentrations generally associated with lower PSYM scores and metrics.

There were consistent relationships suggesting that the occurrence of wetlands in the vicinity of ponds leads to higher PSYM scores, particularly where these wetland are very close (within 5 m). In contrast, there was a generally negative relationship between the presence of an inflow to a pond and lower PSYM metrics, probably linked to a damaging influence from stream-borne pollutants on pond quality.

Conductivity, pH, and alkalinity were moderately important predictors in the PLS models of PSYM scores, mainly through their influence on the trophic ranking score (TRS) metric. PSYM includes a correction for pH, so it is not clear why increasing pH/conductivity/alkalinity should lead to higher PSYM scores: this may reflect some known limitations of the PSYM model in predicting TRS correctly in acid sites (Biggs *et al*. 2000).

Arable land use in the 0-5 m and 0-100 m zones was also a moderately strong predictor, particularly associated with lower scores for the number of submerged and marginal plant metric.

Table 5.8 **Summary of variable importance (VIP) for PSYM score and the metrics Number of Submerged and Emergent Taxa (SE_NTX) and Trophic Ranking Score (TRS), showing loading of environmental variables associated with each PLS component (Comp). All included metrics have VIP values ≥ 0.7**

Environmental variable	SE_NTX Score			TRS Score			PSYM Score		
	VIP rank	VIP loading	Comp 1	VIP rank	VIP loading	Comp 1	VIP rank	VIP loading	Comp 1
Pond area	•	<0.7	•	•	<0.7	•	•	<0.7	•
pH	•	<0.7	•	6	1.69	0.30	7	1.22	0.22
Alkalinity	•	<0.7	•	7	1.21	0.22	10	0.82	0.15
Conductivity	•	<0.7	•	5	1.72	0.31	6	1.40	0.25
Soluble reactive phosphorus	2	2.08	-0.37	4	1.73	0.31	•	<0.7	•
Total oxidised nitrogen	4	1.56	-0.28	8	1.17	-0.21	2	2.51	-0.45
Tree shade (% cover of pond)	1	2.30	-0.41	1	1.94	-0.35	11	0.73	-0.13
Grazing (% pond margin grazed)	•	<0.7	•	•	<0.7	•	•	<0.7	•
Road runoff present	•	<0.7	•	•	<0.7	•	•	<0.7	•
Heavy waterbird impact	•	<0.7	•	•	<0.7	•	•	<0.7	•
Heavy fish impact (score 3+)	10	1.14	0.20	•	<0.7	•	•	<0.7	•
Inflow present	•	<0.7	•	9	1.08	-0.19	8	0.84	-0.15
Land use around the pond (% cover):									
0-5 m Arable	12	0.96	-0.17	•	<0.7	•	•	<0.7	•
0-5 m Improved grassland	8	1.24	0.22	•	<0.7	•	•	<0.7	•
0-5 m Buildings & garden	•	<0.7	•	12	0.75	-0.13	•	<0.7	•
0-5 m Unimproved grassland	•	<0.7	•	•	<0.7	•	•	<0.7	•
0-5 m Heathland	•	<0.7	•	10	0.98	-0.17	3	1.53	-0.27
0-5 m Trees and woodland	3	1.69	-0.30	2	1.93	0.35	•	<0.7	•
0-100 m Arable	7	1.26	-0.23	•	<0.7	•	7	0.99	-0.18
0-100 m Improved grassland	13	0.70	0.13	•	<0.7	•	•	<0.7	•
0-100 m Buildings & garden	•	<0.7	•	•	<0.7	•	•	<0.7	•
0-100 m Unimproved grassland	•	<0.7	•	13	0.72	-0.12	•	<0.7	•
0-100 m Heathland	•	<0.7	•	11	0.92	-0.13	4	1.51	-0.27
0-100 m Trees and woodland	6	1.44	0.26	3	1.88	0.34	1	2.70	0.48
0-5 m Bog, fen, marsh	9	1.21	0.22	•	<0.7	•	•	<0.7	•
0-5 m Pond, stream, ditch	11	1.04	0.19	•	<0.7	•	•	<0.7	•
0-5 m Water and wetlands	5	1.46	0.26	•	<0.7	•	•	<0.7	•
0-100 m Bog, fen, marsh	•	<0.7	•	•	<0.7	•	•	<0.7	•
0-100 m Pond, stream, ditch)	•	<0.7	•	•	<0.7	•	10	0.78	0.14
0-100 m Water and wetlands	•	<0.7	•	•	<0.7	•	•	<0.7	•

Change in pond quality in the lowlands between 1996 and 2007

Findings from LPS96 suggested many lowland ponds were in poor condition in the mid 1990s. Comparison of 1996 and 2007 data indicate that the ecological quality of ponds has declined further during the last decade.

In terms of overall quality, the percentage of lowland ponds in England and Wales that were assessed as Moderate or Good quality decreased from 40% to 28%, whilst the number of Poor or Very Poor quality ponds increased from 60% to 72% between 1996 and 2007 (Figure 5.6).

A trend towards degradation was also shown by the three individual PSYM metrics, although the difference was significant only for one metric: number of submerged and emergent plant species (Table 5.9).

Table 5.9. Change in mean PSYM metric values for lowland ponds in England and Wales between 1996 and 2007. Arrows denote significant change (P<0.05) in the direction shown.

PSYM metric	LPS96	CS in 2007	Mean change per site	Significant change
Number of Submerged and Emergent Plant species	8.2	6.7	-1.5	↓
Number of Uncommon Species	0.88	0.85	-0.03	
Trophic Ranking Score (higher values indicate a site is more enriched)	9.1	9.2	+0.1	

Why is pond quality declining in the lowlands?

The marked decrease in plant species richness (Section 5.1) and decline in pond quality shown by PSYM over the last 11 years warrants investigation of likely causes. There are a number of possible explanations, both anthropogenic and natural, for such a decline. The most likely explanations are discussed below.

Relationships between biological quality and environmental variables were investigated for England and Wales through Partial Least Squares regression of data describing the change in PYSM metric values between 1996 and 2007 (see additional information in Section 2.5). The PLS models incorporated environmental variables (e.g. nitrogen levels, presence of a stream inflow) measured in 2007, with the exception of tree shade which was based in change in tree shade between 1996 and 2007. The results from this analysis are shown in Table 5.9.

Impact of weather conditions and water levels on pond biota and field surveying
LPS96 was undertaken in an unusually dry year. In contrast, the summer of 2007 was wetter than average (see Section 2.6), with pond water levels averaging 14 cm higher, and the dry marginal area exposed around the pond reduced to around 25% of the total pond area compared to 40% in 1996 (see Section 4.1). It is possible that these higher water levels could have reduced the number of plants recorded in 2007 either by (a) influencing the number of plants which could be seen by surveyors (deeper water may have made it difficult to access some areas of the pond in 2007), or (b) by impacting plant communities directly, since pond plant communities have been observed to differ in wet and dry years.

However, no significant relationship was detected between changes in water levels and changes in the plant communities. Likewise no relationships were detected between recorded plant richness and monthly or seasonal rainfall totals from the 2007 data. There were no differences in mean Ellenberg moisture scores (see Table 2.3) between the plant assemblages recorded in 1996 and 2007.

Natural physico-chemical variation
Natural changes occurring in ponds, such as succession, could potentially explain pond biota declines. The most likely factors to change over a 10 year period are (a) the extent to which ponds are in-filled by sediment and vegetation and (b) tree shade.

Sediment
It was not possible to measure sediment infill rates in CS ponds in 2007 (see Table 2.3). However, the pattern of plant loss observed in 2007 was not consistent with pond infilling. Ponds that fill with sediment preferentially lose their submerged species and cover; whilst emergent cover (and often richness) is typically increased (Williams *et al*. 2000). CS data show that both submerged *and* emergent species were lost between 1996 and 2007. There was no significant change in plant cover for submerged or emergent plants (see Table 5.4).

Tree shade
A strong relationship was evident between increasing tree shade and decreasing pond condition (PSYM scores). There was also a statistically significant decrease in mean Ellenberg light values for the vegetation in the ponds between 1996 and 2007 (from a value of 7.1 to 7.0), indicating the presence of more shade-tolerant pond plant assemblages in 2007.

Anthropogenic degradation
Declines in pond quality were most likely if the pond received road run-off or had higher nitrogen concentrations. PSYM scores were more likely to decline if ponds had inflows. Additional statistical correlations showed that (a) ponds with inflows had significantly higher levels of nitrogen and phosphorus, and (b) ponds receiving road runoff had significantly higher soluble reactive phosphorus levels.

There were few significant relationships between land use and declines in pond quality assessed by PSYM score. There were weak relationships suggesting that ponds were less likely to degrade if they had improved grassland within 5 m of the pond, and degrade more if there was arable land in the near surrounds. However, neither of these relationships held true at 0-100 m distance from the pond, and it is likely that these are mainly a shade-associated response (see above), created because ponds in improved grassland have significantly less tree-shade, and ponds in arable areas (with no grazing pressure to reduce tree growth) have significantly more (Table 5.10).

Table 5.10 Summary of variable importance (VIP) for PSYM change in Lowland Pond Survey sites between 1996 and 2007 showing loading of environmental variables associated with each PLS component (Comp). All included metrics have VIP values ≥ 0.7.

Environmental variable	Difference in PSYM Score		
	VIP rank	VIP loading	Comp 1
Pond area	19	0.78	-0.09
pH	•	<0.7	•
Alkalinity	16	0.91	0.02
Conductivity	•	<0.7	•
Soluble reactive phosphorus	•	<0.7	•
Total oxidised nitrogen	5	1.28	-0.27
Tree shade (% cover of pond)	13	0.98	-0.20
Change in tree shade: 1996 to 2007	1	1.65	-0.31
Grazing (% pond margin grazed)	14	0.97	0.19
Road runoff present	2	1.56	-0.31
Heavy waterbird impact	•	<0.7	•
Heavy fish impact (score 3+)	10	1.06	-0.09
Inflow present	12	1.01	-0.21
Land use around the pond (% cover):			
0-5 m Arable	17	0.86	-0.16
0-5 m Improved grassland	11	1.03	0.17
0-5 m Unimproved grassland	•	<0.7	•
0-5 m Trees and woodland	4	1.33	-0.26
0-100 m Arable	•	<0.7	•
0-100 m Improved grassland		<0.7	•
0-100 m Buildings & gardens	•	<0.7	•
0-100 m Unimproved grassland	•	<0.7	•
0-100 m Trees and woodland	9	1.10	0.11
0-5 m Bog, fen, marsh	6	1.17	0.23
0-5 m Pond, stream, ditch	8	1.12	0.23
0-5 m Water and wetlands	3	1.55	0.32
0-100 m Bog, fen, marsh	15	0.95	0.18
0-100 m Pond, stream, ditch	18	0.80	0.16
0-100 m Water and wetlands	8	1.12	-0.11

Note: 0-5 m and 0-100 m Heathland and Moorland were both excluded from this analysis as all values were zero. The variable 0-5 m Urban, buildings and gardens was also excluded from the analysis because, with only 2 non-zero values, it severely distorted the VIP results.

Isolation and richness in adjacent waterbodies.

A final possible reason for the decline in pond quality and richness is isolation. There is some evidence for this in the PLS analysis with positive relationships between PSYM scores and the presence of standing and running waters within the 0-5 and 0-100 m land use zones around a pond. However, it should be noted that the cause of some of this relationship may be caused by the wetlands buffering the pond's catchment.

Photo 5.3 Ponds were more likely to maintain their plant richness between 1996 and 2007 if they had other waterbodies or wetlands in their near surrounds.

5.4 Priority habitats

In 2007 high quality ponds became Priority Habitats under the UK Biodiversity Action Plan (BAP). Priority Habitats are those which have been identified in the UK BAP as being at risk. This includes habitats with a high rate of decline, those that are functionally critical and those which are important for Priority Species.

Five criteria are used to define whether a pond meets priority status (see Appendix 2). These criteria are wide-ranging and include plant, invertebrate, amphibian and pond-type measures. A pond can qualify as a priority pond on the basis of one or more of any criterion.

Plant-based priority pond assessments

Plant data from CS were used to identify priority ponds using three plant-based criteria:

1. Presence of a Nationally Scarce, Red Data Book, Biodiversity Action Plan or legally protected plant species
2. Exceptionally rich site for plants: supporting ≥30 wetland plant species
3. Classified in the top PSYM category (Good) with a PSYM score ≥75% (available for England and Wales only).

Only 4% of 259 ponds surveyed as part of CS in 2007 qualified as priority ponds on the basis of the first of these criteria: the presence of rare plant species. The majority of these ponds were in Scotland (Table

5.11). Only 0.4% of the surveyed ponds qualified on the basis of Criterion 2, species-rich plant communities. 4.6 % of ponds qualified on the basis of PSYM assessments. However, this total does not include PSYM assessments for Scotland.

In total 8% of the 259 ponds qualified as priority ponds on the basis of all plant criteria, excluding PSYM assessments in Scotland. Most ponds qualified on the basis of only one criterion. A single site qualified on all three criteria.

Although plant-based priority pond numbers can be used for monitoring trends in CS ponds, using plant data alone to assess whether a pond meets priority status is likely to considerably underestimate the proportion of priority ponds. This means that the current Countryside Survey can provide only a minimum estimate of the number of priority pond sites in Britain. More of the survey ponds would undoubtedly qualify if aquatic invertebrates were included in assessments, and more still if amphibians and other groups (reptiles, birds, mammals) were surveyed.

Table 5.11 Percentage of ponds in England, Scotland and Wales qualifying as Priority Habitats using three plant criteria.

	Number of sites	% qualifying under each criterion			
		Rare species	More than 30 plant species %	PSYM >75%	Total priority ponds
England	149	0.8	0.4	4.2	4.6
Scotland	81	3.1	0.0	no data	3.1*
Wales	29	0.0	0.0	0.4	0.4
All	259	3.9	0.4	4.6*	8.1*

* The total excludes PSYM assessments for Scottish ponds.

5.5 New ponds and lost ponds

A substantial number of new ponds have been created in the last decade, so it is valuable to understand their quality relative to older ponds.

In CS there are botanical data for 16 new ponds created since 1998. Of these, 11 were located in England and five in Scotland. There were no new ponds surveyed in Wales. In addition, the Lowland Pond Survey identified and surveyed five ponds created between 1984 and 1996. Resurveys of these ponds provides limited information about lowland ponds that were 11-23 years old when surveyed again in 2007.

Information on lost ponds is particularly scarce with botanical data from only three ponds lost since 1998.

How rich are new ponds?

The mean number of plant species recorded from the 16 new ponds created between 1996 and 2007 was 10.2 species, compared to 7.9 species for older ponds (n=238). There were significantly more plant species in new ponds than older ponds in England, but not Scotland (Table 5.12).

Although these data are limited, the trends concur with the previous LPS96 findings where 15 ponds all less than six years old had a mean richness of 9.8 species, and eleven 6-12 year old ponds had a mean richness of 15.0 species. Overall richness of new ponds was significantly higher than the mean for older ponds (9.4 species).

Table 5.12 Comparison of mean plant species richness of new ponds (created 1998-2007), ponds lost since 2008, and older ponds (created prior to 1984) in relevant countries. New ponds created between 1984 and 1998 are not included in this analysis.

<table>
<tr><th colspan="2">Pond type</th><th>Number of sites</th><th>Number of plant species</th><th>Range</th></tr>
<tr><td rowspan="3">New ponds (0-9 yrs old)</td><td>All Ponds</td><td>16</td><td>10.2</td><td>0-24</td></tr>
<tr><td>England</td><td>11</td><td>11.4</td><td>0-24</td></tr>
<tr><td>Scotland</td><td>5</td><td>7.6</td><td>1-16</td></tr>
<tr><td rowspan="3">Older ponds</td><td>All Ponds</td><td>238</td><td>7.9</td><td>0-32</td></tr>
<tr><td>England</td><td>135</td><td>6.3</td><td>0-32</td></tr>
<tr><td>Scotland</td><td>75</td><td>9.7</td><td>0-27</td></tr>
<tr><td colspan="2">Lost ponds</td><td>3</td><td>14.0</td><td>12-18</td></tr>
</table>

Quality of new ponds

The ecological quality of new ponds created since 1998 was assessed using PSYM, and compared to the PSYM values for older ponds identified as created before 1984 in analysis for the Lowland Pond Survey . This analysis was undertaken for lowland ponds in England because PSYM has not been developed for Scotland, and there are no data from new ponds in Wales. The number of new ponds analysed is therefore low: n=11.

New ponds in England were generally better quality than older ponds, with significantly higher overall PSYM scores and significantly higher scores for two of the three PSYM metrics, *Number of Submerged and Emergent Plant species* and the *Number of Uncommon Species.* There was no significant difference between new and older ponds in their *Trophic Ranking Scores*.

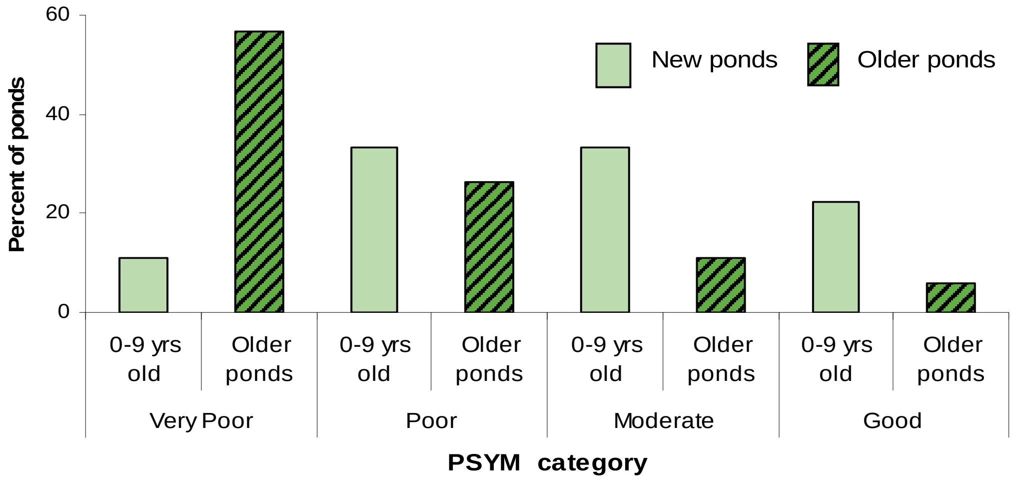
Over half of the new ponds (56%) fell into the top two PSYM quality bands (Good and Moderate). This was true of only 17% of older ponds. The majority of older English ponds (56%) were of Very Poor quality: the lowest PSYM band, whereas only 11% of new ponds were classified as having Very Poor quality (Figure 5.7).

Analysis of the PSYM scores of ponds created between 1990 and 1996 (taken from the Lowland Pond Survey dataset) showed similar results: of the 10 sites, 50% fell into the top two PSYM bands.

Combining LPS96 and Countryside Survey data from 2007 to give a larger dataset of nineteen ponds under 10 years old, around a quarter (24%) had Good PSYM scores, giving them Priority Pond status based on their plant assemblages. This compares to 6% for older ponds in the 2007 dataset.

In total 78 plant species were recorded from the 16 new ponds created between 1998 and 2007. This is 41% of all plant species recorded from the ponds in 2007. None of the new ponds supported rare or Nationally Scarce plant species but they did support four species with a relatively restricted distribution in the UK which are considered 'local' (see Table 2.3). These are: Six-stamened Waterwort (*Elatine hexandra*), the floating liverwort (*Ricciocarpos natans*), Lesser Pondweed (*Potamogeton pusillus*) and Slender Tufted-sedge (*Carex acuta*).

Figure 5.7 Percentage of Countryside Survey 2007 ponds that are new ponds (0-9 years, n=9) and older ponds (24+ years n=113) falling into four PSYM quality category in England. Note that the number of new ponds analysed is low.



How have the new ponds created between 1984 and 1996 developed?

Given the substantial numbers of new ponds created across Britain in the past decade (Section 3.2), a critical issue is whether these new ponds will retain their value in the longer term.

During 2007, Countryside Survey sampled only five ponds created between 1984 and 1996[7], which can be used to investigate these trends. Two of these 11-23 year old ponds were located in semi-natural areas, and both increased in plant richness over the last decade. Both were also priority ponds (based on a Good PSYM score). Plant richness in the three remaining ponds located in areas with more intensive land use (26% - 80% intensive) all declined after 1996. In two of the three sites where PSYM quality could be assessed, pond quality was now Poor or Very Poor.

[7] These are ponds that were mapped for the first time in Countryside Survey in 1990, and then surveyed for the first time in LPS96.

Lost ponds

Environmental data are available from only three ponds lost between 1998 and 2007.

The mean species richness of these ponds when last surveyed in 1996 was 14 species (range 12-18). This is above the mean for lowland ponds in 1996 which was 10 species. Two of the three lost ponds had Good PSYM scores, making them Priority Ponds based on their plant assemblages. The third pond was of Moderate quality.

The three sites supported a total of 32 plant species. Most were common and widespread species, but three can be considered locally uncommon (Table 2.3): Great Yellow-cress (*Rorippa amphibia*), Fat Duckweed (*Lemna gibba*) and Fine-leaved Water-dropwort (*Oenanthe aquatica*).

With only three sites, the sample of lost ponds is very small and therefore very unlikely to be representative of the 18,000 ponds estimated to have been lost in Britain between 1998 and 2007. However the findings, although effectively anecdotal, do provide evidence that ponds of priority quality were lost from the countryside through pond destruction over the last decade.

5.6 Conclusions

Pond quality

Countryside Survey data from 2007 provides consistent evidence that ponds in England and Wales are widely degraded, with around 80% of ponds Poor or Very Poor quality. Levels of degradation in Scotland are more difficult to assess but are likely to be lower.

Analysis suggests that across Britain there is evidence of a relationship between intensive land use variables and poor pond quality. Ponds were significantly poorer in quality or had fewer plant species where they:

(i) had elevated nutrient levels

(ii) were isolated from other waterbodies and wetlands

(iii) were located in areas of arable land

(iv) had inflows.

There was also a relationship between low plant richness and low PSYM score and greater tree shade. This relationship is difficult to disentangle. A decrease in plant richness with increasing tree shade is not unexpected. However, PSYM predictions include the effect of tree shade, so the findings suggest that plant richness in Countryside Survey's shaded ponds is typically lower than would be expected if the ponds were located in semi-natural areas. The finding may be an artefact, due to the associated correlations between shade and arable land (ponds on arable land-use are significantly more shaded). However, it is also possible that shade has a greater negative effect on impacted ponds than it does on pristine sites.

Pond quality decline

Despite the low 1996 baseline, pond quality declined between 1996 and 2007 with a 20% mean drop in plant species richness, and an increase in the proportion of Poor or Very Poor quality ponds from 60% to 72%. There was a broad correlation between land use intensity and reduction in pollution risk, and change in PSYM score between 1996 and 2007. Four individual environmental factors were significantly linked to this decline:

- high nitrogen levels in 2007
- presence of road-runoff in 2007
- presence of a stream inflow in 2007, and
- increasing tree shade between 1996 and 2007.

Set against this, ponds with a higher proportion of waterbodies and wetlands in their surrounds were more likely to maintain their quality over the last decade, particularly where these habitats were closely adjacent to the pond. A number of studies, including the 1996 Lowland Pond Survey, have shown that ponds tend to be better quality, richer or support more uncommon species where they occur in proximity to other wetlands (Linton and Goulder 2003, Williams *et al.* 1998). The current findings support this, by suggesting that ponds may be more resistant to degradation if they occur in proximity to other wetlands. This may be evidence of the protective effects of freshwater networks.

Alien plant species

Across Britain as a whole, around 1 in 10 ponds supported at least one invasive species. The most frequently occurring plants were: New Zealand Pigmyweed, Least Duckweed and Nuttall's Waterweed which each occurred in around 3% of sites. There was no evidence of a significant increase in the occurrence of invasive species in lowland ponds over the last decade. Alien plants were typically associated with ponds that had richer plant communities and, in contrast to nutrient pollution, there was no evidence that they were a negative factor linked to poor pond quality at a national scale.

New ponds

Findings from a small number of new ponds surveyed in CS in 2007 and LPS96 show that new ponds were significantly better quality and supported more plant species than older ponds.

The richness of new ponds was not an unexpected finding: many wetland plants and animals are well adapted to colonising new waterbodies and similar trends have been observed in other studies (Baker and Haliday 1999, Gee *et al*. 1997).

A benefit of the creation of considerable numbers of new ponds over the past decade is that, in the short term at least, it is likely to have increased both the number of Priority Ponds, and the mean plant species richness of ponds in the Britain, at a time when the richness of older ponds is declining (*cf.* Figure 5.2).

Did new ponds retain their value?

Given the numbers of new ponds created in the past decade, a critical issue is will the new ponds retain their biodiversity value in the longer term? Limited data from five 11-23 year old CS ponds concurs with published data (Williams *et al*. 2008) in showing that pond quality and richness was maintained or increased where new ponds were located in semi-natural areas, but declined where ponds were sited in more intensive landscapes.

Lost ponds

Information on the quality of lost ponds in the CS database is very limited. However, of the three small shallow grassland ponds known to have been destroyed between 1996 and 2007, two were of Priority Pond quality, (i.e. of High quality). The third was Moderate quality. All ponds were above average species richness and supported locally uncommon plant species.

Did the new ponds replace the lost ponds?

With such limited information, particularly describing the quality of lost ponds, it is not possible to make a confident assessment of the net effect of pond loss and pond gain on biodiversity.

Within the confines of the CS dataset, both lost and gained ponds had above average species richness, supported uncommon species and were of higher quality than typical countryside ponds. In terms of community type, however there was no overlap in the more uncommon species recorded, and whereas some locally uncommon species in the newer ponds were typical early colonisers, the lost ponds supported species such as Fat Duckweed and Great Yellow-cress which are typically associated with more mature sites.

These limited findings suggest that pond biodiversity gains and losses were broadly similar in terms of number and quality, but that the community types lost when ponds were destroyed were not fully replaced by new pond assemblages.

Note however, that because of the very low numbers of sites considered here, it is not possible to say how broadly applicable these findings are. They should therefore not be generalised to the wider countryside.

Photo 5.4 New ponds colonise rapidly with wetland plants, and within 10 years, many are richer than older countryside ponds. However they may not retain their value in the longer term.

6 Conclusions

This chapter reviews the main results from Countryside Survey in 2007.

6.1 Biodiversity and pond quality

Plant species richness and degradation

In recent years, the considerable biodiversity value of ponds has become more widely acknowledged. Studies have shown that ponds typically support a high proportion (around 70%) of regional and national freshwater biodiversity, and a higher proportion of uncommon species than other waterbody types (Williams *et al*. 2004, Biggs *et al*. 2000, Davies *et al.* 2008, Webb 2008a,b).

In Countryside Survey in 2007, 205 species (around half of GB's wetland plants) were recorded from the 269 ponds surveyed in detail. Of these species, five plant species are of national conservation concern and over 40 can be considered locally uncommon in GB.

At site level, pond plant species richness varied from 0 to 32 species per pond across Great Britain in 2007. The mean species richness was low, at 8.2 species per pond. PSYM analysis showed that many ponds in England and Wales were degraded, with 80% in Poor or Very Poor condition. These ponds supported around 38% of the species that would be expected in pristine ponds and only 21% of the uncommon species.

Good quality, biodiverse ponds were significantly less polluted by nutrients than poor quality ponds and also less likely to be located in intensively managed landscapes, particularly arable farmlands. Good quality ponds were also less likely to have an inflow, were typically less shaded than impacted ponds, and also more likely to have other waterbodies, (including ponds, streams, ditches and wetlands like fens and bogs), in their near surrounds.

These findings from 2007 concur with the results of other GB studies including the Lowland Pond Survey 1996 and the National Pond Survey (Williams *et al*. 1998, Biggs *et al.* 2000). As observed in other studies, the negative relationship between tree shade and pond quality may be partly an artefact of the positive relationship between shade and arable land use. However, similar findings elsewhere suggest that shade may have a disproportionally negative effect on enriched ponds because there are few common plant species characteristic of both shaded and high nutrient level waterbodies (Williams *et al.* 2000).

Pond quality decline

Comparison of lowland ponds in 1996 and 2007 showed that, on average, the number of plant species declined by around 20% over the decade. This was accompanied by a drop in the number of Good or Moderate quality ponds from 40% to 28%.

The CS data provide a first opportunity to look at factors linked to *change* in pond quality. Ponds were especially likely to decline where they were high in nutrients, increased in shade over the decade, or were more isolated from other waterbodies and wetlands. Ponds which received road-runoff or had inflows from streams or ditches were also more likely to degrade.

This is the first national study of trends in pond quality in GB, and it is not known how widely these results can be extrapolated to other biotic groups or if they are representative of a longer term, ongoing decline in pond quality.

Conclusions

Overall CS findings indicate that countryside ponds are extensively degraded and that, in the lowlands at least, pond quality and plant richness have declined from an already low baseline between 1996 and 2007. Factors which analyses indicate have the potential to mitigate against pond quality decline include:

- protection of ponds from agricultural pollutants, including nutrients
- higher densities of new waterbodies which increase the connectivity in the freshwater landscape, particularly waterbodies located in non-intensive areas without inflows or road-runoff
- reduction in tree shade particularly in recently over-shaded sites in agricultural landscapes.

6.2 Pond numbers, loss and gain

Pond numbers

Countryside Survey data show that ponds are an abundant freshwater habitat in Britain. The total pond stock estimated from 2007 data is 478,000, giving a mean density of 2.1 ponds per km^2.

There was a high turnover in pond numbers between 1998 and 2007, with an estimated 18,000 ponds lost and up to 70,600 new ponds created. In numerical terms, the loss of ponds was more than offset by creation of new ponds with an estimated net increase of 1.4% per annum.

The value of new ponds

Ecological data from 0-9 year old ponds surveyed in 2007 indicate that new ponds were relatively species-rich, supported uncommon species and were likely to be of higher quality than older waterbodies.

New ponds are known to colonise rapidly with plants, macroinvertebrates and amphibians (Baker and Halliday 1999, Gee *et al*. 1997, Biggs *et al.* 2005), and a number of other studies have provided evidence which corroborate these findings showing that, in both semi-natural and degraded landscapes, the richness of new ponds typically exceeds the mean richness of older ponds within a few years of their creation (Williams *et al*.1998, 2008, Petranka *et al*. 2003).

The critical question is will new pond quality be maintained in the longer term? Evidence from other surveys suggests this is possible, but likely to depend on the quality of the ponds' surrounding land use and range of other impacts to which they are subjected (Williams and Whitfield 2009, Davies *et al*. 2004, Williams *et al*. 2008). The very limited 2007 data available supports this view: indicating that 11-23 year old ponds increased in species-richness after 1996 if they were located in semi-natural surrounds, but decreased in richness when located in areas of more intensive land use.

On this basis, assessment of the land use around new (0-9 year old) Countryside Survey ponds in 2007 suggests that most ponds are likely to be sub-optimal for biodiversity in the medium to long term: with the majority (73%) of new ponds surrounded by between 25% -100% intensive land use, and around half of the ponds fed by streams or ditches.

Conclusions

The significant increase in the number of ponds in Britain over the last decade has begun to redress the historic loss of ponds which occurred over the last century (see Chapter 1). This gain in pond numbers potentially provides broad biodiversity benefits. In particular, CS data show that new ponds have:

(i) increased the *area* of pond habitats available for freshwater species

(ii) reduced between-waterbody distance, potentially increasing *connectivity* and therefore opportunities for species to move across the landscape and recolonise existing waterbodies where extinctions occur.

There is also evidence to suggest that creation of new ponds may have increased the number of high-quality (Priority Habitat) ponds in the landscape. However, as noted above, the extent to which new ponds can support biodiverse assemblages in the longer term is likely to depend on the quality of their surrounds and the level of impacts they experience. CS data suggest that to achieve this, new ponds should be located where they are buffered from agricultural or other intensive land-use. There is no evidence from CS in 2007 that this was the case. Of the new ponds studied in detail, only 6% had semi-natural surrounds, and all these were in Scotland. The quality of most new CS ponds studied may therefore decline as the waterbodies age.

Value of lost ponds

Although Countryside Survey 2007 data show that a large number of ponds are still being lost from the countryside, there are too few data to enable the quality of these lost ponds to be assessed.

Climate change

There is widespread scientific acceptance that global climate change is likely to have a major impact on Britain's climate over the coming decades with a probable shift towards warmer, drier summers and milder, wetter winters, with a net reduction in water availability and an increase in extreme weather events (Environment Agency 2009).

Ponds are not currently a habitat included within national climate change monitoring programmes, so Countryside Survey provides one of the few tools for assessing the impact of climate change on small waterbodies.

CS data suggests that at least a quarter of lowland ponds are shallow bowls of variable seasonality: drying out in drier years, but remaining wet in years with higher rainfall.

In addition, LPS96 showed that a large proportion of the remaining permanent ponds are quite shallow, and could undergo a transition from a permanent to a semi-permanent state in the relatively near future though natural infilling (Williams *et al*.1998).

Data from other studies has shown that pond wetland plant and invertebrate communities are strongly affected by water permanence, with hydroperiod being the main driver of community type at a regional level (Collinson *et al.* 1995, Nicolet *et al.* 2004). This suggests that any climate-induced changes which alter pond hydroperiod are likely to have profound effects on pond assemblages.

Neither the occurrence of large numbers of seasonal ponds, nor the transition from permanent to temporary waters is inherently undesirable for biodiversity. Semi-permanent and seasonal ponds are distinctive natural waterbody types to which many freshwater plants and animals are well adapted. However, the habitat provided by permanent ponds is potentially ecologically rich and important for many species of invertebrates, aquatic plants and some amphibians which cannot use seasonal sites.

The main concerns about the impact of climate change on ponds are twofold: (i) that the number of permanent pond habitats is reduced, to the detriment of species which depend on this waterbody type, and, potentially more significantly, (ii) that climate shifts and weather extremes increase the rates of local extinctions in ponds (see above), reducing pond richness still further because, in many areas, there are few near-by sources for recolonisation.

As noted above, creation of new ponds has the potential to help combat some of this loss, both by providing new permanent and semi-permanent freshwater habitats, and creating ‘stepping stones’ to enable freshwater species to move across the landscape. The benefits of creation will be considerably enhanced if high quality new ponds can be created, to provide clean-water habitats which will sustain rich assemblages and uncommon species in the long term.

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Appendix 1. Pond associated habitats and species protected under the Habitats Directive[8]

3110 Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae)*

1) Shallow oligotrophic waters with few minerals and base poor, with an aquatic to amphibious low perennial vegetation belonging to the *Littorelletalia uniflorae* order, on oligotrophic soils of lake and pond banks (sometimes on peaty soils). This vegetation consists of one or more zones, dominated by *Littorella*, *Lobelia dortmana* or *Isoetes,* although not all zones may not be found at a given site.
2) Plants: *Isoetes lacustris*, *I. echinospora*, *Littorella uniflora*, *Lobelia dortmanna*, *Deschampsia setacea*, *Subularia aquatica*, *Juncus bulbosus*, *Pilularia globulifera*, *#Luronium natans*, *Potamogeton polygonifolius*; in the Boreal region also *Myriophyllum alterniflorum*, *Drepanocladus* spp., *Warnstorfia* spp. and *Fontinalis* spp.

3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or *Isoeto-Nanojuncetea*

1) 22.12 x 22.31 - aquatic to amphibious short perennial vegetation, oligotrophic to mesotrophic, of lake, pond and pool banks and water-land interfaces belonging to the *Littorelletalia uniflorae* order.
22.12 x 22.32 - amphibious short annual vegetation, pioneer of land interface zones of lakes, pools and ponds with nutrient poor soils, or which grows during periodic drying of these standing waters: *Isoeto-Nanojuncetea* class. These two units can grow together in close association or separately. Characteristic plant species are generally small ephemerophytes.
2) Plants: 22.12 x 22.31: *Littorella uniflora*, *Luronium natans*, *Potamogeton polygonifolius*, *Pilularia globulifera*, *Juncus bulbosus* ssp. *bulbosus*, *Eleocharis acicularis*, *Sparganium minimum*.
22.12 X 22.32 : *Lindernia procumbens*, *Elatine* spp., *Eleocharis ovata*, *Juncus tenageia*, *Cyperus fuscus*, *C.flavescens*, *C.michelianus*, *Limosella aquatica*, *Schoenoplectus supinus, Scirpus setaceus*, *Juncus bufonius*, *Centaurium pulchellum*, *Centunculus minimus*, *Cicendia filiformis*.

3140 Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.

1) Lakes and pools with waters fairly rich in dissolved bases (pH often 6-7) (21.12) or with mostly blue to greenish, very clear, waters poor (to moderate) in nutrients, base-rich (pH often >7.5)
(21.15). The bottom of these unpolluted water bodies are covered with charophyte, *Chara* and *Nitella*, algal carpets. In the Boreal region this habitat type includes small calcareous-rich oligomesotrophic gyttja pools with dense *Chara* (dominating species is *C. strigosa*) carpets, often surrounded by various eutrophic fens and pine bogs.
2) Plants: *Chara* spp., *Nitella* spp.

3150 Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* - type vegetation

1) Lakes and ponds with mostly dirty grey to blue-green, more or less turbid, waters, particularly rich in dissolved bases (pH usually > 7), with free-floating surface communities of the *Hydrocharition* or, in deep, open waters, with associations of large pondweeds (*Magnopotamion*).
2) Plants: *Hydrocharition - Lemna* spp., *Spirodela* spp., *Wolffia* spp., *Hydrocharis morsus-ranae, Stratiotes aloides, Utricularia australis, U. vulgaris, #Aldrovanda vesiculosa,* Ferns (*Azolla*), Liverworts (*Riccia* spp., *Ricciocarpus* spp.); *Magnopotamion - Potamogeton lucens, P. praelongus, P. zizii*, *P. perfoliatus*.

3160 Natural dystrophic lakes and ponds

1) Natural lakes and ponds with brown tinted water due to peat and humic acids, generally on peaty soils in bogs or in heaths with natural evolution toward bogs. pH is often low, 3 to 6. Plant communities belong to the order *Utricularietalia*.
2) Plants: *Utricularia* spp, *Rhynchospora alba*, *R. fusca*, *Sparganium minimum*, *Sphagnum* species. In the Boreal region also *Nuphar lutea*, *N. pumila*, *Carex lasiocarpa*, *C. rostrata*, *Nymphaea candida*, *Drepanocladus* spp., *Warnstorfia trichophylla*, *W. procera*.
Animals: Odonata (dragonflies and damselflies)

[8] *Information source*: Interpretation Manual of the European Union Habitats (2007) European Commission DG Environment (Nature and Biodiversity).

3170 *Mediterranean temporary ponds

1) Very shallow temporary ponds (a few centimetres deep) which exist only in winter or late spring, with a flora mainly composed of Mediterranean therophytic and geophytic species belonging to the alliances *Isoetion, Nanocyperion flavescentis, Preslion cervinae, Agrostion salmanticae, Heleochloion* and *Lythrion tribracteati.*
2) Plants: *Agrostis pourretii, Centaurium spicatum, Chaetopogon fasciculatus, Cicendia filiformis, Crypsis aculeata, C. alopecuroides, C. schoenoides, Cyperus flavescens, C. fuscus, C. michelianus, Damasonium alisma, Elatine macropoda, Eryngium corniculatum, E. galioides, Exaculum pusillum, Fimbristylis bisumbellata, Glinus lotoides, Gnaphalium uliginosum, Illecebrum verticillatum, Isoetes boryana, I. delilei, I. duriei, I. heldreichii, I. histrix, I. malinverniana, I. velata, Juncus buffonius, J. capitatus, J. pygmaeus, J. tenageia, Lythrum castellanum, L. flexuosum, L. tribracteatum, Marsilea batardae, M. strigosa, Mentha cervina, Ranunculus dichotomiflorus, R. lateriflorus, Serapias lingua, S. neglecta, S. vomeracea.*

3180 * Turloughs

1) Temporary lakes principally filled by subterranean waters and particular to karstic limestone areas. Most flood in the autumn and then dry up between April and July. However, some may flood at any time of the year after heavy rainfall and dry out again in a few days; others, close to the sea, may be affected by the tide in summer. These lakes fill and empty at particular places. The soils are quite variable, including limestone bedrock, marls, peat, clay and humus, while aquatic conditions range from ultra oligotrophic to eutrophic. The vegetation mainly belongs to the alliance *Lolio-Potentillion anserinae* Tx. 1947, but also to the *Caricion davallianae* Klika 1934.
2) Plants: *Cinclidotus fontinaloides, Fontinalis antipyretica* (Bryophyta).
Animals: *Tanymastix stagnalis* (wet phase) and the beetles *Agonum lugens*, *A. livens, Badister meridionalis, Blethisa multipunctata* and *Pelophila borealis* (dry phase) 15.

2190 Humid dune slacks

1) Humid depressions of dunal systems. Humid dune-slacks are extremely rich and specialised habitats very threatened by the lowering of water tables.
16.31 - Dune-slack pools (*Charetum tomentosae, Elodeetum canadense, Hippuridetum vulgaris, Hottonietum palustris, Potametum pectinati*): fresh-water aquatic communities (cf. 22.4) of permanent dune-slack water bodies.
16.32 - Dune-slack pioneer swards (*Juncenion bufonii* p.: *Gentiano-Erythraeetum littoralis, Hydrocotylo-Baldellion*): pioneer formations of humid sands and dune pool fringes, on soils with low salinity.
16.33 - Dune-slack fens: calcareous and, occasionally, acidic fen formations (cf. 54.2, 54.4, in particular 54.21, 54.2H, 54.49), often invaded by creeping willow, occupying the wettest parts of dune-slacks.
16.34 - Dune-slack grasslands: humid grasslands and rushbeds (see 37.31, 37.4) of dune-slacks, also often with creeping willows (*Salix rosmarinifolia*, *S. arenaria*).
16.35 - Dune-slack reedbeds, sedgebeds and canebeds: reedbeds, tall-sedge communities and canebeds (cf. 53.1, 53.2, 53.3) of dune-slacks.

21A0 Machairs (* in Ireland)

1) Complex habitat comprised of a sandy coastal plain resulting partially from grazing and/or rotational cultivation, in an oceanic location with a cool, moist climate. The wind blown sand has a significant percentage of shell derived material, forming a lime rich soil with pH values normally greater than 7. Vegetation is herbaceous, with a low frequency of sand binding species.
2) Plants: *Cochlearia scotica, Dactylorhiza fuchsii* ssp. *hebridensis, Euphrasia marshallii, Festuca rubra, Galium verum, Lotus corniculatus, Plantago lanceolata, Poa pratensis, Trifolium repens*.
4) Lakes (ponds and small lakes in Scotland) of widely varying salinity, pH and chemical composition, transitions to saltmarsh and blanket bog are associated habitats. In the United Kingdom, twelve different types of vegetation under the National Vegetation Classification can be identified.

* UK BAP Priority Habitat

Appendix 2. Priority Pond criteria[9]

BAP Priority Habitat Ponds are defined as permanent and seasonal standing water bodies up to 2ha[10] in extent, which meet one or more of the following criteria.

- *Habitats of high conservation importance.* Ponds that meet criteria under Annex 1 of the Habitats Directive.
- *Species of high conservation importance*. Ponds supporting Red Data Book species, BAP species, species fully protected under the Wildlife and Countryside Act Schedule 5 and 8, Habitats Directive Annex II species, a Nationally Scarce wetland plant species[11], or three Nationally Scarce aquatic invertebrate species.
- *Exceptional assemblages of key biotic groups*: Ponds supporting exceptional populations or numbers of key species. Based on (i) criteria specified in guidelines for the selection of biological SSSIs (currently amphibians and dragonflies only), and (ii) exceptionally rich sites for plants or invertebrates (i.e. supporting ≥30 wetland plant species[2] or ≥50 aquatic macroinvertebrate species).
- *Ponds of high ecological quality:* Ponds classified in the top PSYM category ("high") for ecological quality (i.e. having a PSYM score ≥75%). [PSYM (the Predictive SYstem for Multimetrics) is a method for assessing the biological quality of still waters in England and Wales. Plant species and / or invertebrate families are surveyed using a standard method. The PSYM model makes predictions for the site based on environmental data and using a minimally impaired pond dataset. Comparison of the prediction and observed data gives a % score for ponds quality.]
- *Other important ponds:* Individual ponds or groups of ponds with a limited geographic distribution recognised as important because of their age, rarity of type or landscape context e.g. pingos, duneslack ponds, machair ponds.
- Estimates based on the relatively small pond data sets currently available suggest that around 20% of the c.400,000 ponds outside curtilage in the UK might meet one or more of the above criteria.

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[9] *Information source*: Species and Habitat review report 2007, Annexes 4-6, p131 See: www.ukbap.org.uk.

[10] The "Lakes" HAP 2005 Targets review quantification of the lakes resource in UK was based on lakes >1 ha in size. This overlap can be managed by liaison between the two HAPs.

[11] Includes emergent, submerged and floating-leaved plant species.

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For further information on Countryside Survey see www.countrysidesurvey.org.uk

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