Interim Report R&D Project 383

Experimental Management of Wetland Habitats at Pinkhill Meadow

Pond Action

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Experimental Management of Wetland Habitats at Pinkhill Meadow

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EXECUTIVE SUMMARY

1. INTRODUCTION

This report describes the interim results of survey, monitoring and experimental work undertaken by Pond Action for the NRA National R&D Project F01(91) 2 383 'Wetland creation/river corridor enhancement'. The project has two main parts:

(i) a post-project appraisal of the nature conservation value of a typical off-river enhancement scheme.
(ii) an experimental investigation of the management of vegetation in newly created wetland habitats.

The work is being undertaken at the new Pinkhill Meadow Nature Reserve, Farmoor Reservoir, Oxfordshire. where a new 2ha wetland has been created on existing flood meadow adjacent to the River Thames. The Reserve was established by Thames Water Utilities Limited and NRA Thames Region in two phases between July 1990 and February 1992, with ecological advice from Pond Action. In Phase 1 four ponds of varying size, depth and water regime were created. These were extended in Phase 2 to establish a mosaic of wetland habitats with permanent and temporary water, mud flats and areas of new wet meadow.

2. POST-PROJECT APPRAISAL

Post-project appraisal has focussed on assessing the nature conservation value of the new wetland habitats, with monitoring of water chemistry, wetland plants, macroinvertebrates, waders and waterfowl. To date, water chemistry, plant and invertebrate surveys have mostly concentrated on the four Phase 1 ponds (Main Pond, Scrape, Groundwater Pond and Surfacewater Pond). Bird surveys have dealt with the whole site.

2.1. Water chemistry

Monitoring of water chemistry suggests that the four Phase 1 ponds are chemically similar with no systematic differences between the groundwater and surfacewater fed ponds. The pH of the ponds is fairly typical of mid-Oxfordshire standing waters. Phosphate (SRP.P) levels were moderate to low, and total oxidised nitrogen (TON) concentrations also low (with some exceptions), for Oxfordshire ponds.

2.2. Wetland plants

There has been extensive natural colonisation of the site, particularly in low marginal areas, areas adjoining the existing meadow and the deep-water areas of the Main Pond. The site was designed so that some areas would colonise slowly, to provide bare mud for waders: these areas have mostly remained uncolonised. Six main plant communities have been distinguished so far, reflecting differences in water levels and substrates.

Compared with other Oxfordshire ponds, the number of species recorded in the Main Pond in 1992 was high, in other ponds it was near average. The number of plant species recorded from the site as a whole increased from 36 in 1991 to 49 in 1992. No very uncommon wetland plant species were recorded, but all the ponds supported at least one nationally local species and the Main Pond supported four. All the ponds supported plant communities of 'moderate' national conservation value (on a scale of low, moderate, high or very high).

2.3. Aquatic macroinvertebrates

The total number of macroinvertebrate species recorded from the four Phase 1 ponds increased from 12 in July 1990 to 84 in July 1992. The earliest colonists were species which fly freely (eg water beetles, water bugs, mayflies). Dragonfly species increased steadily over the period of survey and leeches, crustaceans and snails gradually became established. One rare and 14 local species have been recorded so far. All the ponds supported invertebrate communities of 'high' national conservation value (on a scale of low, moderate, high, very high).

2.4 Birds

16 species of wader have been recorded on the Pinkhill wetlands so far. Almost all wader activity has been concentrated on the Main Pond, particularly the islands, the muddy western edges and the bund between the Main Pond and the Scrape.The Scrape itself has so far proved of little attraction to waders.

Daily bird records collected since 1982 by birdwatchers visiting Farmoor Reservoir have given a baseline with which to compare wader numbers at Farmoor following excavation of the Pinkhill wetlands. The reliability of birdwatcher data was confirmed with additional survey work by Pond Action.

Multiple regression analysis of daily bird records was used to predict the numbers of waders that would have been expected at Farmoor during the autumn migration in the absence of the Pinkhill Reserve. Comparison of predicted with actually observed numbers for autumn 1990, 1991 and 1992 suggests that there has been a significant increase in the number of waders recorded on the Farmoor Reservoir site following the construction of the Pinkhill wetlands.

3. EXPERIMENTAL PONDS

Seven experimental ponds were created in February 1992 and will be monitored over the next two years. Two experiments were designed.

Experiment 1 (Ponds 1 - 3) is concerned with management for the establishment of species-rich plant communities in new wetland habitats. The ponds were planted-up during July 1992 with nine wetland species. Monitoring of the ponds in September 1992 suggests that the success rate of establishment has been variable. The success of the planting is unlikely to be completely clear until next summer.

Experiment 2 (Ponds 4 - 7) is an investigation of the relationship between plant species-richness and macroinvertebrate species- richness. One pair of ponds will be maintained as 'species-poor', and the other pair as 'species-rich' sites. The ponds were planted up with emergent and aquatic plants in late June /early July 1992. Monitoring in September 1992 indicates that marginal plants are establishing well, although establishment of aquatic species seems more variable.

TECHNICAL SUMMARY

1. INTRODUCTION

This report describes the interim results of survey, monitoring and experimental work undertaken by Pond Action for the NRA National R&D Project F01(91) 2 383 'Wetland creation/river corridor enhancement'. The work is being undertaken at the new Pinkhill Meadow Nature Reserve, Farmoor Reservoir, Oxfordshire. The project was initiated in 1990 as an NRA Thames Region Operational Investigation, and became a national R&D Project in 1992.

The project has two main parts:

- a post-project assessment of the nature conservation value of an off-river enhancement scheme, using the newly created Pinkhill Meadow Nature Reserve as an example of NRA enhancement schemes.
- an experimental investigation of the management of wetland vegetation in newly created wetland habitats to promote the establishment of species-rich plant and invertebrate communities.

2. PINKHILL MEADOW NATURE RESERVE

Pinkhill Meadow Nature Reserve was created on land owned by Thames Water Utilities Ltd. (TWUL) at its Farmoor Reservoir site. Establishment of the Reserve was a joint TWUL and NRA Thames Region project. The Pinkhill Reserve lies within floodplain grassland and is surrounded on two sides by a meander bend of the River Thames. The Reserve was established to increase the variety of wetland habitats on the Farmoor site and, in particular, to provide shallow water habitats for wading birds. It was also designed to provide a variety of habitats for aquatic plants and invertebrates. Pond Action gave ecological advice during design and construction of the reserve.

The Reserve was created in two stages. In Phase 1 (June - July 1990) the first four ponds, of varying size, depth and water regime, were created. In Phase 2 (December 1991 - February 1992) these ponds were considerably extended to create a mosaic of wetland habitats, including permanent and temporary waters, mud-flats and areas of wet meadow.

3. POST-PROJECT APPRAISAL

Post-project assessment work has focussed on assessing the nature conservation value of the newly created wetland habitats. Monitoring programmes have aimed to describe basic water chemistry, colonisation by aquatic plants and macroinvertebrates, and the use of the site by waders and other water birds.

Water and chemical sampling has been concentrated on the four original waterbodies created during Phase 1 of the project (ie the Main Pond, Scrape, Groundwater Pond and Surfacewater Pond). Plant and bird surveys have dealt with the whole of the site.

3.1 Water chemistry

The aims of water chemistry monitoring have been:

- to provide baseline data which can aid interpretation of the wildlife community data.
- to monitor the chemical differences between ponds, through time.

Water samples were collected monthly between April 1991 and March 1992. Recommencing bi-monthly in July 1992.

Results suggest that the ponds are chemically similar. There seem to be no systematic differences between the chemistry of ponds fed by groundwater and those fed by surfacewater.

The pH of the ponds predominantly fell in the range of 7 - 8.5, which is fairly typical of standing waters in mid-Oxfordshire. Phosphate (SRP.P) levels were all moderate to low for this area (less than 0.05 mg/l). Total oxidised nitrogen (TON) concentrations were also relatively low for Oxfordshire ponds (most fell below the analytical detection limit of 0.1 mg/l). However, TON concentrations were higher in winter 1991/92, when concentrations in some ponds rose to 6 mg/l. This increase may in part have been due to disturbance associated with the Phase 2 constructions and/or inputs of groundwater from the adjacent R. Thames.

3.2 Wetland plants

The main aims of plant survey work on the site have been:

- to describe the development of the wetland plant community.
- to assess the conservation value of the plant community. Surveys were undertaken in summer 1991 and 1992.

3.2.1 Development of the wetland plant community

Most Phase 1 ponds were completely reworked during Phase 2 construction so that, with the exception of deep water areas, colonisation on the site more-or-less started from scratch in February 1992.

Plant colonisation during the 1992 growing season was patchy. Areas that were particularly well-colonised were: (i) low marginal areas with some topsoil present, eg areas of new wet meadow and some shallow pools; (ii) areas immediately adjacent to the existing meadow, where nutrients, seeds and stoloniferous plants spread onto the new site; and (iii) deep- water areas of the Main Pond, where aquatics, particularly *Chara vulgaris* and *Potamogeton pusillus*, formed locally extensive stands.

The site was specifically designed so that some areas of low ground would colonise slowly and retain bare areas of mud for wading birds. These areas, in particular the western margins of the Main Pond and the Scrape, have, in general, as was intended, remained uncolonised.

It is currently possible to distinguish six main plant communities on the site. These communities broadly reflect the level of the ground with respect to water level and the type of substrate present. It is likely that, as the site matures, it will be possible to distinguish further communities.

3.2.2 Conservation value of the wetland plant community

The conservation value of the plant community of individual ponds has been assessed on the basis of (i) the number of wetland plant species present; and (ii) the occurrence of nationally uncommon plant species. This information has been used to place each pond in one of four National Conservation Categories: low, moderate, high or very high.

Pinkhill Site as a whole

Despite the drastic reworking of the site during Phase 2 excavation, the wetland site supported 49 wetland plant species in 1992. There is very little information with which to compare this rate of colonisation but the total number of species seems moderate or high compared to other wetland sites of similar size in Oxfordshire.

Individual Ponds

Individual ponds on the Pinkhill site varied considerably in the number of species (and also local species) that they supported. In particular, the Main Pond supported much higher numbers of plant species (37 in total) than the other ponds (10 - 23 species). The Main Pond was particularly rich in aquatic plants (8 species recorded, including 3 *Potamogeton* spp). Compared with other ponds in Oxfordshire, the number of species recorded in the Main Pond was high. In the other Pinkhill ponds, the number of species was near-average.

No very uncommon wetland plant species have been recorded from the site, but 9 species which are considered to be nationally 'local' were found.

The main pond supported 4 nationally local species (*Potamogeton obtusifolius*, *Potamogeton perfoliatus*, *Potamogeton pusillus*, *Ranunculus trichophyllus*). Other ponds all supported one local species (*Ranunculus trichophyllus*).

The national conservation value of the plant communities in all the ponds was in the 'moderate' category (on four point scale: low, moderate, high, very high). However the individual Conservation Index was higher for the Main Pond than for other ponds on the site.

3.3. Aquatic macroinvertebrates

The main aims of the invertebrate survey work carried out on the Main Pond, Groundwater Pond, Surfacewater Pond and Scrape have been:

- to describe the colonisation of the four ponds by macroinvertebrates.
- to assess the nature conservation value of the macroinvertebrate communities of the four ponds.
- to assess the relative importance of different microhabitats within the ponds for macroinvertebrates.

3.3.1 Colonisation of the ponds

Surveys were carried out in spring, summer, autumn and winter in the first year of the study (July 1990 - May 1991). Since then surveys have been carried out annually.

The numbers of invertebrate species recorded from the four ponds increased from between five and seven in the first sample, to between 25 and 45 in the July 1992 sample. The cumulative total of species for all four ponds increased from 12 in the first season to 84 after five samples.

During the first twelve months of colonisation, the abundance of macroinvertebrates increased systematically throughout the year. The earliest colonisers were species which fly freely (eg water beetles, water bugs, mayflies), and some of these (e.g. the mayflies *Cloeon dipterum* and *Caenis luctuosa*, and the diving beetle *Hydroglyphus pusillus*) became particularly abundant during the first year.

Since the first survey, the water beetles and water bugs have continued to constitute a major part of the fauna in terms of numbers of species. In addition, a rich still-water mayfly community has already developed in the ponds, the number of dragonfly species has steadily increased over the period of survey, leech and crustacean species have become established, and the most recent survey (July 1992) produced the first records of snails for the site. Although only three species were recorded, two of these, the Wandering Snail (*Lymnaea peregra*) and the Dwarf Pond Snail (*Lymnaea truncatula*), were distributed widely over the site.

3.3.2 Species-richness and the occurrence of rare and local species

The cumulative total of 84 species for the site (to July 1992) included one rare and 14 local species. All four of the ponds supported communities which were of 'high' national conservation value. All sites have relatively rich macroinvertebrate communities, with good numbers of local and notable species (between seven for the Groundwater Pond and 11 for the Main Pond).

3.3.3 Invertebrate community structure

In order to describe invertebrate community structure in the four Pinkhill ponds, the results from surveys of pond microhabitats were analysed, using the ordination technique Detrended Correspondence Analysis (DECORANA).

The May 1991 analysis indicated that each pond had a reasonably distinct macroinvertebrate community. The major difference in the macroinvertebrate composition of the microhabitat samples appeared to be correlated with the proportion of beetles and corixid bugs present.

The addition of the data from the July 1992 survey allowed a re-interpretation of the results of the 1991 survey. The differences in the macroinvertebrate composition of the ponds seen in 1991 appeared to be secondary to the effects of colonisation. The colonisation of the ponds as indicated by DECORANA appears to be associated with a decrease in the importance of beetles in the analysis and an increase in the importance of bugs. Several species, including the more slowly-colonising species (such as the Dwarf Pond Snail *Lymnaea truncatula*) were highly indicative of the major changes in the macroinvertebrate community as highlighted by the DECORANA analysis.

3.4 Birds

Bird monitoring work has had three main objectives:

- To record the species of wader and waterfowl using the new Pinkhill wetlands.
- To determine which areas of the Pinkhill wetlands are most attractive to different wetland birds.
- To determine whether numbers of waders using the Farmoor site as a whole have increased following the creation of the new wetlands.

A total of 16 species of wader (and 34 wetland species altogether) have been recorded from the Pinkhill wetlands between 1990 and 1992. Uncommon visitors have included Temminck's Stint and Garganey.

No wetland birds bred on the site in 1990 or 1991 breeding seasons, but in 1992 Little Ringed Plover, Lapwing and Tufted Duck all reared young.

Almost all wetland bird activity was concentrated on the Main Pond and its margins. The areas which were used most heavily were the islands, the muddy western edges, and the bund between the Main Pond and the Scrape.The Scrape itself has so far proved of little attraction to waders.

Preliminary analyses of habitat preference data suggested that migrant waders made more use of the island habitats than did the resident Little Ringed Plovers, which tended to forage around the pond edges.

Daily bird records collected by local birdwatchers visiting Farmoor Reservoir since 1982 have been used to give a baseline with which to compare wader numbers following excavation of the Pinkhill wetlands. Bird survey work undertaken by Pond Action indicates that the data gathered by birdwatchers gives reliable estimates of wader numbers.

Multiple regression analysis (MRA) has been used to correlate monthly wader counts with environmental data (principally climate data) in order to model the seasonal and between-year variations in wader numbers using Farmoor.

These MRA equations can successfully predict the numbers of waders that would be expected at Farmoor in the absence of the Pinkhill Reserve. Comparison of the predicted with the actually observed numbers of waders for the last two years suggests that there has been a significant increase in the number of waders recorded on the Farmoor site following the construction of the Pinkhill wetlands.

4. EXPERIMENTAL PONDS

Seven experimental ponds were created during the Phase 2 excavations in February 1992. Ponds were planted-up with wetland plants in summer 1992.

4.1 Experiment 1 (Ponds 1 - 3): an investigation of management techniques for establishing species-rich plant communities in new wetlands

Three ponds are being used for experiments on management for the establishment of species-rich plant communities in new habitats. These were planted up during July 1992 with nine wetland species: *Alisma plantago-aquatica*, *Glyceria fluitans*, *Phalaris arundinacea*, *Polygonum amphibium*, *Ranunculus sceleratus*, *Typha latifolia*, *Veronica beccabunga*, *Agrostis stolonifera* and *Juncus articulatus*.

Water levels were exceptionally high during the summer months of 1992. Species were planted into water which was 0.15 m - 0.2 m deep instead of the 0 - 0.1 m deep which had been expected and would have been preferable. In the month after planting water levels increased again by up to 0.15 m.
Monitoring of the ponds in September 1992 suggests that the success rate of establishment has been variable. *Typha*, *Juncus articulatus* and *Glyceria fluitans* appear to have established well, the other species more poorly. This may in part have been due to the very high water levels, although autumn die-back may also have contributed. The success of the planting is unlikely to be completely clear until next summer.

4.2 Experiment 2 (Ponds 4 - 7): an investigation of the relationship between the species-richness of aquatic macroinvertebrate communities and wetland plant species-richness

Four ponds are being used to investigate the relationship between plant species-richness and macroinvertebrate species- richness. One pair of ponds will be maintained as 'species-poor' sites, supporting only one stand-forming emergent plant (*Glyceria maxima*) and one submerged plant (*Potamogeton pusillus*). The other pair of ponds will be maintained as 'species-rich' sites, and have been planted with five stand-forming emergent species (*G.maxima*, *Sparganium erectum*, *Phragmites arundinacea*, *Schoenoplectus lacustris*, *Carex riparia*) and five submerged species (*P.pusillus*, *Ceratophyllum demersum*, *Myriophyllum spicatum*, *Elodea nuttallii*, *Ranunculus trichophyllus*).All four ponds will be managed to maintain the original number of species planted. Other colonising species will be removed.

The ponds were planted up with marginal plants in late June/early July. Emergent plants were put in at a density of five plants per square metre. Aquatic plants were put in at the density of two small bunches per square metre. Monitoring in September 1992 indicates that marginal plants are establishing well, although establishment of aquatic species seems more variable.

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1. INTRODUCTION

This report describes the interim results of survey, monitoring and experimental work undertaken by Pond Action for the NRA National R&D Project F01(91) 2 383 "Wetland Creation/River Corridor Enhancement". The work is being undertaken at the new Pinkhill Meadow Nature Reserve, Farmoor Reservoir, Oxfordshire. The project was initiated in 1990 as an NRA Thames Region Operational Invetigation, becoming a national R&D Project in 1992.

The project has two main parts:

(i) a post-project assessment of the nature conservation value of a river corridor enhancement scheme (the new Pinkhill Meadow Nature Reserve at Farmoor Reservoir, Oxford).

(ii) an experimental investigation of the management of wetland vegetation to promote plant and invertebrate community diversity, using seven experimental ponds on the Pinkhill Meadow Nature Reserve.

Work on part (i) of the project began in 1990. Work on part (ii) started in 1992.

1.1 Background

1.1.1 Background to the study

Wetland creation and enhancement schemes are widely perceived as being an important tool for maintaining or re-establishing the nature conservation value of river corridors. Enhancement schemes are an important part of the NRA's river conservation work. They are also frequently proposed in private sector planning applications, where the (perceived) benefits to nature conservation of enhancements are used to give a "planning gain" or to offset habitat loss or degradation elsewhere.

Despite their popularity, there is little information about the real conservation benefits of wetland enhancement and creation schemes. The NRA is currently addressing this problem through a number of projects, including R&D Project F01(91)11, "Appraisal of conservation enhancement of flood defence works", Project FRC/111/F/1 "River Rehabilitation - NRA Head Office Feasibility Study", as well as the work at Pinkhill Meadow.

Post-project assessment of the habitat creation work at Pinkhill will:

(i) provide data on the conservation value of the plant, invertebrate and bird communities of new off-river wetland enhancements.
(ii) provide data that will allow designs for similar schemes to be refined in the future.

The programme of experimental work will provide information about practical management of enhancement schemes and their effect on nature conservation value.

1.1.2 Initiation of the Pinkhill Wetland Enhancement Project

The Pinkhill Wetland Enhancement Project was initiated in 1990 by Thames Water Utilities Ltd. (TWUL) and NRA (Thames Region). Construction works were jointly funded by TWUL and NRA (Thames). The aim of the project was to create a new wetland nature reserve within the TWUL site at Farmoor Reservoir, near Oxford. The area was also intended from the outset to function as a monitoring site. The initial stages of monitoring were funded by NRA (Thames Region).

Pond Action provided ecological advice during the creation of the nature reserve and on-site supervision during the construction work. A description of the Pinkhill reserve and its creation is given in Table 1.1. A map of the site is shown on page 4.

1.2 Objectives of the Pinkhill project

1.2.1 Post-project monitoring

Post-project monitoring of the Pinkhill site has aimed to describe:

(i) water quality in the ponds, providing basic data which will help interpretation of the developing wildlife communities.

(ii) the development and conservation value of the wetland plant communities of the site.

(iii) the development and conservation value of the aquatic invertebrate communities of the site.

(iv) the use of the site as a feeding and breeding habitat for birds, particularly waders and waterfowl.

1.2.2 Experimental site management

The objectives of experimental site management are to set up experimental areas in which to investigate:

(i) Practical management methods used to establish species-rich plant communities in wetland habitats created during enhancement schemes: eg management after planting by selective cutting, weeding or herbicide treatment.

(ii) The influence of plant species-richness on the species-richness of aquatic macroinvertebrate communities in ponds created as part of wetland enhancement schemes.

1.2.3 Useful information

- A map of Pinkhill is shown on page 4.
- A timetable showing all the creation and monitoring work done for the Pinkhill project so far is given in Table 1.1
- A list of Pond Action reports relating to Pinkhill is given in Appendix 1.
- An outline of the Pinkhill research and monitoring programme is also given in Appendix 1.

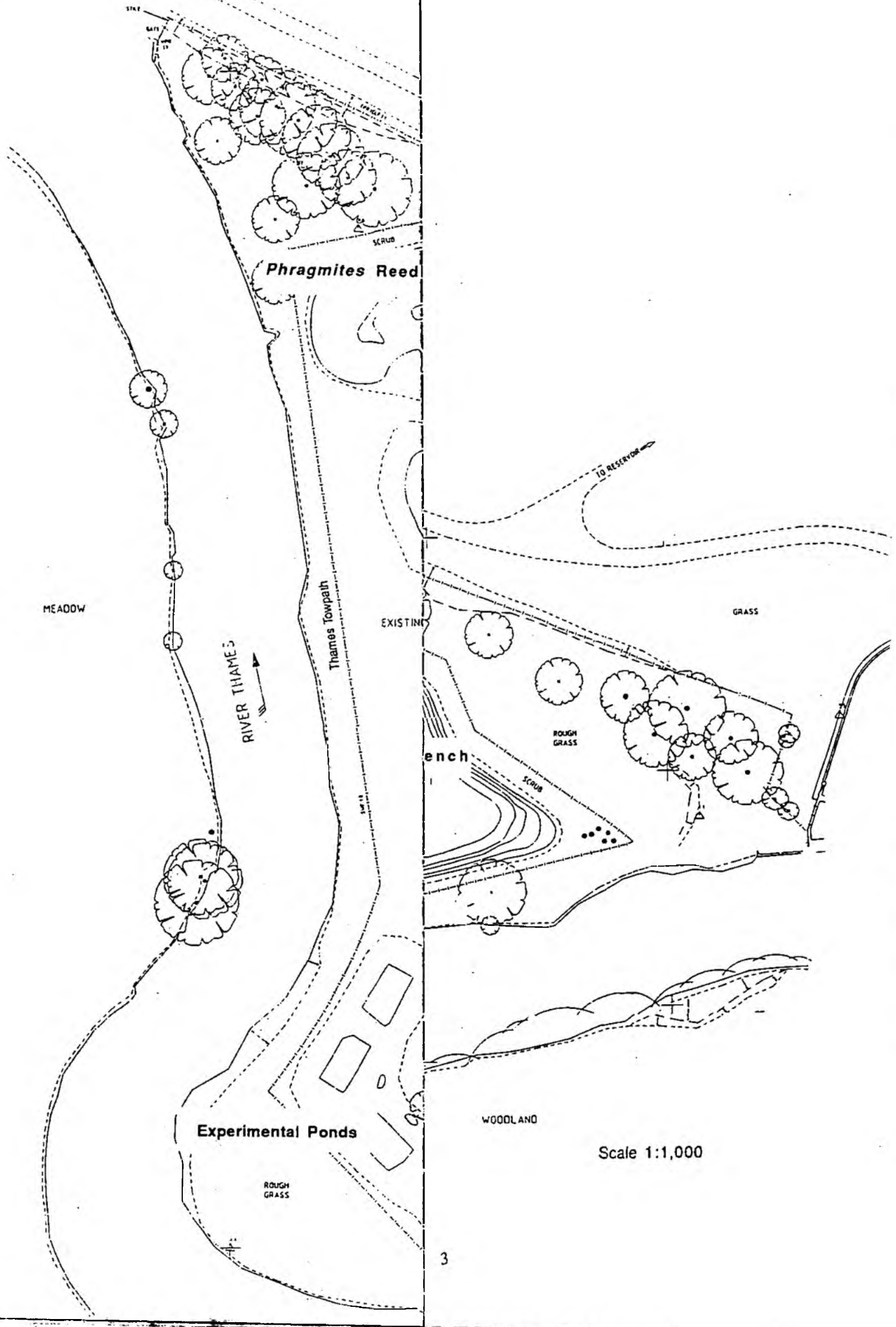
1.3 Aims of the report

This progress report describes the results of monitoring of the Pinkhill ponds since the initiation of Phase 1 of the Pinkhill Meadow Wetland Enhancement Project.

This includes information on:

- Water chemistry (see Section 2)
- Plant communities (see Section 3)
- Invertebrate communities (see Section 4)
- Birds (see Section 5).

The report also describes the first stages of work on the experimental ponds (see Section 6).


Phragmites Reed
SCRUB
TO RESERVOIR
MEADOW
RIVER THAMES
Thames Towpath
EXISTING
GRASS
ROUGH GRASS
SCRUB
WOODLAND
Experimental Ponds
ROUGH GRASS

Scale 1:1,000

Figure 1.1 Pinkhill Meadow. Work undertaken between April 1990 and October 1992

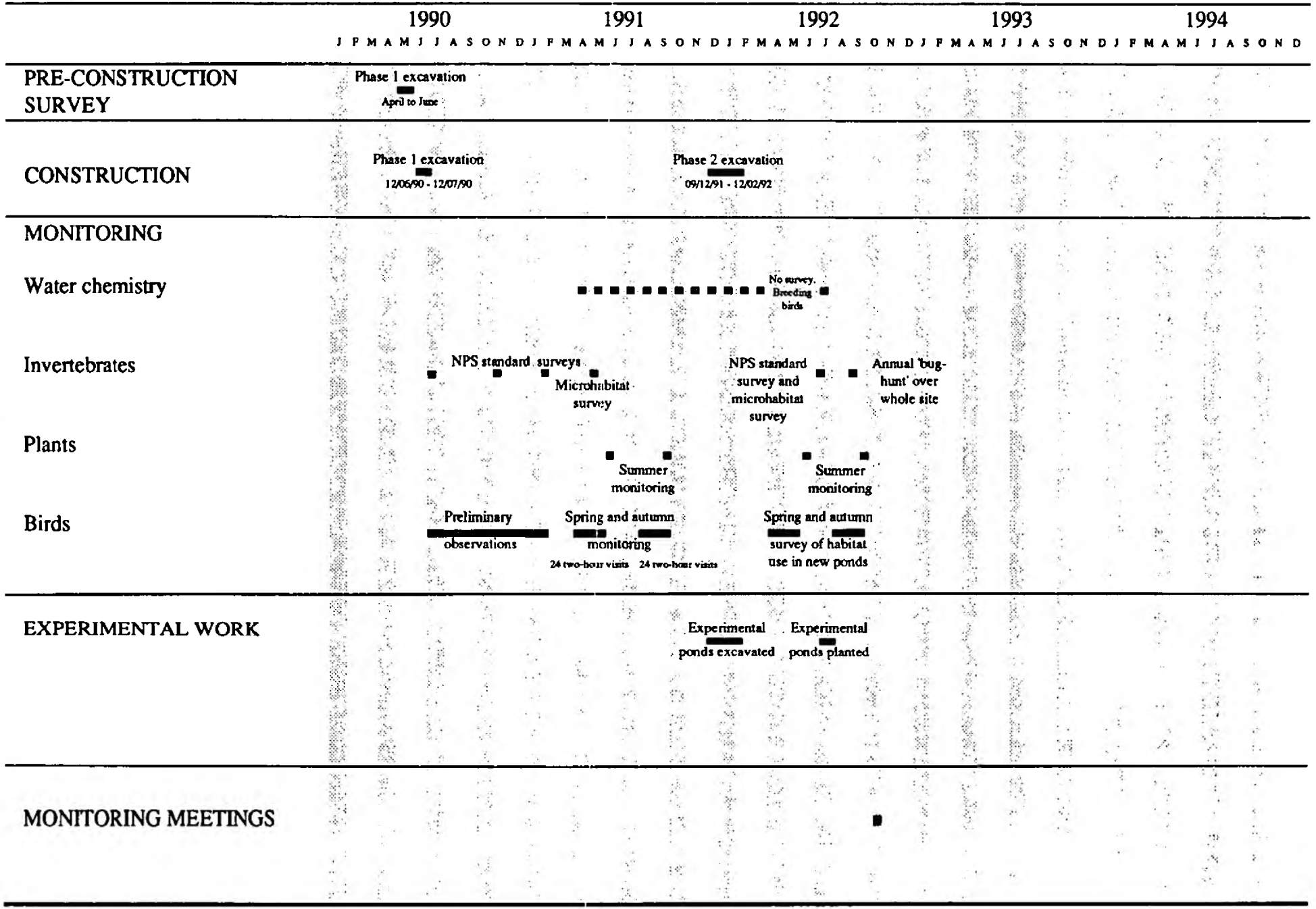


Table 1.1 Creation of the Pinkhill Nature Reserve

Physical characteristics of the Pinkhill site

Pinkhill Meadow is an area of floodplain grassland surrounded on two sides by a meander bend in the River Thames (SP 439067). The meadow lies directly upon deposits of R.Thames alluvium of variable thickness (0.8 m to more than 4 m). The alluvium in turn overlies River Terrace gravels, which support a shallow confined aquifer. Water levels of the **unconfined** aquifer lie approximately 0.5 m below the meadow surface, but fluctuate (with the level of the R.Thames) by approximately 0.4 m during the year. It is likely that the gravel aquifer is in at least partial hydraulic continuity with the River Thames. Excavations into the alluvial layer alone fill slowly with 'surfacewater'. The water levels in surfacewater pools fluctuate more than those extending into the gravels: they are generally higher in winter and lower in summer.

Construction of the Pinkhill Meadow Wetland

The construction of the Pinkhill Meadow Wetland occurred in three main stages:

(i) Pre-excavation Monitoring (April - May 1990):

Initial plant surveys of Pinkhill meadow indicated that it supported four main plant communities (Wet Meadow, Leve, Degraded (rye-grass) Meadow, Rich Meadow). The first three communities contained little of interest; the Rich Meadow, however, supported a number of 'old meadow' indicators, including *Ophioglossum vulgatum* and *Silaum silaus*. The Phase 1 and Phase 2 excavations were designed to retain the maximum amount of this high quality community. The main exception was a single 1-m^2 turf containing a number of *Ophioglossum* plants. This turf was transplanted into a suitable area of meadow 10 m from its original location.

(ii) Phase 1 excavation (June - July 1990):

Phase 1 involved the creation of four waterbodies: (a) a large groundwater-fed ('main') pond (0.2 ha) with a maximum depth of 2.5 m and with gravel and mud islands to provide bird sanctuaries; (b) a shallow 'scrape' (0.4 m maximum depth), separated from the main pond by a narrow bund, but linked to it through a pipe with a flexible elbow joint to give some water level control; (c) and (d) two small ponds (each 0.3 ha), one groundwater-fed and one dug only into the alluvium and fed by surfacewater. In addition, areas of 'new wet meadow' were created around the Main Pond to provide a complementary habitat. A small (10 m^2) trial *Phragmites* trench was also excavated and lined with topsoil in order to experiment with the possibilities of introducing *Phragmites* reed-beds onto the site.

(iii) Phase 2 excavation (December 1991 - February 1992):

Preliminary observation on the colonisation of the Phase 1 site by plants, invertebrates and birds provided information which helped to make the Phase 2 design more sophisticated than it would otherwise have been. The main aims of Phase 2 were to to provide a greater area of open water and to create a greater variety of wetland habitats.

The four ponds created in Phase 1 were enlarged, and two other large ponds created (see Map 1). In addition, areas with an undulating microtopography close to water level (between 200 mm above and 200 mm below standard water level) were excavated. This allowed the creation of a mosaic of wetland habitats including permanent and temporary pools of varying sizes, mud flats and wet meadow areas. Additional substrate variety was created by importing gravel to cover islands and some of the pond margins. To reduce the effects of human disturbance of the site, two *Phragmites* reed beds, bordering the eastern half of the site, were created. Finally, seven experimental ponds were excavated in the western corner of the meadow, in order to allow two management experiments to be undertaken.

2. WATER CHEMISTRY

2.1 Introduction

The aims of water chemistry monitoring of the site have been:

(i) to provide baseline environmental data which can be used during interpretation of the wildlife community data.

(ii) to compare the quality of surfacewater and groundwater ponds on the site.

(iii) to monitor changes in pond water chemistry through time.

Water samples were taken monthly for the first year of the survey (April 1991 - March 1992). No samples were collected during the bird breeding season, to minimise disturbance. Sampling recommenced on 29th July 1992 and will continue at two-monthly intervals (except for the breeding season) for the rest of the monitoring programme.

Water chemistry monitoring was undertaken on the four waterbodies created during Phase 1 of the project (ie the Main Pond, Scrape, Groundwater Pond and Surfacewater Pond).

The following determinands were measured:

(i) pH.
(ii) Total suspended solids.
(iii) Conductivity.
(iv) Total oxidised nitrogen (TON).
(v) Ionised ammoniacal nitrogen (NH_4^+N).
(vi) Unionised ammoniacal nitrogen ($NH_3.N$).
(vii) Soluble reactive phosphate (SRP.P).
(viii) Biochemical Oxygen Demand (BOD).

Methods used to collect water samples are described in Appendix 2.

2.2 Results

During the sampling programme five determinands occurred at low levels. Four of these (BOD, TON, $NH_4^+.N$ and SRP.P) remained below the analytical detection limit for much of the period of the study. The fith, unionised ammoniacal nitrogen ($NH_3.N$), was not detected during any analyses.

Results for the remaining determinands are shown graphically on pages 10-12 and discussed below.

It should be noted that Graphs 1-6 show the averaged values from duplicate samples for each determinand. Where only one of the values for a duplicate was above the detection limit, this value was averaged with the detection limit itself. On a few occasions, results were not provided by the NRA laboratory for some determinands.

2.2.1 Total Oxidised Nitrogen (TON) (Graph 1)

Graph 1 shows TON plotted on a log 10 scale. TON was generally at its higest concentration in winter and spring. In May levels fell considerably and no TON was detected throughout the summer (detection limit 0.1 mg/l) In late autumn and winter TON levels rose again at all four sites. In February levels remained high in the Surfacewater and Groundwater ponds but fell again in the Scrape and the Main pond. Nitrate levels remained high into March in the Groundwater pond, but had fallen to below the detection limit by July.

An autumn and winter rise in TON is typical of many waterbodies, resulting from the degradation of organic material. It is possible that the February 1992 decrease in TON in the Main Pond and Scrape may have resulted from disturbance caused by the Phase 2 construction work on site, since both these waterbodies had groundwater pumped into and out of them during the previous month.

The level of TON in the Groundwater pond in February (6 mg/l) is particularly high for a still waterbody in Oxfordshire (Pond Action unpublished results). This pond lies very close to the River Thames and may be in partial hydraulic continuity with the river where nitrate levels are typically in the order of 10 mg/l at this time of year.

2.2.2 Soluble Reactive Phosphate (SRP.P) (Graph 2)

The results for SRP.P were rather variable. On eight of the 26 occasions when SRP.P was detected, only one of a duplicate sample was above the detection limit. In addition, where both duplicates had detectable levels of SRP.P the results were often rather inconsistent.

The overall trends in phosphate levels were rather similar to those for TON with levels generally below the detection limit (0.01 mg/l) during the summer, but rising in autumn and winter. The main exception is an unexpected level of SRP.P in all the ponds in July 1992. There would not appear to be any obvious explanation for the consistently high level at this time. As with nitrate the overall trend is likely to be mainly due to the effect of degradation of organic material, although the mechanical disturbance during the Phase 2 excavation may have influenced some readings, particularly in the Main Pond and Scrape.

2.2.3 Ionised Ammoniacal Nitrogen (NH_4^+N)

The NH_4^+.N levels were insufficient to enable any analysis of the results. Readings were only above the detection limit on three occasions, and even then never consistently as a duplicate sample.

2.2.4 Biological Oxygen Demand (BOD) (Graph 3)

The results for BOD are not particularly consistent between the ponds and are difficult to interpret. Only in September is the BOD above the detection limit in all four sites. This 'peak' is sustained into November in all but the Surfacewater pond. The 'peak' is most likely to be the result of the increased decay of the summer productivity, though the erratic nature of the results would caution against reading too much into them.

2.2.5 Chloride (Graph 4)

During the period April to January the chloride levels in the ponds are relatively consistent, being highest in the Main pond and the Scrape and lower in the Groundwater and Surfacewater ponds. There is one exception to this: an anomalously high level in the Surfacewater pond in September. This level was recorded in both samples taken on that date, and was over twice as high as any other level recorded for the pond on any previous date. This level, taken in isolation, would put the pond in the top 5% of ponds analysed during the Oxfordshire Pond Survey (136 ponds analysed). The reasons for this peak are not clear. The winter and spring samples analysed from the ponds show an apparent increase in the chloride concentration in the surface water pond. This slight change in the relative levels of chloride, with the level in the Surfacewater pond increasing, might be due to a gradual concentration of solutes in this hydrologically isolated site.

2.2.6 pH (Graph 5)

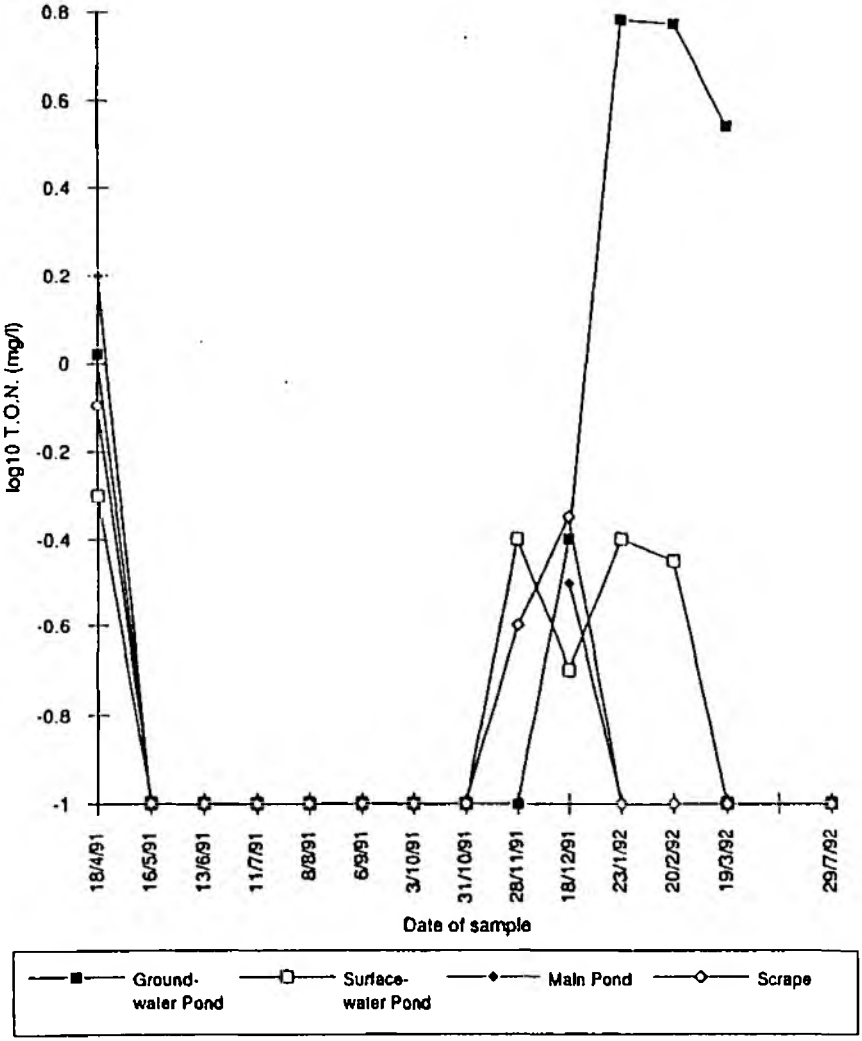
The pH of the sites was relatively constant throughout the period of survey and was similar between sites. The main exception to this occurred in July when the pH of all samples except those from the Main pond and one sample from the Scrape rose dramatically (from an average in the previous month of 7.8 to an average of 9.6 in July). The rise in pH may be linked with temperature (see section 2.2.5), caused, for example, by higher rates of photosynthesis (leading to a decreased amount of CO_2 in the water) and/or lower CO_2 levels in the water due to the decreased solubility of the gas at higher temperatures. The single low pH reading from the Scrape might be due to the sample

being taken from an area of locally colder water (the temperature of the water is taken as close as is practically possible to the sampling site, but due to problems of sediment disturbance, not exactly at the sampling site.)

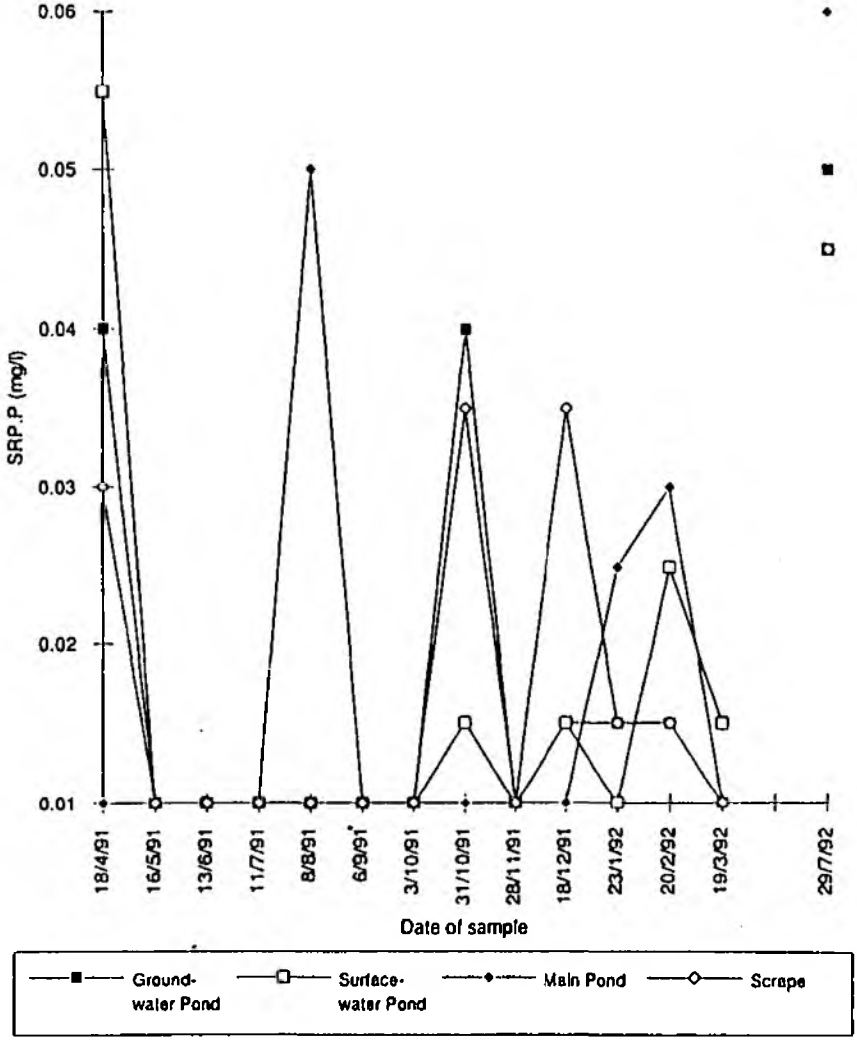
2.2.7 Temperature (Graph 6)

Temperature peaked during July and was relatively similar in all sites. The Main pond was generally slightly cooler than the other waterbodies in summer and slightly warmer in winter, probably due to its greater water mass. In particular, the Main Pond avoided the July 1991 peak in temperature seen in all the other ponds.

GRAPH 1: Change in concentration of total oxidised nitrogen (T.O.N) with time in four ponds on Pinkhill Meadows between 18/4/91 and 29/7/92 (log scale)

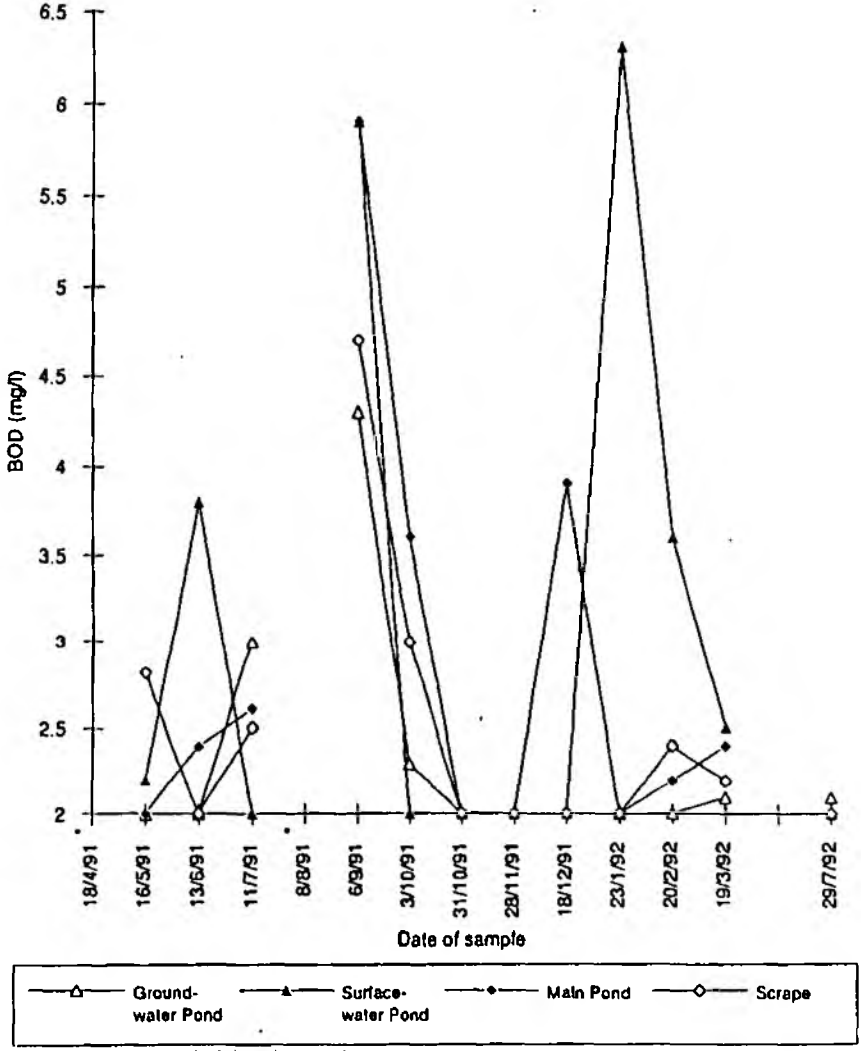


GRAPH 2: Change in concentration of soluble reactive phosphate phosphorus (SRP.P) in four ponds on Pinkhill Meadows between 18/4/91 and 29/7/92



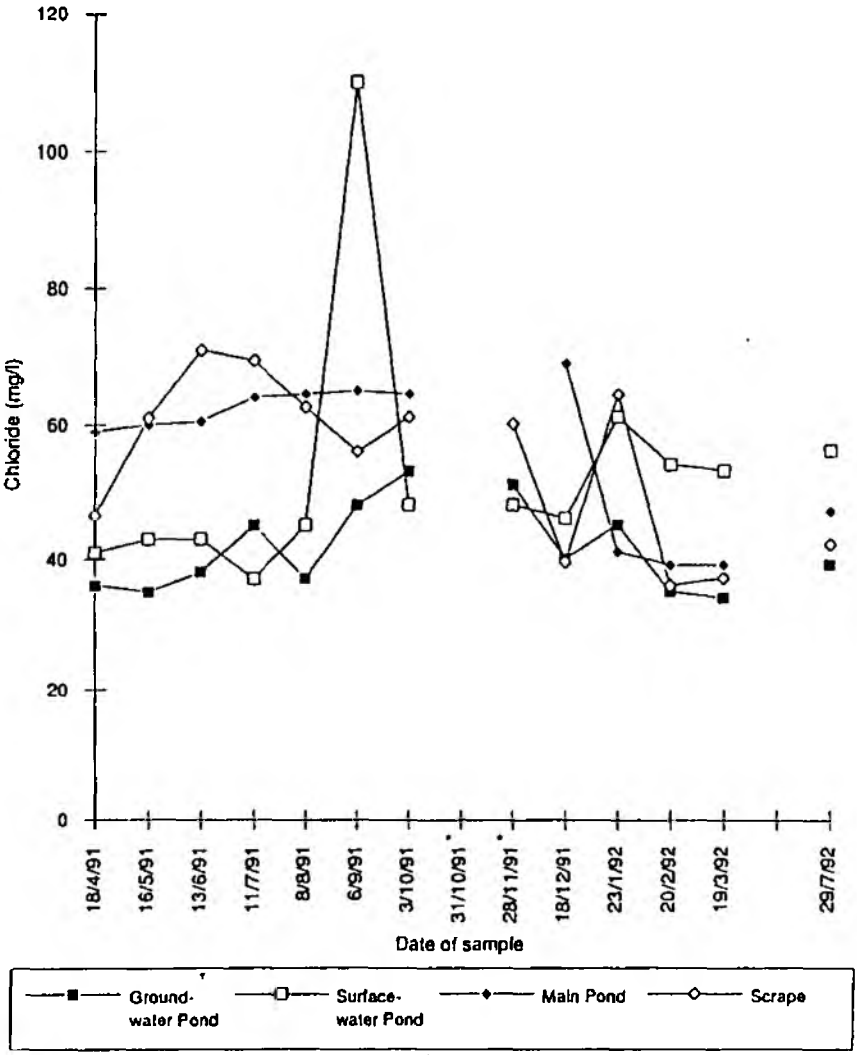
* Results not supplied by analysis

GRAPH 3: Change in Biochemical Oxygen Demand (BOD) in four ponds on Pinkhill Meadows between 18/4/91 and 29/7/92



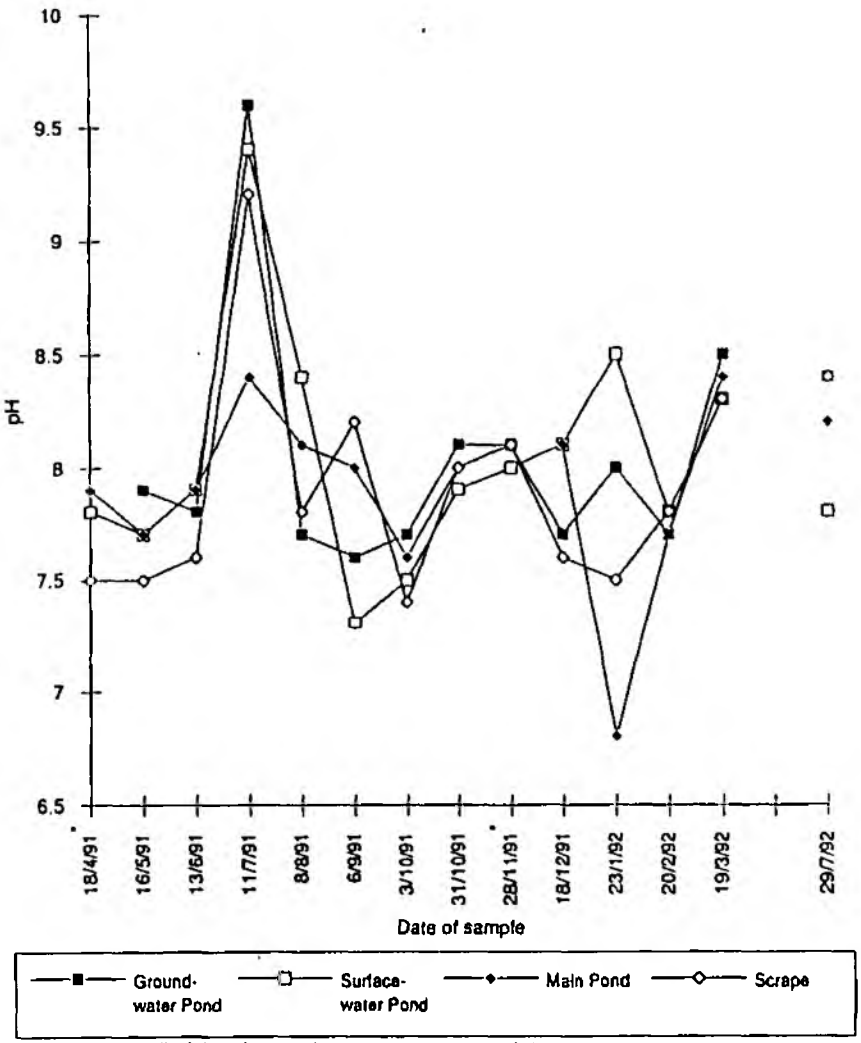
* No results supplied by the analysts

GRAPH 4: Change in chloride concentration in four ponds on Pinkhill Meadows between 18/4/91 and 29/7/92



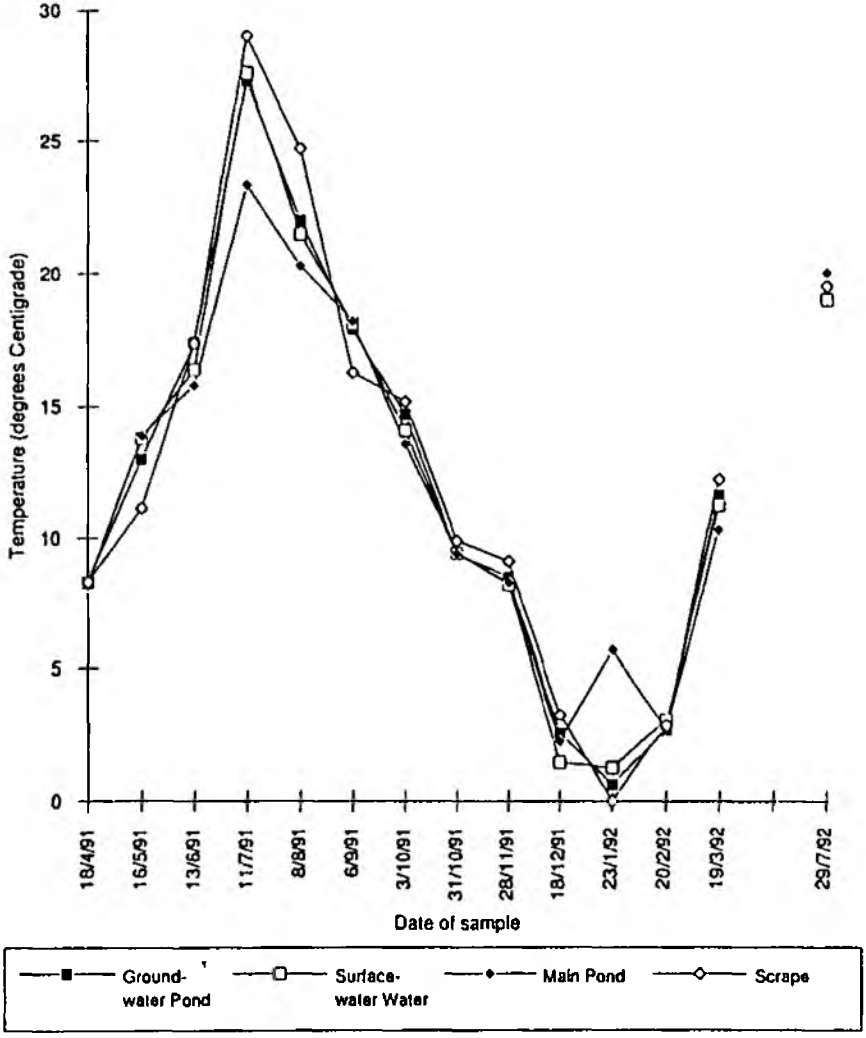
* Results supplied by the analysts were not complete

GRAPH 5: Change in pH in four ponds on Pinkhill Meadows between 18/4/9 1 and 29/7/92



* Results supplied by the analysis were not complete

GRAPH 6: Change in temperature in four ponds on Pinkhill Meadows between 18/4/91 and 29/7/92



3. WETLAND PLANTS

3.1 Introduction

The main aims of plant survey work on the site have been:

(i) To list the wetland plants which have colonised the new site
(ii) To describe the development of the wetland plant community
(iii) To provide estimates of the abundance of vegetation colonising the site
(iv) To assess the conservation value of the new plant community
(v) To monitor the success of *Ophioglossum* relocation on Pinkhill meadow

Surveys were undertaken in summer 1991 and 1992. The methods used to survey wetland plants are described in Appendix 3.

3.2 The number of wetland plants colonising the site (1991 and 1992)

A total of 50 wetland plant species have been recorded from the Pinkhill wetland since its creation in 1990. Of these species, 36 were recorded in 1991, and 49 in 1992 (see Table 3.1 below). It is probable that the one species present in 1991 but not 1992 (*Glyceria plicata*) was removed during the Phase 2 excavations and has not recolonised the site.

Table 3.1 The number of wetland plant species recorded from the Pinkhill wetland (1991-1992)

MP - Main Pond **SW** - Surfacewater Pond **GW** - Groundwater Pond **SC** - Scrape **TS** - Total Site
(Year of survey: 91- Summer 1991 92 - Summer 1992)

	MP		GW		SW		SC		TS	
	91	92	91	92	91	92	91	92	91	92
Total number of species	19	37	13	16	10	12	16	23	36	49
No. of marginal species	15	29	12	14	10	10	15	21	32	40
No. of aquatic species	4	8	1	2	0	2	1	2	4	9

The 50 wetland plant species recorded include five species which were artificially introduced to the site. Four of these (*Phragmites australis*, *Schoenoplectus lacustris*, *Glyceria maxima* and *Sparganium erectum*) were introduced in 1991 during the planting-up of a Trial Reed-bed with *Phragmites* rhizomes taken from an adjacent site. The fifth species, *Mimulus guttatus*, was accidentally introduced in 1992 with pot-grown *Phragmites* purchased from a commercial supplier.

The average number of emergent and aquatic plant species in individual ponds could be broadly correlated with their area (see Table 3.2. below).

Table 3.2 Average number of plant species recorded from ponds on the Pinkhill wetland in 1991 and 1992

POND	SIZE	AVERAGE NUMBER OF SPECIES (EMERGENT)	(AQUATIC)
Main Pond	0.46 ha	22	6.5
Scrape	0.15 ha	18	1.5
Surfacewater Pond	0.03 ha	11	1
Groundwater Pond	0.02 ha	13	1.5

3.3 Abundance of vegetation

Total plant cover on the site was assessed in both summer 1991 and summer 1992 but abundance was mapped for the first time in 1992 when an accurate base map became available.

The majority of the marginal areas of the ponds were physically reworked during Phase 2 construction, so that around most of the pond edges and in the new wet meadow areas, colonisation started from scratch in February 1992. In contrast the existing open-water areas remained relatively undisturbed by Phase 2 excavation work.

3.3.1 1991 vegetation abundance

Marginal plant cover during Phase 1 was generally less than 20%. The main exceptions were:

(i) areas where topsoil had been re-laid (ie the margins of the Scrape, and Trial *Phragmites* Trench), where plant cover was generally 70%-100%.

(ii) the edges of the wetland, within 1-3 m of the existing meadow. Here colonisation from the adjacent meadow gave plant cover of up to 70%.

In 1991 **aquatic** plant cover was almost entirely provided by *Chara vulgaris*. This grew over extensive areas of the Main Pond (covering approximately 60% of the bottom). However *Chara* occupied less than 5% of the Groundwater Pond and Scrape and it was absent from the Surfacewater Pond.

3.3.2 1992 vegetation abundance

Plant cover in 1992 was generally greater than in 1991, despite the disruption caused by the Phase 2 excavation work. However colonisation was patchy. Areas which were particularly well or poorly colonised are described briefly below.

Well colonised areas:

Areas which were particularly well colonised were:

(i) Areas with some topsoil present: eg areas of new wet meadow where thin layers of topsoil had remained after excavation and also some of the shallow pools where topsoil had been re-laid to give local variation in substrate type.

(ii) Small areas of the Phase 1 pond margins which were not disturbed during the Phase 2 excavations: eg the NE corner of the Scrape and also the Trial *Phragmites* Trench.

(iii) Areas immediately adjacent to the existing meadow, where nutrients, seeds and stoloniferous plants had spread onto the new wetland.

(iv) Open water areas of the Main Pond where aquatics, particularly *Chara vulgaris* and *Potamogeton pusillus*, formed locally extensive stands.

(v) It was also noted that colonisation by both marginal and aquatic species was enhanced along the northern edge of waterbodies, probably as a result of wind or water-borne seeds collecting along the downwind banks.

Poorly colonised marginal areas:

Some areas of the new wetland have been very poorly colonised. In many places, this is the result of specific design features which were incorporated in order to retain bare areas of mud for wading birds.

Areas which have had very little plant colonisation include:

(i) Areas designed for wading birds, particularly the shallow back slope of the Main Pond and the open water areas in the Scrape. Despite being little affected by the Phase 2 excavation, these remained bare as a result of (i) the disturbance stress caused by fluctuating water levels and (ii) the clayey alluvium substrate

(ii) Deeper water areas of the larger ponds (other than the Main Pond) which have, as yet, been little colonised by either marginal or aquatic species.

3.4 Plant Communities

3.4.1 1991 Communities

The 1991 plant communities which developed between the Phase 1 and Phase 2 excavations were generally of limited extent and complexity. The main communities were:

Meadow Community

Present on the upper banks of the Phase 1 excavation, immediately adjacent to the existing meadow communities. This community also developed locally in areas where meadow top-soil was re-laid around the margins of the Scrape.

Wetland grass and herb community

Sparsely present around the edge of the main waterbodies and occurring much more densely within the Trial *Phragmites* Trench where top-soil was deposited in the shallow bed.

Aquatic plant community

Dominated by *Chara vulgaris* and particularly abundant in the Main Pond, where it avoided only the very shallow areas.

3.4.2 1992 Communities

It is currently possible to distinguish five main plant communities on the site: these broadly reflect the height of the ground with respect to water level and the type of substrate. It is likely that as the site matures and develops it will be possible to distinguish further communities (See Map 2.).

Meadow

Developing in areas which are rarely, if at all flooded during the year. Dominated by meadow plants and ruderals and particularly characteristic of areas where topsoil had been left or relaid. The community is dominated by meadow grasses such as *Alopecurus pratensis*, ruderal herbs such as *Chenopodium rubrum*, *Trifolium pratense*, *Polygonum persicaria*, *Ranunculus repens*, *Cirsium arvense*, and occasionally some of the more uncommon meadow forbs, eg *Silaum silaus* and *Sanguisorba officionalis* which have probably grown up from the topsoil seedbank.

Mixed meadow and marginal wetland ruderals

Developing in areas which remain above water level for most of the year but are occasionally inundated during periods of high water levels. Particularly characteristic of areas where topsoil is thin or absent. The community is dominated by a mixture of terrestrial ruderals and marginal wetland herbs, in particular *Chenopodium rubrum*, *Trifolium pratense*, *Polygonum persicaria*, *Ranunculus repens*, *Veronica beccabunga* and *Ranunculus sceleratus*, as well as damp-ground grasses like *Alopecurus geniculatus* and *Agrostis stolonifera*.

Wetland herbs and grasses

Developing near to, or below, water level on the edges of ponds and pools. Particularly well developed where topsoil is present. The plant community is characterised by wetland herbs such as: *Veronica beccabunga*, *V. catenata*, *V. anagallis-aquatica*, *Ranunculus sceleratus* and *Alisma plantago-aquatica*, as well as marginal grasses and rushes such as *Juncus inflexus*, *Juncus articulatus*, *Glyceria fluitans* and *Agrostis stolonifera*. *Typha latifolia* and *Polygonum amphibium* are also locally common.

Wetland grasses

This community, dominated by grasses and rushes, has mainly developed on bare alluvium substrates, generally in slightly deeper water or further from the pond edge than the wetland herb and grass community. The wetland grass community is typically dominated by *Juncus articulatus*, *Glyceria fluitans* and *Agrostis stolonifera* with some *Typha latifolia* or *Phalaris arundinacea*.

Phragmites australis

Commercially grown *Phragmites australis* has been planted in specifically excavated beds around the north-east and south-east corners of the Pinkhill site. In addition to the *Phragmites* itself, these beds have also been sparsely colonised by a mixture of aquatic and marginal species including *Chara vulgaris* and, locally, *Zannichellia palustris*, *Alisma plantago-aquatica*, *Ranunculus sceleratus* and *Veronica* spp..

Aquatics

Submerged plants generally formed monodominant stands in areas of permanent water. In a few areas, however, *Chara vulgaris* and *Ranunculus trichophyllus* grew together in shallow pools, and *C.vulgaris* and *Potamogeton pusillus* occurred together in deeper water in the Main Pond. The distribution of individual aquatic species is briefly outlined below.

Chara and *Ranunculus trichophyllus* occurred both as monodominant stands and together. Both grew in deeper water in the Main Pond, and in the shallow pools around the edge of the Main Pond and the Northern Reed-pool.

Potamogeton pusillus was the dominant submerged plant in the Main Pond, forming very extensive stands in deep water and growing more sparsely in shallow water around the edge of the Main Pond and the Southern Reed-pool.

Map 2. Plant communities recorded from Pinkhill Meadow wetland (Summer 1992)

The Main Pond also supported small stands of four other submerged species: *Callitriche* sp., *Myriophyllum spicatum*, *Potamogeton compressus*, and *Potamogeton perfoliatus*.

Zannichellia palustris was present on the site in three locations, all within the Northern Reed-pool.

3.5 The conservation value of the wetland plant community

The conservation value of the plant community of individual ponds has been assessed on the basis of (i) the number of wetland plant species present, and (ii) the occurrence of nationally uncommon plant species. (See Table 3.5 for the definitions of terms used in this report).

This information has been used to place each pond in one of four National Conservation Categories: low, moderate, high or very high. Definitions of these categories are given in Table 3.6.

Details of the methods used to assess the conservation value of plant and animal communities are given in Appendices 3 and 4.

3.5.1 Current conservation value of the site

Wetland as a whole

In 1991 the Pinkhill site supported 36 wetland plant species; by 1992 it was 49. There is too little information about similar sites to accurately judge whether this rate of colonisation is high or low, but experience would suggest that the total number of species is currently moderate to high compared to other wetland sites of similar size in Oxfordshire.

No very uncommon wetland plant species have been recorded from the site to date, but a number of species which could be considered to be nationally 'local' were found (see Table 3.3 overleaf).

Individual ponds on the Pinkhill site varied in the numbers of species and local species that they supported; however their overall national conservation values were all moderate.

Main Pond

In 1991 the Main Pond supported an average number of wetland plant species compared to other ponds surveyed in Oxfordshire. By 1992 the numbers of both marginal and aquatic species were well above average (see histograms in Appendix 3.1 to compare with Oxfordshire data). By 1992 the pond also supported five nationally local plant species, all of which were submerged aquatics (see Table 3.3 overleaf). Overall, the national conservation value of the pond was considered to be moderate in both 1991 and 1992.

Scrape

In 1991 the Scrape supported an average to below-average number of marginal and aquatic plants compared to other ponds in Oxfordshire. In 1992, however, the number of marginal species had risen to above average. One local plant species was recorded for the first time in 1992 (see Table 3.3). Overall, the national conservation value of the pond was considered to be low in 1991 and moderate in 1992.

Groundwater Pond

The Groundwater Pond supported a below-average number of plant species in 1991. By 1992 aquatics were still below average, but the number of marginal species was near-average. One nationally uncommon species was recorded in 1992 (see Table 3.3). Overall, the national conservation value of the pond was considered to be low in

1991 and moderate in 1992.

Surfacewater Pond

The Surfacewater Pond supported a below-average number of marginal and aquatic plants in 1991 and 1992. One nationally uncommon species was recorded in 1992 (see Table 3.3). Overall, the national conservation value of the pond was considered to be low in 1991 and moderate in 1992.

3.6 Discussion: Colonisation of the ponds

Despite the newness of the site and the paucity of cover, the number of species recorded from **some** ponds on the site was relatively high compared to other ponds in Oxfordshire. This was particularly true of the marginal plant community in the Main Pond and Scrape, and of the aquatic plant community in the Main Pond.

The high number of marginal species may be due to a combination of factors, but must certainly result in part from the close proximity of other species-rich wetlands, particularly the existing Pinkhill Meadow floodplain soils and the adjacent River Thames: over 70% of the wetland species recorded from the new pond margins are species already present either on the R.Thames banks or the Meadow (Pond Action 1990).

The reasons that the Main Pond currently supports more aquatic and marginal plant species than any of the other ponds on the site may be due to (i) the greater variety of habitats, particularly areas of top-soiled pools and hummocky edges bordering the pond, and (ii) greater chances for colonisation in the Main Pond due to its larger size and much more frequent use by birds. The larger number of **aquatic** species may also have been encouraged by the greater depth in this pond (2.5 m maximum depth, compared to 1 m in most other pools) or by the presence of groundwater and groundwater flow in the Main Pond.

Table 3.3 Uncommon wetland plants recorded from the Pinkhill Meadow wetland

Abbreviations:

MP - Main Pond **SW** - Surfacewater Pond **GW** - Groundwater Pond **SC** - Scrape **TS** - Total Site

Survey : **91**- Summer 1991 **92** - Summer 1992

Local* species	MP		GW		SW		SC		TS	
	91	92	91	92	91	92	91	92	91	92
Potamogeton obtusifolius	-	+	-	-	-	-	-	-	-	+
Potamogeton perfoliatus	-	+	-	-	-	-	-	-	-	+
Potamogeton pusillus	-	+	-	-	-	-	-	-	-	+
Ranunculus trichophyllus	+	+	-	+	-	+	-	+	+	+
Zannichellia palustris	-	-	-	-	-	-	-	-	-	+
TOTAL	1	4	0	1	0	1	0	1	1	5

*Local: Recorded from between 100 and 700 10 x 10 km grid squares in Britain.

Table 3.4 Summary of the numbers of wetland plant species recorded from Pinkhill Meadow

	MP		GW		SW		SC		TS	
	91	92	91	92	91	92	91	92	91	92
No. of marginal species	15	29	12	14	10	10	15	21	32	40
No. of aquatic species	4	8	1	2	0	2	1	2	4	9
Total no. of species	19	37	13	16	10	12	16	23	36	49
No. of nationally local spp.	1	4	0	1	0	1	0	1	1	5
Conservation Score	20	42	13	17	10	13	16	24	37	5
Conservation Index	1.05	1.14	1.00	1.06	1.00	1.08	1.00	1.04	1.03	1.14
Conservation Category*	Mod	Mod	Low	Mod	Low	Mod	Low	Mod	Mod	Mod

*See Table 3.6 and Appendix 3 for explanation

Table 3.5 Definition of terms used for plant and macroinvertebrate species in this report and conservation scores for each category

Description	Score	Plants	Invertebrates
Common	1	Recorded from >700 10x10km grid squares in Britain.	Generally regarded as commom.
Local	2	Recorded from between 101 and 700 grid squares in Britain.	Generally regarded as local.
Nationally Scarce B	4	Nationally Scarce. Recorded from 31-100 grid squares in Britain.	Nationally Notable B. Recorded from 31-100 grid squares in Britain.
Nationally Scarce A	8	Nationally Scarce. Recorded from16-30 grid squares in Britain.	Nationally Notable A. Recorded from16-30 grid squares in Britain.
RDB 3	16	Red Data Book: Category 3 (rare), Perring and Farrell (1977).	Red Data Book: Category 3 (rare), Shirt (1987), Bratton (1991).
RDB 2	32	Red Data Book: Category 2 (vulnerable), Perring and Farrell (1977).	Red Data Book: Category 2 (vulnerable), Shirt (1987), Bratton (1991).
RDB 1	64	Red Data Book: Category 1 (endangered), Perring and Farrell (1977).	Red Data Book: Category 1 (endangered), Shirt (1987, Bratton (1991).

Notes:

Plant distribution information should be derived from the following sources:

Aquatic plants: Croft, Preston and Forrest (1991)
Emergent wetland plants: Palmer and Newbold (1983), Perring and Farrell (1983) Perring and Walters (1990).
Aquatic macroinvertebrates: Ball (1986). See also Appendix 4 for distribution data of individual taxa

Table 3.6 Provisional system for assessing the conservation value of plant and aquatic macroinvertebrate communities

CONSERVATION CATEGORY	DESCRIPTION OF TYPE OF COMMUNITY
VERY HIGH	Typically supporting a very rich community of plant and/or macroinvertebrate species, including local and rare (RDB) species (though note that some sites with rare species can be relatively species-poor). Sites in this category would normally have National Conservation Indices in excess of 1.5.
HIGH	Supporting a rich community of common plants and/or macro-invertebrate species. Generally an above-average number of local species recorded . No RDB species. Sites in this category would normally have National Conservation Indices between 1.2 and 1.5.
MODERATE	Supporting a moderately rich or rich community of common plant and/or macroinvertebrate species, with at least one local species. Sites in this category would normally have National Conservation Indices between 1.01 and 1.19.
LOW	Supporting a species-poor community of common plants and macro-invertebrates. No rare or local species. Sites in this category will have National Conservation Indices of 1.00.

3.7 Monitoring of *Ophioglossum vulgatum* (Adderstongue Fern) relocation.

During the Phase 1 excavation of the Pinkhill site in 1990 a $1m^2$ area of meadow turf supporting seven plants of *Ophioglossum vulgatum* was transported approximately 10m and replanted in an adjacent area of meadow. This turf has been monitored in 1991 and 1992 to assess the success of the *Ophioglossum* relocation

Unfortunately in the years after the Phase 1 excavation the meadow was very rarely cut and *Ophioglossum* was not recorded in 1991 or 1992, either in the transplanted turf or in any of the surrounding grassland areas (where it was formerly common). It is likely this loss was caused by competition from surrounding tall rank vegetation in the meadow. It is hoped that remedial measures to reestablish the original meadow community will encourage the reappearance of this species on the meadow in future years.

4. AQUATIC MACROINVERTEBRATES

4.1 Introduction

This section presents the results of studies of the macroinvertebrates in the four main survey ponds on Pinkhill Meadows: ie the Main Pond, Groundwater Pond, Surfacewater Pond and Scrape (See Map 1.).

During the year following construction, four surveys of each pond were made. These surveys were carried out in July 1990, November 1990, February 1991 and May 1991. A further survey was made 14 months later in July 1992. The May 1991 and July 1992 surveys were more detailed than those preceding them. Details of survey dates are given in Table 1.1, and details of methodology are presented in Appendix 4.1.

In addition to the surveys of these four individual ponds, a survey of the aquatic macroinvertebrates of the entire Pinkhill Meadow wetland was carried out in September 1992. The methodology for this survey is presented in Appendix 4.1 and the results in Section 4.6.

The surveys of the aquatic macroinvertebrates had three main aims:

(i) to describe the colonisation by macroinvertebrates of the four ponds.
(ii) to assess the nature conservation value of the macroinvertebrate communities of the four ponds
(iii) to assess the relative importance for macroinvertebrates of different microhabitats within the ponds.

Colonisation of the ponds was described in terms of the numbers of species recorded in each pond and the abundance of individual species recorded in each pond. Macroinvertebrate community structure of the ponds was analysed using the ordination technique Detrended Correspondence Analysis (DECORANA).

The current nature conservation value of the communities was assessed using Pond Action's provisional technique for assessing the conservation value of invertebrate communities (see Table 3.6).

The value of the different microhabitats within each pond was assessed by comparing the number of species found in each microhabitat.

Table 4.1 Macroinvertebrate taxa collected at Pinkhill Meadow and the taxonomic levels to which they were identified

Groups identified to species level (where present)

Tricladida	(Flatworms)
Hirudinea	(Leeches)
Gastropoda	(Snails and limpets)
Bivalvia (excluding *Pisidium* sp.)	(Bivalves)
Malacostraca	(Shrimps and slaters)
Ephemeroptera	(Mayflies)
Odonata	(Dragonflies and damselflies)
Plecoptera	(Stoneflies)
Heteroptera	(Water bugs)
Megaloptera	(Alderflies)
Trichoptera	(Caddis flies)
Coleoptera*	(Water beetles)

*Adults from the following families of Coleoptera were identified: Dryopidae, Elminthidae, Gyrinidae, Hygrobiidae, Haliplidae, Noteridae, Dytiscidae, Heteroceridae, Hydraenidae, Hydrophilidae.

4.2 Results of the standard surveys

4.2.1 The numbers of species recorded in the four ponds during the standard surveys

The numbers of invertebrate species recorded from the four ponds increased from between five and seven in the first (July 1990) sample, to between 25 and 45 in the final (July 92) sample. The cumulative total of species for all four ponds increased from 12 in the first season to 84 after all five seasons.

Since the commencement of survey work, there has been a steady increase in the number of species recorded from the individual ponds. However, there are two main exceptions:

(i) The numbers of species recorded declined over the first winter in the Main Pond and the Groundwater Pond, with less species being taken in the February 1991 surveys than in the November 1990 surveys.The February sample was taken after a period of ice cover, which might explain the fall-off in species numbers.

(ii) Fewer species were also recorded in the July 1992 survey of the Surfacewater Pond than in the preceeding survey (May 1991). Reasons for the decrease in species numbers (from 40 to 31) between these two dates are not clear, though the July 1992 surveys did follow a period of construction work on the site.

Numbers of species in the major groups of macroinvertebrates are summarised in Appendix 4.2. Full species lists for surveys of all four ponds in four seasons are give in Appendix 4.3.

4.2.2 Abundance of macroinvertebrates in the standard surveys

During the first twelve months of colonisation, the abundance of macroinvertebrates increased throughout the year (though with a slight decrease after the winter months). Some species (e.g. the mayflies *Cloeon dipterum* and *Caenis luctuosa* and the diving beetle *Hydroglyphus pusillus*) were particularly abundant during the first year.

In the July 1992 survey, after the second year of colonisation, the abundance of several species was much less than in the previous survey (May 1991). Notable amongst those species declining were a mayfly *Caenis luctuosa*, a diving beetle *Hydroglyphus pusillus* and a lesser water boatman *Sigara lateralis* . All these species had been present in large numbers in the May 1991 survey. During the second year, however, some of the slower-colonising species became more abundant in the ponds. Particularly notable were the Dwarf Pond Snail *Lymnaea truncatula* (in all but the Groundwater Pond), a water slater, *Asellus aquaticus* (in the Main Pond), and the Wandering Snail *Lymnaea peregra* (in the Main Pond, and to a lesser extent in the Scrape).

Due to the scarcity of mayflies in the July 1992 survey (these had previously been present in their thousands), the overall total of macroinvertebrates in this survey was much less than in the previous (May 1991) survey. It seems most likely that this was a seasonal effect, though a year-on-year effect cannot be ruled out.

It should be noted that all estimates of abundance are **relative** and should be treated with caution, as the hand-netting techniques employed are designed primarily to estimate species numbers and not to estimate abundances.

4.2.3 Composition of the macroinvertebrate communities of the ponds shown by the standard surveys

The earliest colonisers of the Pinkhill Meadow ponds were those species which fly freely. Several water beetles and water bugs and two species of mayfly were recorded from the ponds in July 1990, only a few weeks after construction in the same month. Since this first survey, the water beetles and water bugs have continued to constitute a major part of the fauna in terms of numbers of species. In the most recent survey (July 1992), water beetles accounted for between 33% and 54% of the species recorded from any one pond. The water bugs also contributed significantly to species-richness (between 18% and 27%).

As the communities mature, other more slowly colonising groups, such as the snails, might be expected to become more dominant and the beetles and bugs might be expected to make a less important contribution to species-richness. The data from the Pinkhill Meadow surveys allows an early test of this idea. Over all seasons, the percentage of beetles and bugs decreased ($p = <.025$: Spearman's Rank). However, this decrease is small, and neither group on its own shows a statistically significant decline in terms of percentage of the fauna.

A rich still-water mayfly community has already developed in the ponds. Six of the eight species typically found in lowland, nutrient-rich, ponds have already been recorded. The caddis fly fauna appears to be developing quite well. Many species of caddis fly are very seasonal (ie only found as identifiable larvae in the spring months). Current problems with sampling the ponds in spring (due to possible disturbance of breeding birds) will therefore make a reliable assessment of the caddis colonisation of the site difficult.

The numbers of species of snail, leech, crustacean and dragonfly have steadily increased over the period of survey. The most recent survey (July 1992) recorded the first records of snails for the site. Though only three species were recorded, two of the species, the Wandering Snail (*Lymnaea peregra*) and the Dwarf Pond Snail (*Lymnaea truncatula*) were distributed widely over the site.

4.2.4 Species-richness in comparison with other sites

At this early stage in the colonisation of the Pinkhill Meadow ponds it is difficult to compare the rate of colonisation with other sites. This is mainly because there is little comparable information about invertebrate colonisation of new ponds in Britain.

The best direct comparison available at present is with the three-ha Dean's Farm East gravel-pit lake at Caversham, near Reading. Because this site is large it can best be compared with the **Main** Pond at Pinkhill.

Dean's Farm East Lake (DFEL) was recently surveyed by Pond Action using comparable methods. (Pond Action, 1990). The pond is one-two years old (similar to Pinkhill Main Pond in 1991/1992) and also close to the River Thames. The Lake is about six times larger than the Pinkhill Main Pond, steep-sided and deep (estimated maximum depth approximately five meters). The lake has not been reprofiled to increase its nature conservation value.

The numbers of invertebrate species recorded from Pinkhill Main Pond were around twice those recorded from DFEL (35 compared to 15 in spring; 46 compared to 24 in summer). In addition, three seasons of sampling from DFEL yielded only two **local** species compared to the 11 local species recorded in Pinkhill Main Pond. The comparisons suggest that features of the design of Pinkhill Main pond are encouraging the development of a relatively species-rich invertebrate community of relatively high value.

4.3 Decorana analysis of the microhabitat surveys

4.3.1 Differences in the communities of the four ponds as demonstrated by DECORANA

Data set, analysis and presentation

Macroinvertebrate species abundance data, obtained from the May 1991 and July 1992 microhabitat sampling, was analysed using the ordination technique Detrended Correspondence Analysis, running as the Fortran programme DECORANA. The data-set consisted of 128 samples from four sites in the two seasons.

Each polygon on the DECORANA diagram (see Figures 4.1 and 4.2) encloses the ordination coordinates of all the microhabitats (not shown individually) from one pond in one season*. In this way the polygons represent, graphically, the total range of variation in the macroinvertebrate communities of each pond in each season.

The 1991 analysis

DECORANA analysis following the 1991 survey (Figure 4.1) indicated that the ponds had reasonably distinct macroinvertebrate communities. The first axis of the 1991 DECORANA was positively correlated with the proportion of water beetles in the samples and negatively correlated with the proportion of corixid bugs (lesser water boatmen) i.e. looking at the DECORANA plot, the samples on the right have a high proportion of water beetles and a low proportion of corixids.

The polygon enclosing the ordination coordinates of samples from the Surfacewater Pond was stretched to the right by the presence of four samples from the grassy margins of the pond, which had a large number of beetle species.

Whilst the ponds appeared to be separated in the 1991 analysis the separation was, principally, on the second axis. It was not possible to discern any trend in the composition of samples along this axis with respect to any of the major groups of macroinvertebrates.

*Note: Two samples from the 1992 survey differed significantly from the other samples taken from their ponds. These are plotted separately on the diagram.

1991 and 1992 analysis

The addition of the data from the 1992 survey allowed not only an interpretation of the 1992 data, but also a **re-interpretation** of the 1991 data.

It can be seen from Figure 4.2 that the polygons of the 1991 survey vary most along the second axis of DECORANA (not the first as before). Analysis of this axis shows that samples from the top of the axis have a high proportion of water beetles, whereas samples from the bottom of the axis have a high proportion of corixid bugs. This is exactly the same relationship as was seen for Axis 1 of the 1991 analysis.

The disposition of individual ponds along the second axis is also similar to that along the first axis of the 1991 survey. For example, the Surfacewater Pond polygon is now stretched towards the top of the axis (compared to the right hand side of the first axis of the 1991 analysis) and the Main Pond polygon is now on the the bottom of the second axis (compared to the left hand side of the first axis of the 1991 analysis).

It seems, then, that the major variation in the communities seen in the 1991 survey has been relegated to secondary importance in terms of the whole (1991 and 1992) data set.

The major difference in the macroinvertebrate communities in the whole data set is represented by the first axis of DECORANA (Figure 4.2). It is clear from the diagram that the main difference in the data set results from a change in the macroinvertebrate communities of the site between the two occasions of sampling. The possible reasons for this difference will be discussed later.

The first axis of DECORANA is positively correlated with the proportion of water bug species in the samples and negatively correlated with the proportion of water beetle species in the samples. This is quite similar to the type of community changes along the second axis, except that the water bugs as a group (not just the corixids) show the best correlations. The first axis is also correlated with the numbers of species of snail in the samples (though there are very few in terms of numbers of species).

Looking at the first axis in terms of individual species, certain species are indicative of either the left or the right hand sides of the axis. In practice these species are indicative of the 1991 or 1992 surveys. Species indicative of the 1992 survey include the Common Darter (*Sympetrum striolatum*), the Dwarf Pond Snail (*Lymnaea truncatula*), the Wandering Snail (*Lymnaea peregra*) and the glossiphoniid leech, *Helobdella stagnalis*. Species indicative of the 1991 survey include the mayflies *Caenis luctuosa* and *Ephemera vulgata*, and the small diving beetle *Hydroglyphus pusillus*. Species which are indicative of a particular year are not necessarily absent in the other year, but are much less frequent. For example, the Common Darter was present in 43 of the 1992 samples but only one of the 1991 samples.

4.3.2 Environmental factors causing differences in the composition of the macroinvertebrate communities

The main difference in the macroinvertebrate communities in the data set is represented by the difference between the two years. There are two possible reasons for this difference:

i) A seasonal (spring/summer) difference in the macroinvertebrate communities
ii) A difference due to the maturation of the communities

Obviously the communities of the ponds are maturing and there is an ongoing process of colonisation. Three of the indicative species of the (summer) 1992 samples are slow-colonising species (one leech and two snails). The decrease in the proportion of beetle species which characterises the first axis is an effect which might be expected as colonisation proceeds, as other, more slowly-colonising, species become more prevalent. However, the most strongly indicative species of the (spring) 1991 samples are mayflies, which might be expected to be under-recorded (due to their small size) in a summer survey.

It is likely that the observed effects are the result of both factors (seasonality and colonisation) operating in concert. However, more species are strongly indicative of the 1992 survey than of the 1991 survey. For example, the best indicator of the 1991 survey is the mayfly *Caenis luctuosa*, which was, nevertheless, present in 14 samples in the 1992 survey. It is likely, therefore, that the main factor in the change in the communities is colonisation and the maturation of the invertebrate communities.

The second axis of DECORANA does not appear to separate the 1992 samples as well as the 1991 samples, though the general order along the axis remains the same between the two years. The Main Pond is still characterised by a high ratio of corixids to beetles with samples from the Surfacewater Pond appearing more varied, but still tending to have a high ratio of beetles to corixids. In general, water beetles tend to favour smaller sites than water bugs, though this is generally thought to be due to preference of bugs for more open vegetation. Obviously the difference in the communities at Pinkhill Meadows is not due to a difference in vegetation structure. **The differences in community structure seen at Pinkhill Meadows appear to be similar to those which might have been predicted at a later stage in development.**

4.4 The relative importance of different microhabitats for macroinvertebrates of the four main survey ponds

The species-richness of each microhabitat is listed in Table 4.2. The range of microhabitats within the ponds is currently small, mainly because of the sparseness of aquatic and marginal plants. The microhabitats differ, both in number and type, between the two surveys as they reflect the progressive colonisation of the site by aquatic and wetland plants.

In the May 1991 survey, species-richness varied from 11 (marginal grass microhabitat of the Scrape) to 22 (marginal grass/*Chara vulgaris* microhabitat of the Main pond). This relatively small variation probably reflects the similarity of the microhabitats. The marginal grasses and *Chara* microhabitats consisted of rather sparse stands of vegetation and so were rather similar to the non-vegetated microhabitats.

In the July 1992 survey, species-richness varied from eight (gravels in deep water in the Groundwater Pond) to 29 (*Chara* sp. in the Main Pond). It should be noted that in the 1992 survey the species numbers for the the habitats from the Main Pond survey are derived from two individual samples. This compares with 4 samples from habitats of the other ponds. Combining the *Chara* sp. and shallow grass microhabitats from the Main Pond in July 1992 (to get a microhabitat approximately equivalent to the marginal grasses and *Chara* sp. habitat from the May 1991 survey) gives a value of 36 species from both habitats combined.

In the main Pond and the Scrape the number of species appears to increase fairly uniformly between the two surveys. The results for the Surfacewater Pond show little obvious change and the results from the Groundwater Pond show an overall reduction between the two years.

4.5 The nature conservation value of the macroinvertebrate communities in the four main survey ponds

The cumulative total of 84 species included one rare and 14 local species. The occurrence of uncommon species on the Pinkhill site is detailed in Appendix 4.3 and descriptions of their national distributions are given in Appendix 4.4. Definitions of terms used to describe the rarity of species are given in Table 3.5.

National Conservation Indices were calculated for all the ponds (see Appendix 4.2). This index is explained in section 4.1.4. Values of the index associated with the different categories of conservation value are given, together with criteria for assessing the conservation value of macroinvertebrate communities, in Table 3.6.

Using the criteria outlined in Table 3.6, all four of the ponds supported communities which were of 'high' value. The five-season National Conservation Indices (NCI's) of the sites, which should give the best measure of conservation value, vary between 1.22 and 1.29. As would be expected, the single season NCI's are more variable, ranging from 1 to 1.43. All sites have relatively rich macroinvertebrate communities, with good numbers of local and notable species (between seven for the Groundwater Pond and 11 for the Main Pond).

It should be noted that *Coelambus nigrolineatus* is only provisionally categorised as 'rare' (it is a Red Data Book 3* species). It is regarded here as a Notable B species, owing to the uncertainty surrounding its distribution and current range expansion. Obviously, if subsequent recording shows *C.nigrolineatus* to be genuinely rare, then the value of the macroinvertebrate communities of the Main Pond and the Scrape would need to be revised; i.e. they would then be re-classified as being of 'very high' nature conservation value.

4.6 Results of the 'bug-hunt' survey across the whole of the Pinkhill Wetland site

4.6.1 Introduction

This section presents the results of a 'bug-hunt' survey of aquatic macroinvertebrates in all the waterbodies on the Pinkhill Meadows site. Surveys were carried out on 25 and 28 September 1992. The methodology used for the survey is described in Appendix 4.1.

The 'bug-hunt' had two main aims:
(i) To assess macroinvertebrate colonisation over the whole of the new wetland site.
(ii) To update and broaden the assessment of invertebrate conservation value over the whole wetland.

4.6.2 The number of species recorded in the 14 different areas of the site

The method of sampling used in 'bug-hunt' surveys is inherently prone to collector bias. This bias was minimised by standardising the time spent at each part of the site and by using only two recorders who are known to have a similar efficiency in this type of work. Nevertheless, the results of the bug hunt really only give a broad picture for the site as a whole: detailed comparisons between the number of invertebrate species found in different areas of the site, should be undertaken with caution.

The range in numbers of invertebrate species recorded from the different areas of the site was small: from 28 in the Groundwater Pond to 38 in the most southerly Pond (south). The total number of species recorded during the survey was 85. This compares with 61 species which were recorded during the standard surveys of the four original ponds during the summer 1992 survey and 84 species which had been recorded from the four original ponds since monitoring began.

The survey recorded 21 species which had not been previously found on the site, including two local and one Nationally Notable B species. Of these 21 species, eight were recorded from the four main survey ponds and 13 species were recorded from previously unsurveyed areas.

Of the new records, 11 were recorded from only one area of the site and most were recorded from just one or two areas of the site. Most of the 11 records were of one or two specimens, though a ramshorn snail, *Bathyomphalus contortus*, was recorded in relatively high abundance from the trial *Phragmites* trench. Four new species were recorded from several areas of the site: these were the Whirlpool Ramshorn (*Anisus vortex*) from five areas, The Broad Bodied Chaser (*Libellula depressa*) from eight areas, a dytiscid beetle, *Ilybius fuliginosus*, from five areas and a noterid beetle, *Noterus clavicornis*, from eight areas. These four species were all newly recorded in at least on of the four original ponds suggesting a new colonisation rather than a lack of previous recording.

Of the 21 new records, seven were of species in the more slowly-colonising groups (flatworms, snails, leeches and crustaceans). This represents a doubling of numbers of species in these groups on the site. Records of one other group, the dragonflies, increased noticeably during this survey (from four species to eight).

4.6.3 Differences in the macroinvertebrate communities on the site

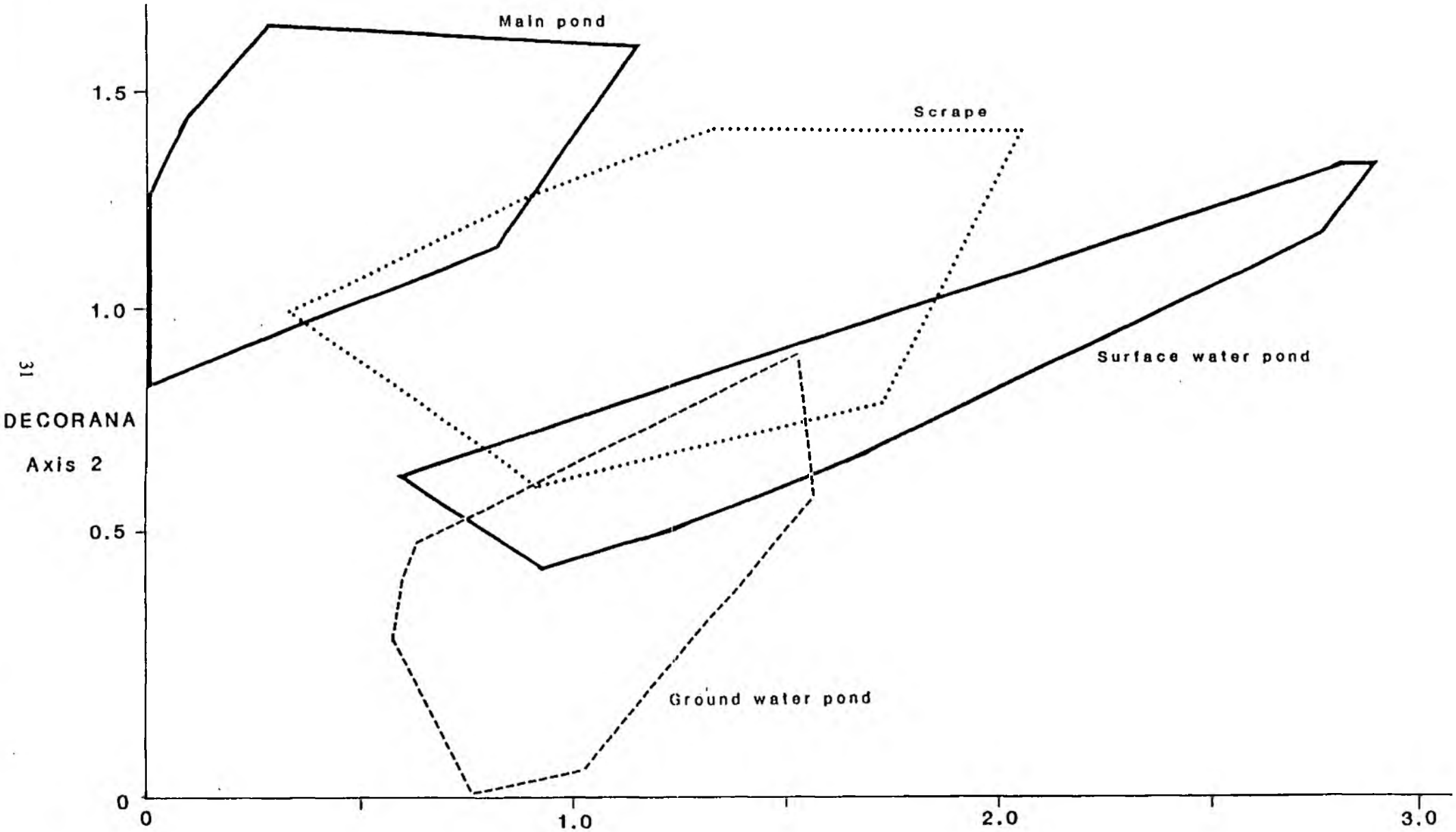
In order to assess how the communities varied across the site, the total numbers of species and the percentage number of species in the major groups (i.e. flatworms, beetles etc.) were tested against various characteristics of the different waterbodies. Amongst those characteristics which showed significant correlations were distance from the south east corner of the site (the area which is closest to the Thames), age of the water bodies and average depth.

Correlations with distance from the south east corner of the site and with depth were tested using Spearman's Rank Correlation Coefficient. Several groups showed weak (not statistically significant) correlations with distance from the south east corner and one group (water snails) was highly significantly correlated ($p = <0.01$) with this distance. The results suggest that there may be an ongoing process of colonisation of the site by snails with the main source for colonisation being the Thames where it flows most closely to the waterbodies on the site. This being followed by a movement of the snails across the site towards the most northerly waterbodies.

The only correlation was a positive relationship between depth and the percentage number of mayfly species present. This is quite probably a reflection of the nature of the underlying geology with the deeper sites being more likely to penetrate into the gravels and thus provide habitat for the ephemerid and some of the caenid mayflies.

Correlations with age of waterbodies was assessed by the Mann-Whitney U test. Seven areas were described as being old (the four original ponds - five areas, the trial *Phragmites* trench, and the undulating margins (north) which are usually in direct contact with the Main Pond. The other seven areas were described as being new. One group, the leeches, was highly significantly correlated with age ($p = <0.005$). This correlation might suggest that, unlike the snails, the colonisation of the site by leeches relies more on a random introduction to the site (perhaps by birds), than on colonisation from a single source and by a single corridor across the site.

Figure 4.1. DECORANA ordination of May 1991 microhabitat samples from Pinkhill Meadows



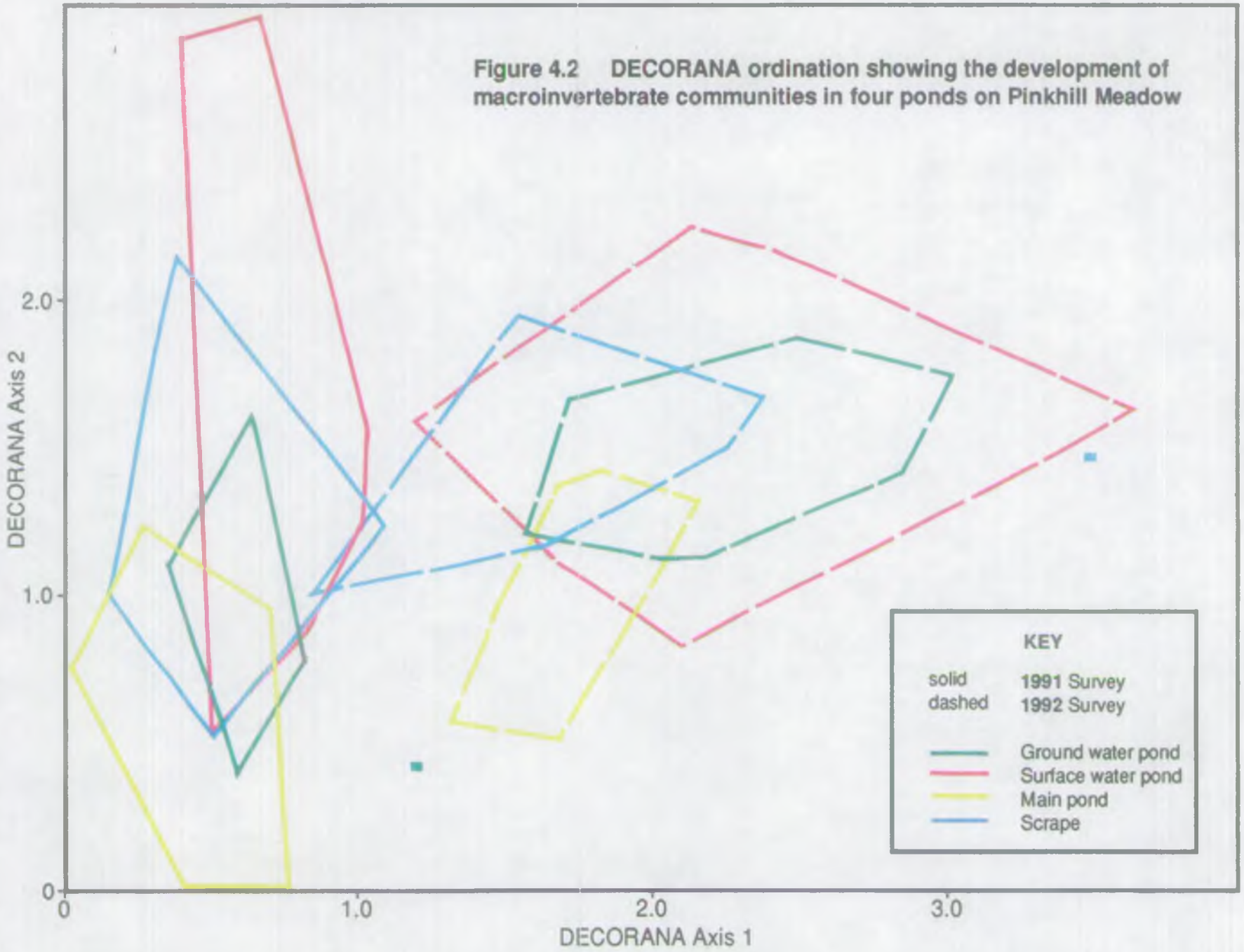


Figure 4.2 DECORANA ordination showing the development of macroinvertebrate communities in four ponds on Pinkhill Meadow

Table 4.2 Numbers of species recorded in each microhabitat in the spring and summer surveys

1991		1992	
Site and habitat	**No. of species**	**Site and habitat**	**No. of species**
Main Pond		**Main Pond**	
Marginal grasses & *Chara* sp.	22	*Chara* sp.	29
Shingle	19	Grasses (shallow)	28
Gravels	17	Grasses (deep)	25
Sandy/muddy bank	16	*Potamogeton* sp.	25
		Juncus spp.	22
		Mud (deep)	19
		Gravels	16
		Mud (shallow)	8
Groundwater Pond		**Groundwater Pond**	
Gravels (deep) A	20	Marginal grasses	16
Gravels and mud (shallow) A	14	*Juncus* spp.	13
Gravels and mud (shallow) B	13	Gravels and mud (shallow)	13
Gravels (deep) B	12	Gravels (deep)	7
Surfacewater Pond		**Surfacewater Pond**	
Marginal grasses	17	Marginal grasses	22
Shallow ruts	16	Shallow ruts	16
Deep ruts	15	Smooth shallows	10
Smooth shallows	12	Deep ruts	8
Scrape		**Scrape**	
Open water	13	Muddy bank	19
Shingle	13	*Juncus* spp. and marginal grasses	17
Muddy bank	12	Marginal grasses	16
Marginal grasses	11	Shingle	12

5. BIRDS

5.1 Objectives of bird moitoring work

Bird monitoring at the Pinkhill site has three main objectives:

(i) To record the species of waders and waterfowl using the Pinkhill Meadow wetlands.

(ii) To determine which areas of the Pinkhill wetlands are most attractive to different wetland birds.

(iii) To determine whether numbers of waders using the Farmoor site as a whole have increased following the creation of the new wetlands (ie are more birds attracted to Farmoor because of the Pinkhill wetlands or do the same number of birds simply redistribute themselves on the site?).

The results of these three aspects of the monitoring programme are described below. Survey and analytical methods are described in Appendix 5.1. The programme of work undertaken to date is summarised in Figure 1.1.

5.2 Results of Objective 1: Waders and waterfowl recorded on the Pinkhill Meadow wetlands

5.2.1 Sources of data

Four sources of data were combined in compiling the species list for the Pinkhill wetlands:

(i) the 1991 spring and autumn monitoring programme results (surveys undertaken by Pond Action).
(ii) observations recorded by birdwatchers in the Farmoor Reservoir log-book.
(iii) habitat-preferences monitoring data from spring 1992 onwards (surveys undertaken by Pond Action).
(iv) observations recorded by birdwatchers in the newly established Pinkhill Meadow log-book (from June 1992 onwards).

Table 5.1 lists the wetland birds (excluding wetland passerines like pied wagtails and reed buntings) recorded on Pinkhill Meadow since May 1990.

Between winter 1991 and spring 1992 the area of the Pinkhill wetlands increased approximately three-fold as a result of the Phase 2 construction. For this reason the results of survey work are described separately for the pre- and post-Phase 2 periods.

5.2.2 Wetland birds recorded on Pinkhill Meadow, June 1990 to September 1992

Phase 1: (July 1990 to December 1992)

In the 20 months from July 1990 to December 1991, 21 wetland species were recorded on Pinkhill Meadow (see Table 5.1). 12 species of wader were recorded on Pinkhill.

Phase 2: (February 1992 onwards)

Since February 1992, 29 wetland species have been recorded on Pinkhill Meadow, including 14 wader species (2 breeding).

Waders recorded between February and September were Oystercatcher, Little-ringed Plover, Ringed plover,

Lapwing, Dunlin, Sanderling, Redshank, Greenshank, Common Sandpiper, Green Sandpiper, Curlew, Whimbrel, Black-tailed Godwit and Snipe.

Lapwings were present from April to August with up to 200 immatures seen during July. Apart from Lapwing, Common Sandpipers were the most abundant waders, particularly during August when birds were present almost daily. The maximum number of species recorded was 12 birds on 31 August. Other waders were recorded in low numbers. During September, Snipe were present almost daily with up to five birds seen at one time.

Only three species of duck were recorded on Pinkhill between February and September. Mallard and Tufted Duck were present throughout the year in varying numbers and one male Garganey was seen on 4 April.

5.2.3 Wetland birds breeding on Pinkhill Meadow

No wetland species were known to have bred on Pinkhill in Phase 1 (1990-1991). However, during this year (summer 1992) at least three species, Little Ringed Plover, Lapwing and Tufted Duck, bred on the site.

Little Ringed Plover

Little Ringed Plovers were present in the 1991 season but although mating was observed on Pinkhill, they did not breed. In 1992 a pair took up residence in the first week of April and remained on the site until late July (last record in Pinkhill log-book 22 July). No Little Ringed Plovers were seen on Pinkhill during this autumn.

This year's breeding pair nested on the largest gravel island of the Main Pond, with scrape-making from the second week of April onwards. Birds were first recorded sitting on the nest on 10 May and four young hatched between 30 May and 2 June.

The young birds quickly moved off the island and foraged widely around the Main Pond. Habitat-preference data (see Section 5.4) was gathered on the habitats used by the adults and young.

Lapwing

Up to four lapwings were regularly present on the site from the second week in April and a pair remained to breed, although nest scrape excavation did not begin until the third week in May. The nest was located at the opposite end of the Main Island to the Little Ringed Plovers nest.

Incubation of eggs probably began on 26 May. The eggs hatched late in June and three young were seen from the last week of June onward. Two young were probably reared. In addition, large flocks of immature lapwings (up to 200 birds) were present during late June and early July.

Tufted Duck

Small flocks of Tufted Ducks (up to 12 birds) used Pinkhill meadow during spring 1992 with occasional higher numbers (eg 60 birds on 4 July). A nest with hatched eggs was found during plant surveying in July 1992 July on the small eastern mud islands in the Main Pond. One female reared a single duckling.

Table 5.1 Wetland Birds (excluding passerines) recorded on the Pinkhill Meadow Wetlands, May 1990 to September 1992

	1990-1991	1992
Great crested grebe		+
Little grebe		+
Cormorant		+
Heron	+	
Mute swan	+	+
Canada goose	+	+
Shelduck	+	
Mallard	+	+
Pintail	+	
Garganey		+
Tufted duck	+	B
Moorhen		+
Coot	+	
Oystercatcher	+	+
Little-ringed plover	+	B
Ringed plover	+	+
Lapwing	+	B
Dunlin	+	+
Temminck's stint	+	
Sanderling		+
Redshank		+
Greenshank	+	+
Common sandpiper	+	+
Green sandpiper	+	+
Curlew		+
Whimbrel	+	+
Bar-tailed godwit	+	
Black-tailed godwit		+
Snipe	+	+
Black-headed gull	+	+
Lesser black-backed gull		+
Common tern	+	+
Little tern	+	
Kingfisher		+
Number of wetland species recorded (cumulative total in parentheses)	**21**	**29 (34)**
Number of wader species recorded (cumulative total in parentheses)	**12**	**14 (16)**

B - Bred on the site

Sources of data:

(i) the 1991 spring and autumn monitoring programme results (surveys undertaken by Pond Action).

(ii) observations recorded by birdwatchers in the Farmoor Reservoir log-book.

(iii) habitat-preferences monitoring data from spring 1992 onwards (surveys undertaken by Pond Action).

(iv) observations recorded by birdwatchers in the newly established Pinkhill Meadow log-book (from June 1992 onwards).

5.3 Preliminary results of Objective 2: habitat-preferences of wetland birds on Pinkhill Meadow

5.3.1 Introduction

Habitat-preference surveys were started in spring 1992, following the completion of the Phase 2 excavation. This section describes preliminary results from the spring 1992 surveys. Habitat- preference survey work will continue in spring and autumn 1993 and 1994.

This section of the monitoring programme aims to describe the preferences of wetland birds, especially waders, for habitat features which have been incorporated in the Pinkhill wetlands. These include shallow bare mud, marginal habitats with differing densities of wetland vegetation, marginal areas with and without topsoil, mud and gravel islands, ponds and pools of varying sizes and areas of undulating wet meadow.

Although many of these habitat features are now 'standard' in new wetlands and scrapes designed for birds, their attractivess to different species has not been assessed systematically. This part of the Pinkhill monitoring programme aims to combine detailed observations on bird activity on the site with descriptions of topography and vegetation in order to determine which areas are most attractive to different species.

5.3.2 Survey work

The survey work has two practical components:

(i) Descriptions of the distribution of birds on the site.

(ii) Descriptions of the physical and botanical features of the site.

Bird distribution patterns are recorded on a 5 m x 5 m grid (see Maps 1 and 2) on randomly chosen days. Although most survey work is being undertaken during migration periods, some observations have also been made during the breeding season, principally to record habitat-preferences of Little Ringed Plovers.

Time of recording during the day is chosen at random to avoid biases due to peaks in bird activity. The basic unit of recording is the frequency and duration of bird visits to individual 5 m x 5 m grid squares, with bird locations and activity being described once every five minutes. Survey periods last two hours, so that each individual bird on site can generate a maximum of 24 'contacts' on each site visit.

Statistical analysis will relate bird distribution patterns to the physical and botanical characteristics of individual grid squares.

Survey methods for the habitat preference monitoring work are described in detail in Appendix 5.

5.3.3 Results of habitat-preference survey work

About 2500 contact records (records of individual birds in a 5 m x 5 m grid square) were collected in Spring 1992. These were made up of 17 species: Little Ringed Plover (31% of total records), Mallard (29%), Lapwing (13%), Tufted Duck (6%), Black-headed Gull (5%), Canada Goose (3%), Dunlin (2%), Sanderling (2%), Ringed Plover (3%), Moorhen (2%), Mute Swan (1%), Redshank (1%), Whimbrel (1%) with Common Sandpiper, Greenshank, Curlew and Common Tern all less than 1% of records.

The results of two analyses of this data are shown in Maps 3 and 4. They give a preliminary analyses of data from the first season (spring 1992).

Migrant waders (ie. excluding resident Lapwings and Little Ringed Plovers)

Map 3 shows the use of the site during spring and early summer 1992 (April, May and June) by predominantly migrant waders.

Shading of the grid squares shows intensity of use with the lightest shading showing a single visit to the grid square, with increasing density of shading representing 2-3, 4-7 and 8+ visits to a grid square. Single square visits represented about 40% of all records.

The results indicate that almost all birds were restricted to the shallow areas and islands of the Main Pond. Throughout the spring the Scrape was used only in the area of the bund with the Main Pond. In comparison to Little Ringed Plovers (see below), migrant waders appeared to spend more time on the gravel islands of the Main Pond than on its margins. It was noticable that the eastern margins of the Main Pond, were used consistantly less than other margins. This is most likely to be related to human disturbance from the adjacent footpath.

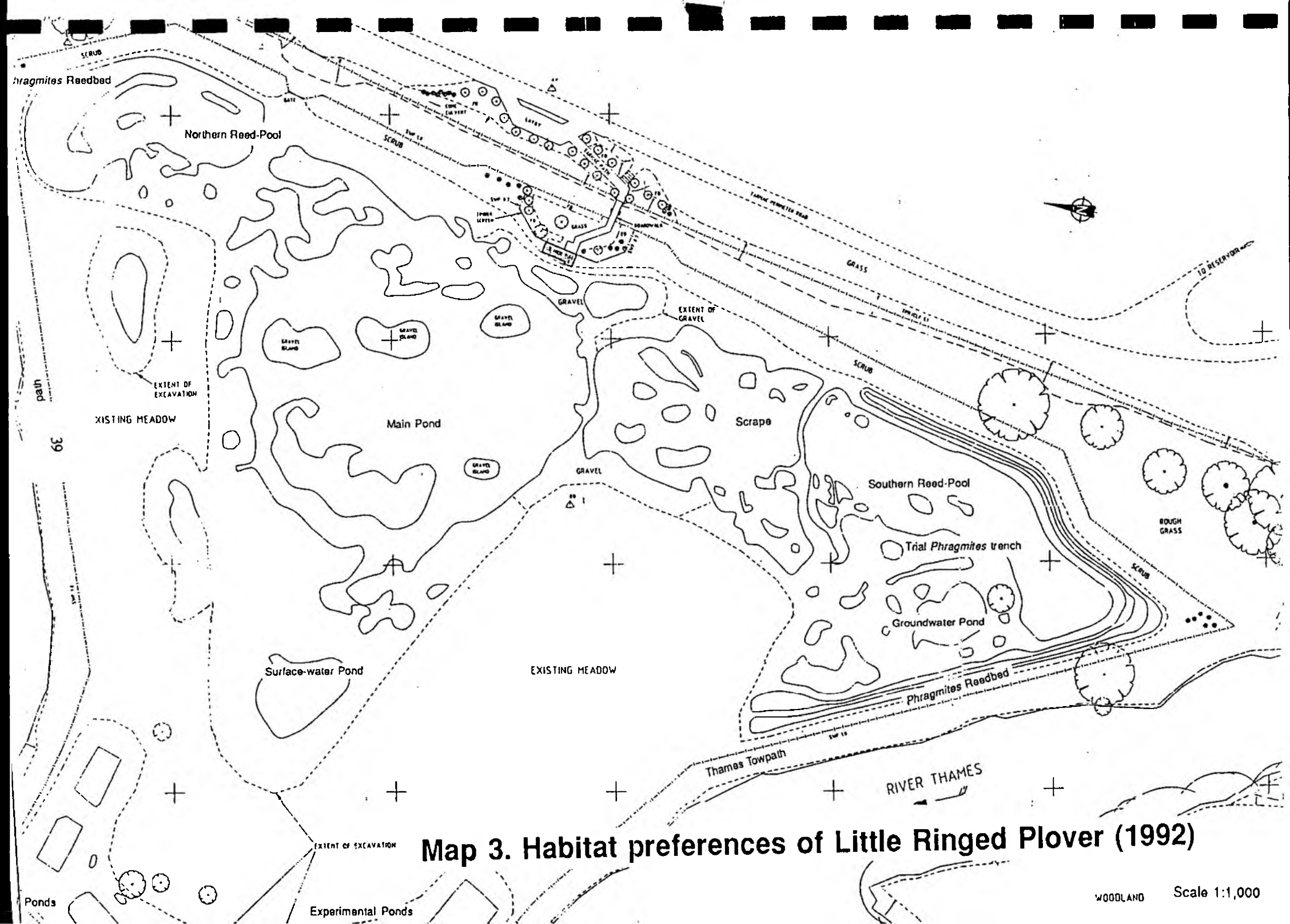
Little Ringed Plover

Little Ringed Plover data consisted of approximately 650 records (ie about three times as many as all migrant waders together). Map 4 shows habitat-preferences of Little Ringed Plover, including chicks. Lightest shading represents a single visit to the grid square, with increasing density of Shading representing 2-3, 4-7 and 8-15 and 16+ visits to a grid square. The nest site is shown by a black square. Single square visits represented about 40% of all records.

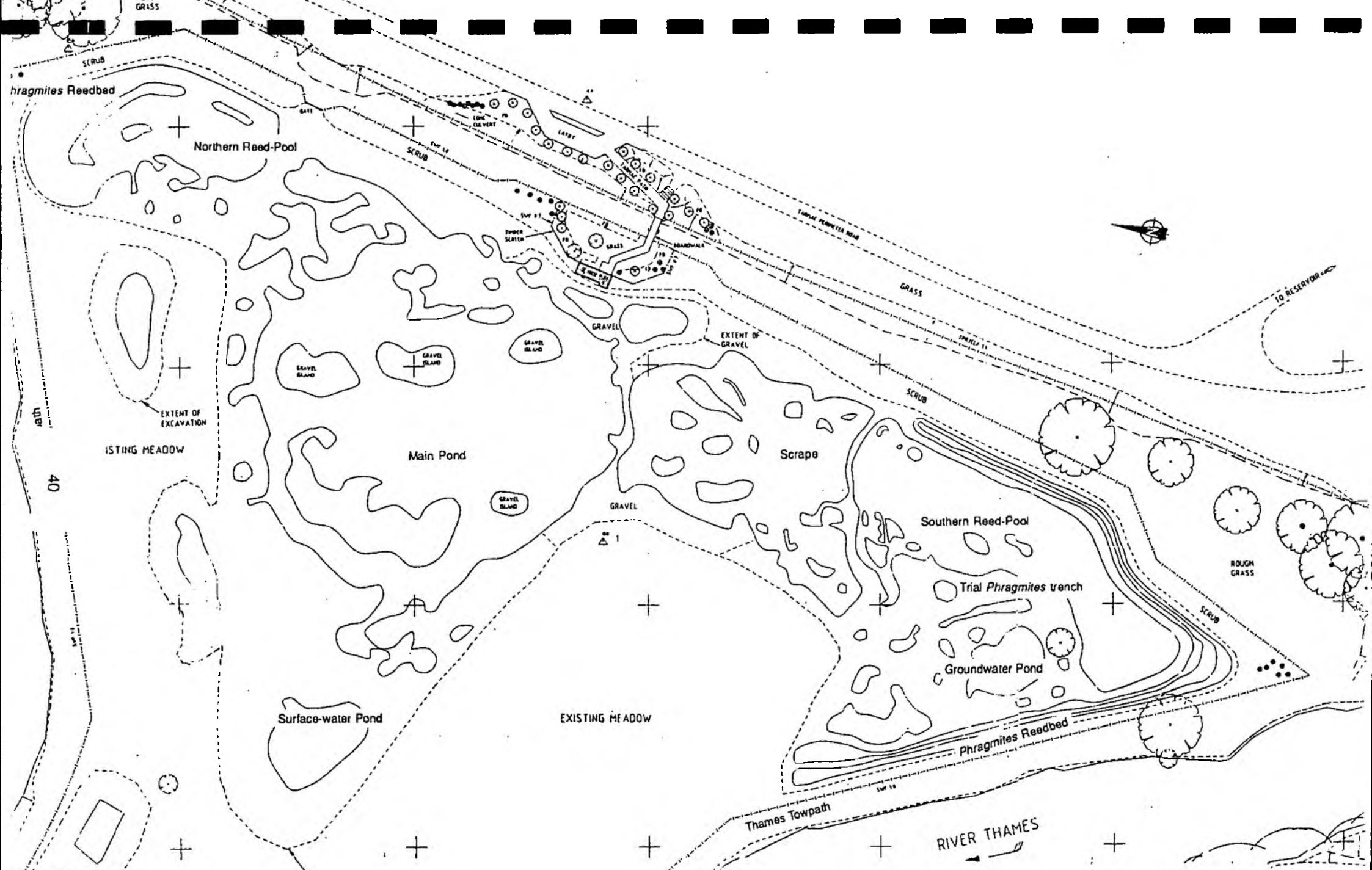
Not supprisingly, the most frequently used area was the nest the large gravel island on the Main Pond. The amount of time spent in this area not only reflected the incubation of the eggs but also a considerable amount of time spent by both birds loafing on the island near the nest. As with all other waders, nearly all Little Ringed Plover activity was concentrated on the Main Pond, with a very few visits to islands in the Scrape. In contrast to other waders, Little Ringed Plovers spent a relatively large amount of time foraging on the south-west shore of the Main Pond.

5.3.4 Further analysis

When more site environmental data becomes available, further work will deal with relating the use of different grid squares by birds to the physical and botanical characteristics of these squares.



Map 3. Habitat preferences of Little Ringed Plover (1992)



Map 4. Habitat preferences of migrant waders (1992)

Scale 1:1,000

5.4 Results of Objective 3: To determine whether numbers of waders using the Farmoor site have increased following the creation of the Pinkhill wetlands

5.4.1 Approach to the work

This has been the main part of the monitoring programme so far and has involved three stages:

(i) Assessment of the reliability of the Farmoor log-book data.

(ii) Description of the relationships between wader numbers and environmental factors (eg weather and seasons) between 1982 and 1990 (ie pre-Pinkhill contruction).

(iii) Predictions of the numbers of waders expected at Farmoor after the construction of the Pinkhill wetlands (ie autumn 1990 onwards).

5.4.2 The reliability of the Farmoor log-book data

The Oxford Ornithological Society has kept a log-book record of birds at Farmoor Reservoir, since January 1982. This has been filled-in by visiting birdwatchers almost daily. Prior to the current study these data had not been analysed in detail but, at the outset of the study, they seemed likely to be a very valuable source of long-term data for the Pinkhill study. In particular, it offered the possibility of an 8 year pre-construction phase survey of bird numbers which could be compared with bird numbers after the construction of Pinkhill. The main problem with the log-book data is that it is filled-in non-systematically and that most birdwatchers record only the species which interest them (eg waders, less common ducks and water birds generally rare in Oxfordshire).

Initial bird monitoring in 1991 therefore aimed to determine whether Farmoor log-book data could provide the basis of monitoring work for the Pinkhill study.

Two questions needed to be answered:

(i) Do the data recorded in the log-book reveal trends similar to those in more systematic surveys?

(ii) Can birdwatcher recording-effort, which varies between years, be described?

5.4.3 Comparison of log-book data and known-effort survey data

Introduction

In order to assess whether the log-book data could be used as a pre-Pinkhill baseline, Pond Action carried out an investigation of the similarities between the log-book data and data collected at the same time.

The objective of this work was to determine whether results recorded in the log-book were similar to those obtained from a survey where recorder biases were, as far as possible, eliminated. In particular, the known-effort survey was designed to eliminiate biases due to (i) selective recording of some species (ii) visits being concentrated on certain days eg during weekends (iii) variations in the numbers of birdwatchers recording observations.

Log-book data from April, May, August, September and October was compared with the results of known-effort survey work undertaken by Pond Action during the same months (2hrs on 52 randomly selected dates, see Table 5.2). The similarity of the two data sets was assessed by correlation analysis. Survey and analytical methods are also described in Appendix 5.

Comparisons were made in terms of the number of bird-days recorded for each species. Correlations between log-book and known effort data were investigated for:

(i) all wetland species.

(ii) all wader species combined.

(iii) individual species.

All wetland species

Correlations between the total number of wetland bird-days recorded in spring and autumn by the two survey methods (log-book and known-effort) were investigated.

Known-effort sampling generally recorded considerably greater total numbers of wetland bird-days than were recorded in the log-book (see Table 5.3). This was mainly due to the fact that several common species (eg mallard and tufted duck) were only recorded systematically in the log-book by one or two observers each month (for example, often at the beginning of the month by the County Recorder).

Despite these differences there were strong correlations between numbers of birds recorded during known-effort surveys and in the log-book. Interestingly correlations were found irrespective of whether all 61 days of log-book data were compared with the known-effort data or just the log-book data from the 24 (spring) and 28 (autumn) days when known-effort surveys were undertaken (see Tables 5.3 and 5.4).

Waders

Log-book total wader-days and known-effort total wader-days were correlated as described above (see Methods, Appendix 5). In all cases correlations were strongest when waders alone were compared (see Tables 5.3 and 5.4) indicating that waders were amongst the most consistently recorded birds.

This reflected the fact that waders were generally well-recorded, because of the interest that visiting birdwatchers have in this group of species and the ease with which they can be recorded. The strongest correlation in spring was between log-book and known-effort data collected on the same 24 days (excluding Golden Plover). In autumn it was between log-book and known-effort data for the same 28 days

Individual species

Correlations between the daily counts of individual species were also investigated. These were the most severe test of the similarity of the two dats-sets. 10 species showed significant correlations between log-book and known-effort data in the spring and eight in the autumn (see Tables 5.3 and 5.4). In both seasons just over half were waders, further reflecting the interest that birdwatchers have in recording these species. In contrast, log-book counts of most of the common species were not correlated with the numbers of birds present.

Conclusions

The comparisons of known-effort and log-book data suggested that:

(i) the log-book data broadly reflected the results of known-effort surveys undertaken at the same times and could be used to estimate numbers of bird-days recorded on the site as a whole.

(ii) waders were amomgst the most accurately recorded birds in the log-book (counts of terns were also quite accurate).

Table 5.2 Bird recording at Farmoor Reservoir during April, May, August, September and October 1991: number of birdwatchers recording observations and dates of Pond Action known-effort surveys

APRIL			MAY		
Date	Birdwatchers recording observations	Known-effort visits	Date	Birdwatchers recording observations	Known-effort visits
1	1	+	1	5	+
2	1	+	2	3	
3	3		3	2	
4	2		4	4	+
5	4	+	5	6	
6	4		6	4	+
7	6	+	7	3	
8	3	+	8	1	
9	4		9	8	
10	4		10	7	
11	2	+	11	3	
12	4		12	3	
13	5	+	13	2	
14	1	+	14	1	
15	2		15	2	
16	1	+	16	2	+
17	2	+	17	2	+
18	3	+	18	5	+
19	2		19	2	+
20	3		20	2	
21	4		21	3	
22	5	+	22	2	+
23	3	+	23	4	+
24	4	+	24	2	
25	3		25	3	
26	4		26	1	
27	8		27	4	
28	4		28	3	
29	4		29	3	
30	4		30	4	
			31	2	+
Total	98	14		98 (196)	10 (24)

AUGUST			SEPTEMBER			OCTOBER		
Date	Number of birdwatcher visits	Known-effort visits	Date	Number of birdwatcher visits	Known-effort visits	Date	Number of birdwatcher visits	Known-effort visits
1	0		1	5		1	5	
2	0	+	2	7	+	2	5	
3	1		3	4		3	8	+
4	0		4	2		4	3	
5	0	+	5	1		5	1	
6	1		6	2		6	2	
7	3	+	7	5	+	7	2	
8	2	+	8	6		8	0	+
9	2		9	4		9	2	+
10	0		10	2	+	10	5	
11	0		11	6		11	2	+
12	4	+	12	3	+			
13	1		13	2	+			
14	1	+	14	2				
15	1		15	4				
16	0	+	16	1				
17	1		17	3				
18	2		18	0	+			
19	3	+	19	0	+			
20	2	+	20	3	+			
21	3		21	9				
22	4	+	22	0				
23	3		23	4	+			
24	5	+	24	4				
25	5		25	1	+			
26	5		26	1				
27	2	+	27	2	+			
28	3		28	0				
29	1		29	3				
30	5		30	3	+			
31	3							
TOTAL	63	12		89	12		35 (187)	4 (28)

Table 5.3 Comparison of total numbers of birds (bird-days) at Farmoor Reservior estimated by known-effort sampling and from the Farmoor log-book for Spring and Autumn 1991.

	SPRING		AUTUMN	
SPECIES	TOTAL BIRD/DAYS (KNOWN-EFFORT DATA)	TOTAL BIRD/DAYS (LOG-BOOK DATA)	TOTAL BIRD/DAYS (KNOWN-EFFORT DATA)	TOTAL BIRD/DAYS (LOG-BOOK DATA)
Great crested grebe	264	142	599	223
Dabchick	23	5	12	13
Black-necked Grebe	-	-	4	16
Gannet	0	1	-	-
Cormorant	464	176	776	412
Heron	6	7	23	3
Mute swan	38	0	411	60
Greylag goose	2	1	1128	300
Canada goose	32	0	67	2
Shelduck	5	12	0	4
Mallard	830	92	2538	584
Wigeon	1	2	7	29
Teal	7	0	7	9
Garganey	0	2	1	3
Shoveler	0	8	1	2
Tufted duck	999	244	6283	3125
Goldeneye	166	114	0	114
Goosander	1	1	0	0
Ruddy duck	0	1	0	0
Wood duck	3	1	0	0
Pintail	-	-	-	11
Scaup	-	-	-	1
Osprey	-	-	-	1
Marsh harrier	-	-	-	1
Moorhen	2	0	25	0
Oystercatcher	0	4	0	8
Little-ringed plover	36	78	-	2
Ringed plover	6	35	7	34
Golden plover	52	0	1	6
Grey plover	1	1	1	1
Turnstone	4	18	2	3
Lapwing	7	6	103	301
Dunlin	44	114	100	171
Temminck's stint	0	1	-	-
Little stint	-	-	7	17
Knot	0	3	1	11
Sanderling	4	35	16	38
Redshank	8	16	1	13
Greenshank	1	2	16	24
Common sandpiper	37	104	120	189
Green sandpiper	1	0	3	4
Curlew sandpiper	-	-	-	2
Ruff	-	-	-	4
Curlew	12	10	-	3
Whimbrel	1	16	-	1
Bar-tailed godwit	17	15	-	-
Black-tailed godwit	0	9	-	-
Snipe	-	-	-	7
Grey phalarope	-	-	1	5
Black-headed gull	141	245	2448	40
Little gull	0	17	-	6
Mediterranean gull	0	1	-	-
Herring gull	1	0	1	11
L. black-backed gull	9	41	32	22
Great black-backed gull	-	-	1	-
Common gull	1	0	1	3
Kittiwake	0	2	-	-
Common tern	73	116	128	108
Arctic tern	13	185	-	6
Little tern	2	3	-	-
Black tern	19	158	12	49
Arctic skua	-	-	1	1
Kingfisher	0	3	2	3
Rock pipit	3	2	7	27
Pied wagtail	126	182	697	371
White wagtail	28	50	9	1
Grey wagtail	0	3	5	14
Yellow wagtail	184	665	749	1342
Reed bunting	23	19	15	2
NUMBER OF SPECIES RECORDED	45	49 (57)	51	64 (67)

Table 5.4. Correlations between known-effort data and log-book data, April and May 1991

CORRELATION	DATA SOURCES COMPARED	SPEARMAN'S RANK CORRELATION	
All species (bird-days).	Log-book: 61 days Known-effort: 24 days	0.643***	(n=66)
All species (bird-days).	Log-book: 24 days Known-effort: 24 days	0.676***	(n=66)
Waders only (bird-days).	Log-book: 61 days Known-effort: 24 days (with golden plover)	0.592**	(n=22)
	Log-book: 24 days Known-effort: 24 days (with golden plover)	0.632**	(n=22)
	Log-book: 61 days Known-effort: 24 days (without golden plover	0.79***	(n=21)
	Log-book: 24 days Known-effort: 24 days (without golden plover)	0.787***	(n=21)
Individual species (only significant correlations are listed)	Log-book: 24 days Known-effort: 24 days		

	NUMBER OF DAYS RECORDED		
	Known-effort data	Log-book data	Spearmans Rank Correlation coefficient (rho)
Turnstone			0.431*
Dunlin			0.767***
Sanderling			0.522**
Common sandpiper			0.808***
Whimbrel			1***
Bar-tailed godwit			0.598**
Common tern			0.692***
Little tern			0.692***
Black tern			0.676**
Yellow wagtail			0.607**

Table 5.5 Correlations between wader bird-days calculated from known-effort data and log-book data for August, September and October 1991

CORRELATION	DATA SOURCES COMPARED	SPEARMAN'S RANK CORRELATION	
All species (bird-days).	Log-book: 71 days Known-effort: 28 days	0.708***	(n=83)
All species (bird-days) except gulls	Log-book: 71 days Known-effort: 28 days	0.742*** 0.654***	(n=77) (n=77)
All species (bird-days).	Log-book: 28 days Known-effort: 28 days	0.601***	(n=83)
Waders only (bird-days).	Log-book: 71 days Known-effort: 28 days	0.801***	(n=24)
	Log-book: 28 days Known-effort: 28 days	0.821***	(n=24)
Individual species (all species with significant correlations).	Log-book: 24 days Known-effort: 24 days		

	NUMBER OF DAYS RECORDED		
	Known-effort data	Log-book data	Spearmans Rank Correlation coefficient (rho)
Dunlin	14	13	0.619***
Little stint	5	8	0.607***
Sanderling	3	3	0.679***
Greenshank	9	7	0.447*
Common sandpiper	28	23	0.515**
Black tern	7	8	0.341*
Rock pipit	2	2	0.46*
Pied wagtail	28	6	0.355*

5.4.4 Variations in birdwatcher effort and effects on numbers of birds recorded

Once it was known that birdwatchers data was reliable, particularly for the waders, it was then posible to investigate variations in log-book recording effort over the years. Preliminary inspection of the data suggested that there was a general relationship between the number of birdwatchers recording observations and the number of birds recorded. This relationship was examined by:

(i) looking for correlations between birdwatcher numbers and bird numbers within the log-book data
(ii) by further comparisons of log-book data and known-effort data from the spring and autumn of 1991.

The number of birdwatchers visiting Farmoor and recording observations in the log-book was estimated from the number of signatures in the log-book (or entries in clearly different handwriting; see Appendix 5 for full description of methods).

Numbers of birdwatchers recording observations in the Farmoor log-book, 1982-1990

Numbers of birdwatchers recording observations in the Farmoor log-book are shown in Figure 5.1. Each month, between 1 (March 1987) and 111 (April 1991) birdwatchers recorded observations in the log-book. Between 1982 and 1991 there was a highly significant increase in the number of birdwatchers recording their observation in the log-book (see inset in Figure 5.1).

Over the same period there was also a highly significant increase in the total number of waders recorded (see Figure 5.2 and Appendix Table 5.1). This trend was also apparent during migration months alone.

The relationship between wader numbers and birdwatcher numbers

Highly significant correlations were found between number of birdwatchers and numbers of waders recorded during the year and at migration periods alone (see Appendix Figures 5.1a. and 5.1b). This partly reflected the fact that, not supprisingly, more birdwatchers visited the reservoir during peak migration periods. However, taken with the significant increase in both bird and birdwatcher numbers between 1982 and 1990, this strongly suggested that more birds were recorded when greater numbers of observers were present.

Figure 5.1 **Numbers of birdwatchers recording observations in the Farmoor Reservoir log-book. Monthly totals, January 1982 to October 1991. Inset shows increase in number of birdwatchers during this period.**

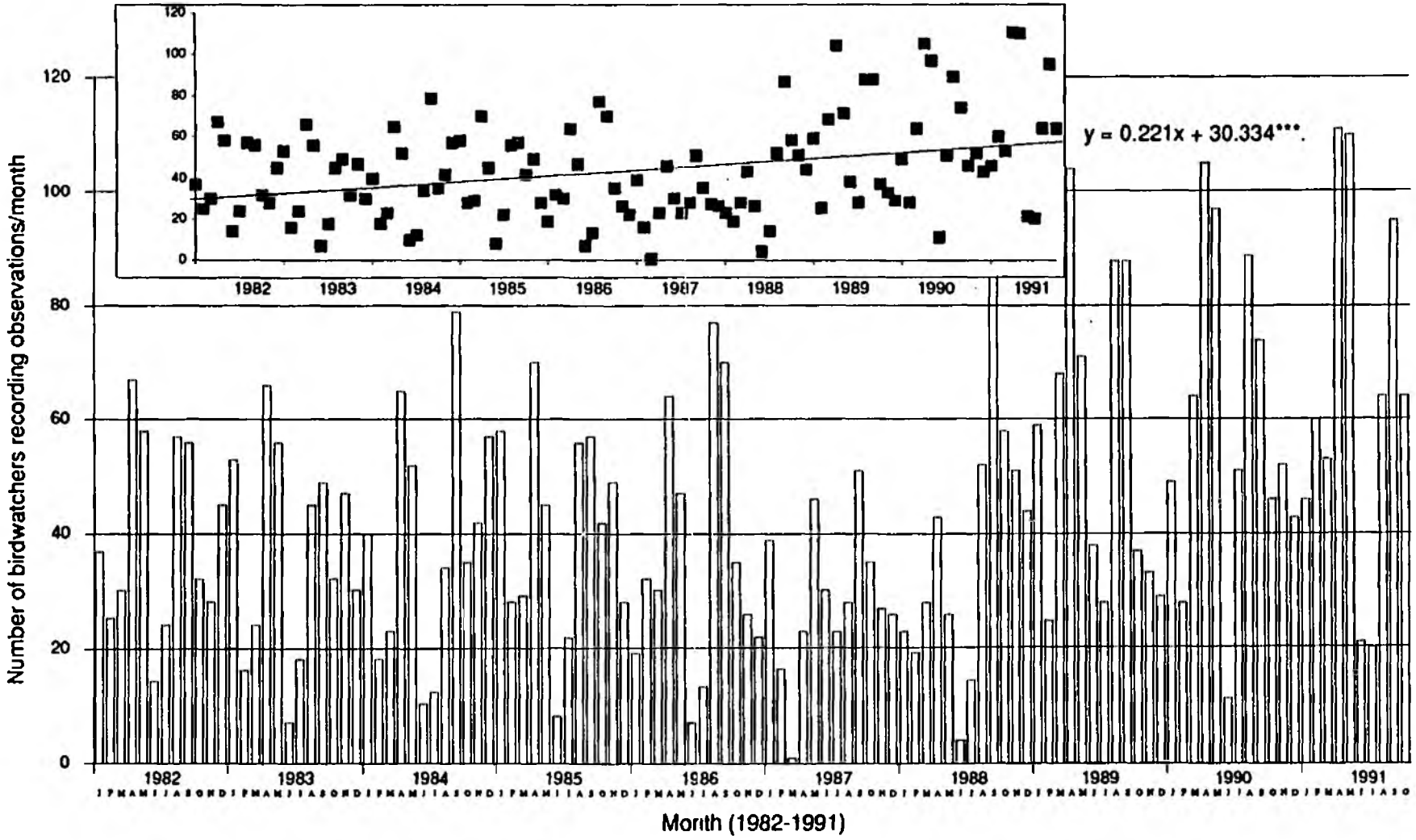
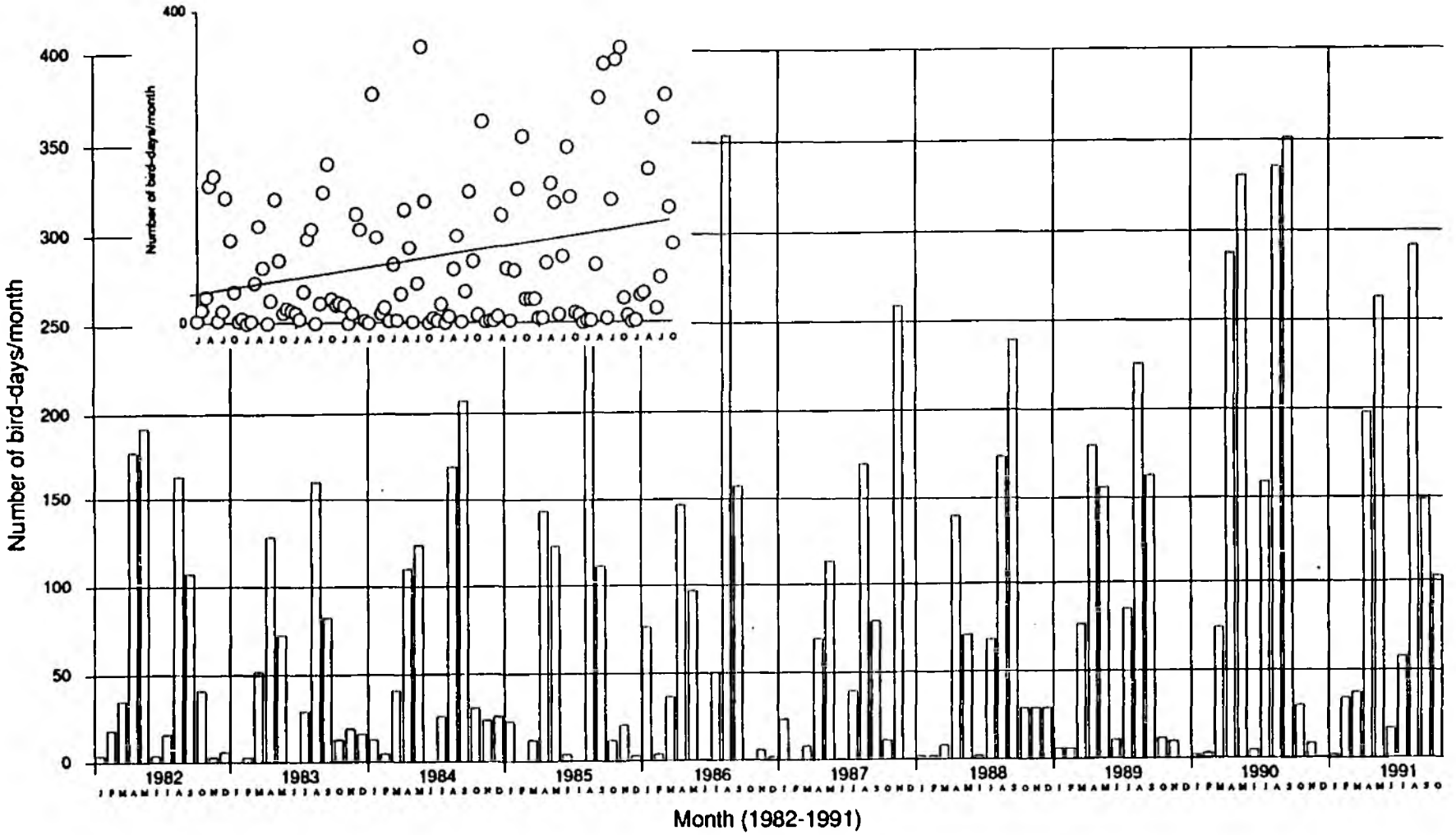


Figure 5.2 Number of waders recorded at Farmoor Reservoir, as bird-days/month; January 1982 to October 1991. Uncorrected for birdwatcher effort. Inset shows apparent increase in wader numbers between 1982 and 1990. y = 0.581x + 42.13***



Short-term effects of birdwatcher effort during 1991 migration months

Comparison of log-book data with known-effort counts made on the same days in spring and autumn 1991 also showed a significant correlations between number of birdwatchers and the difference between constant effort counts and birdwatcher counts (see Figure 5.3 and Appendix Table 5.3). As the number of birdwatchers making observations increased from 0 to 8, the difference between birdwatcher observations and log-book records moved from negative to positive, although the relationship is a fairly noisy one.

Taken together, all the observations of the relationships between numbers of birdwatchers and birds recorded, suggest that birdwatcher effort was mainly responsible for the apparent increase in waders at Farmoor.

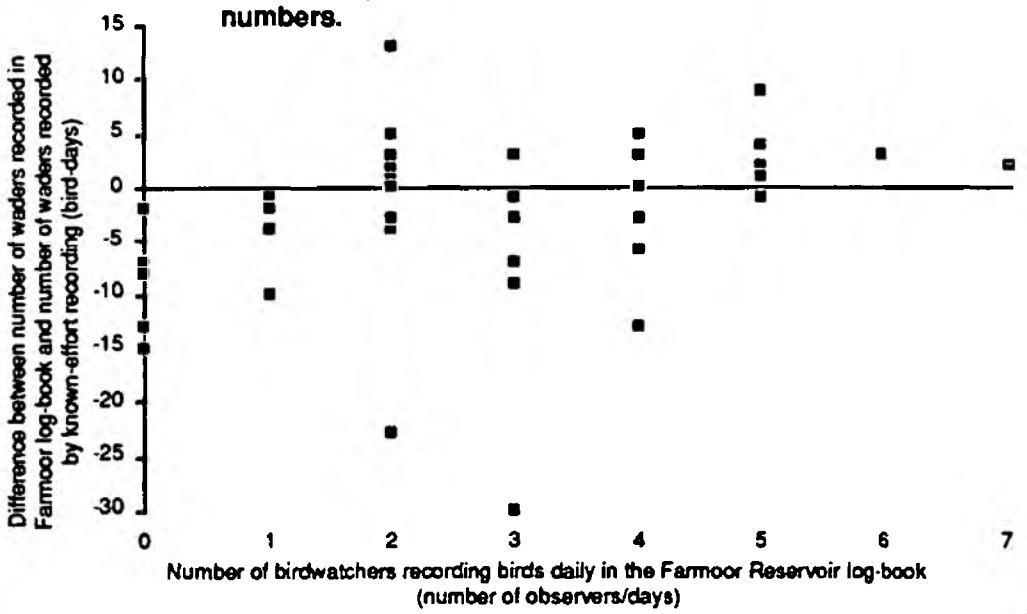
Correction of log-book counts

Since two lines of evidence suggested that bird numbers were related to numbers of birdwatchers recording observations, all log-book counts were corrected to bird-days recorded per birdwatcher. Once wader numbers (as bird-days/month) were divided by number of observer there was no significant change in numbers over the 10 years. Corrected counts are shown in Appendix Table 5.2.

Once corrected for birdwatcher effort, wader numbers appear to have remained mostly stable over the period 1982-1990.

All subsequent analysis of bird numbers using Farmoor log-book data has been based on corrected counts (number of bird-days per birdwatcher recording observations in the log-book).

Figure 5.3. The relationship between number of birdwatchers recording birds in the Farmoor Reservoir log-book and the difference between log-book wader numbers and known-effort wader numbers.



5.4.5 The relationship between wader numbers and environmental factors

Environmental data

Weather data was taken from the Oxford University Meteorological Station (6km due east of Farmoor Reservoir). 21 aspects of climate were included in the analysis: mean daily cloud cover (octals), windspeed (as mean velocity in one of eight wind directions - N, NE, E, SE, S, SW, W, NW), wind direction (as number of days in the month in one of the eight directions), mean daily visibility (on an arbitrary 1-8 scale), mean daily dry bulb temperature (°C), mean daily rainfall (in mm) and mean daily sunshine (hours). Variation in daylength was taken into account by treating the month as a variable (ie March = 1, April = 2, May = 3; August = 1, September = 2, October = 3).

Methods are described in detail in Appendix 5.

Climate data for the period January 1982-September 1992 is given in Appendix Table 5.4. Visibility, rainfall, temperature, cloud cover and sunshine have all been multiplied by 100 in this table.

The relationship between environmental factors and bird numbers was investigated using multiple regression analysis. For the analysis spring months (March, April and May) and autumn (August, September, October) were treated separately.

Waders recorded at Farmoor Reservoir

30 wader species were recorded at Farmoor between 1982 and 1991. The most abundant species were Common Sandpiper, Dunlin and Redshank (see Appendix Table 5.2) which represented 32%, 27% and 17% of birds recorded, respectively (excluding lapwing and golden plover). 14 species contributed less than 1% of the corrected bird records.

Migration at Farmoor Reservoir

The main migration months during the 10 years were April, May, August and September (see Figure 5.2), although wading birds were present at Farmoor in most months of the year.

Factors affecting the numbers of waders

The most important predictor of wader numbers during migration was the month. Climate variables were generally of secondary importance.

Table 5.5 shows the variables which contributed signficantly to explaining the variation in wader numbers. More variation was explained in autumn than in spring. For this report only the most highly predicting equation (Total 2, the total number of bird-days) was used. This equation predicted 92% of variation in wader numbers in autumn using five variables: month, number of days of south winds, strength of south-west winds, mean monthly cloud cover and mean monthly rainfall.

Table 5.6. Environmental vairables explaining variation in wader numbers in multiple regression equations

SPRING

SPECIES	VARIABLES	EQUATION	CORRELATION COEFFICIENT
Common Sandpiper	1	$y = 42.17x_1 + (-40.52)$	$r^2 = 0.731$, $p < 0.0001$
Whimbrel	4, 8, 11, 15	$y = 1.33x_{11} + 4.05x_{13} - 0.87x_8 - 0.49x_4 + 0.59$	$r^2 = 0.694$, $p < 0.0001$
Total species	2, 7, 17, 18	$y = 0.402x_2 - 0.651x_7 - 0.12x_{17} - 0.009x_{18} + 12.89$	$r^2 = 0.668$, $p < 0.0001$

AUTUMN

SPECIES	VARIABLES	EQUATION	CORRELATION COEFFICIENT
Oystercatcher	5, 10, 11	$y = 0.275x_1 + 0.210x_2 + 0.283x_3 - 1.377$	$r^2 = 0.535$, $p < 0.003$
Ringed Plover	1, 2	$y = 2.718x_1 + 18.248x_2 - 26.119$	$r^2 = 0.591$, $p < 0.0001$
Sanderling	6, 7, 18	$y = 0.726x_1 + 0.382x_2 + 0.024x_3 - 16.82$	$r^2 = 0.811$, $p < 0.001$
Dunlin	1, 7, 17	$y = -6.212x_1 + 0.388x_2 + 44.36x_3 - 169.918$	$r^2 = 0.609$, $p < 0.0001$
Common Sandpiper	1, 16, 18,	$y = -7.192x_1 + 0.388x_2 + 44.36x_3 - 169.918$	$r^2 = 0.796$, $p < 0.0001$
Green Sandpiper	6, 18,	$y = 0.239x_6 + 0.005x_{18} - 3.201$	$r^2 = 0.630$, $p < 0.0001$
Curlew Sandpiper	3, 5, 7, 15, 17,	$y = -0.970x_{15} + 0.271x_3 - 0.426x_5 - 0.839x_7 + 0.012x_{17}$	$r^2 = 0.643$, $p < 0.0002$
Total 2	1, 7, 13, 17, 19	$y = 12.799x_{13} - 21.507x_7 + 0.766x_{17} - 223.654x_1 + 0.289x_{19}$	$r^2 = 0.918$, $p < 0.000$

	Oystercatcher	Ringed Plover	Turnstone	Dunlin	Common Sandpiper	Green Sandpiper	Curlew Sandpiper	Whimbrel	Total
1. MONTH		A		A	S, A				A
.WINDSPEED									
2. North		A							
3. North-east							A		
4. North-west								S	
5. South	A			A			A		
6. South-east			A			A			
7. South-west			A				A		A
8. East								S	
9. West									
WIND DIRECTION									
10. North	A								
11. North-east	A							S	
12. North-west									
13. South									A
14. South-east									
15. East							A	S	
16. West					A				
17. CLOUD				A			A		A
18. SUN			A		A	A			
19. RAIN									A
20. TEMPERATURE									
21. VISIBILITY									

5.4.7 Prediction of wader numbers at Farmoor Reservoir following the construction of the Pinkhill wetlands

Predictions of the of number of wader bird-days that would have been expected at Farmoor before the construction of the Pinkhill wetlands were made using Equation 'Total 2' of Table 5.6.

Climate data for autumn months (August, September and October) were used to solve the equation. Recorded numbers of birds were then compared with the number of waders predicted by the equation (see Figure 5.4). Predicted and recorded wader numbers are shown for the three autumn months separately.

As would be expected, before the construction of Pinkhill, observed numbers of waders were similar to the predictions. This is most apparent in August and September, perhaps because more birds are present in these months and numbers are less variable. In October, recorded numbers do not follow predictions so closely (note that predictions can be below zero).

5.5.8 Conclusions

After Pinkhill was constructed, recorded wader numbers **were higher** than predicted numbers in **all** autumn months (see Figure 5.4).

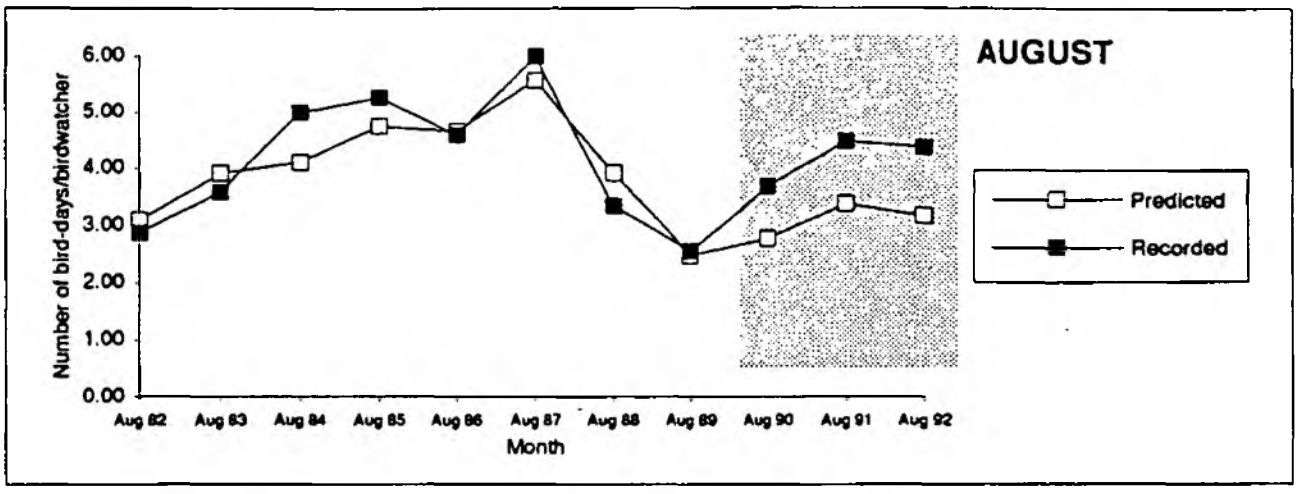
It should be emphasised that this is a preliminary result and that more data will be required to corroberate this. However the results are important for two reasons:

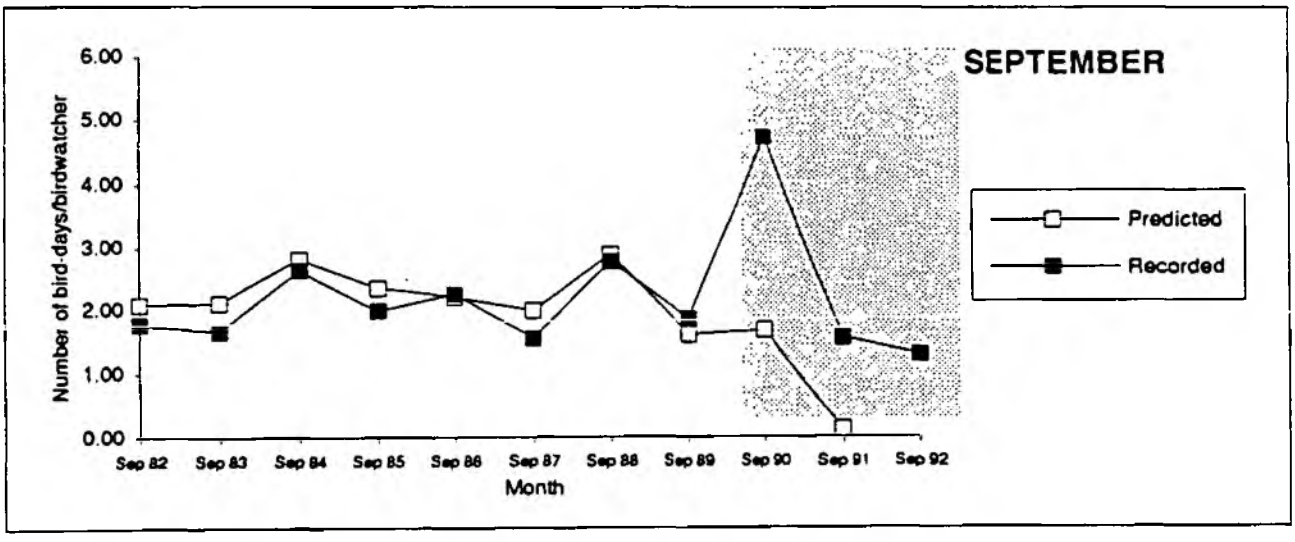
(i) it suggests that wader numbers on the Farmoor site as a whole may be increasing as a result of the construction of the Pinkhill wetlands.

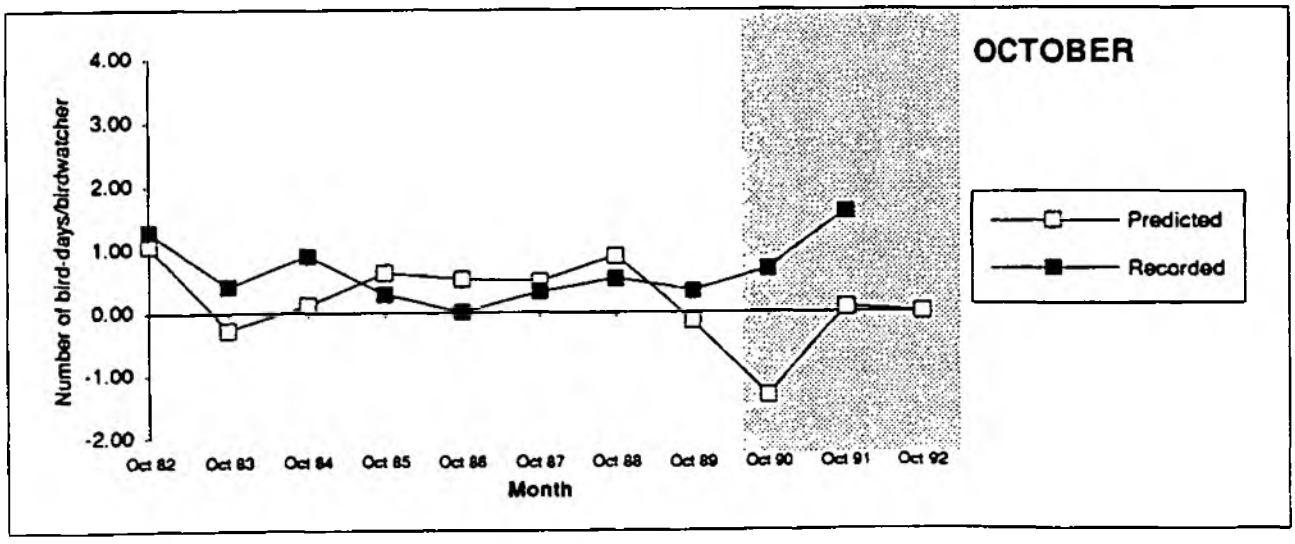
(ii) the result is not obvious from simple observations of wader numbers; the ability to compare with predictions (based on a number of years of log-book data) is essential for detecting an increase in waders in the short-term.

Further analysis will concentrate on the use of process control statistics to determine whether differences between

Figure 5.4 Predicted and recorded wader numbers at Farmoor Reservoir before (pre-June 1990) and after construction of the Pinkhill wetlands







6. EXPERIMENTAL MANAGEMENT OF WETLAND VEGETATION

6.1 Background

Seven experimental ponds were created during Phase 2 of Pinkhill construction. The ponds are being used to undertake two experiments:

(i) Experiment 1 (Ponds one - three): an investigation of management techniques for establishing species-rich plant communities in new wetlands.

(ii) Experiment 2 (Ponds four - seven): an investigation of the relationship between the species-richness of aquatic macroinvertebrate communities and wetland plant species-richness.

6.2 Experiment 1: Establishing species-rich plant communities

This experiment aims to investigate the best means of managing newly planted waterbody margins to establish rich plant communities with a diverse range of emergent, marginal and floating-leaved species.

6.2.1 Experimental Design

New wetland habitats often become dominated by robust emergent plants (especially *Glyceria maxima* and *Typha latifolia*). This trend is usually perceived as undesirable (but see Experiment two below) and management is often directed at the control of these species to maintain species-rich swards. However, in the absence of grazing, the maintenance of species-rich swards may be time consuming or costly. This experiment compares practical methods for maintaining species richness.

The experiment uses three duplicate ponds (each 150 m^2). Each pond is divided into eight randomised blocks which have been planted-up with a variety of wetland plant species using local stock. Each block will be subjected to one of four management treatments (see below and Figure 6.1). To ensure that differences between ponds are taken into account there is a replicate of each treatment in each pond. Statistical analysis will mainly be undertaken by analysis of variance.

The four management techniques have been chosen to represent 'practical' techniques which are most frequently and easily available in the conservation sector.

These management techniques are:

(i) Planted. No management.
(ii) Planted. Cut.
(iii) Planted. Selective hand-weeding of undesirable species.
(iv) Planted. Selective spot-treatment of undesirable species with contact herbicides.

The effectiveness of the management treatments will be assessed in terms of:

(i) composition and structure of the vegetation.
(ii) the time required for the management work.
(iii) estimated cost of the management work.

Permanent quadrats will be set up in the ponds within which the vegetation structure and composition are monitored. Quadrats will be monitored bimonthly.

6.2.2 Progress to date

The ponds were planted up during July 1992. Planting-up was undertaken by Pond Action staff in order to ensure the standard and continuity of the work. Nine species were planted: *Alisma plantago-aquatica, Glyceria fluitans, Phalaris arundinacea, Polygonum amphibium, Ranunculus sceleratus, Typha latifolia, Veronica beccabunga, Agrostis stolonifera* and *Juncus articulatus.*

Species were planted using a stratified random method: each row of the plot was planted with one each of the species, but the location of a species on the row was chosen randomly. All of the wetland species planted in the experimental ponds came from a very local source (the main part of the newly created Pinkhill wetland site!), so individual plants should be well adapted to local conditions.

The planting density was five plants per square metre, which is similar to the average planting density recommended by commercial plant suppliers (Mark Robinson, London Aquatic Company, pers. comm.).

Water levels were exceptionally high during the summer months of 1992. Species were planted into water which was 0.15 - 0.2 m deep, instead of the 0 - 0.1 m deep which had been expected and which would have been preferable. In the month after planting water levels increased again by up to 0.15 m.

Monitoring of these ponds in September 1992 suggests that the success rate of establishment has been variable. *Typha, Juncus articulatus* and *Glyceria fluitans* appear to have established well, the other specie more poorly. This is likely to have been in part due to the very high water levels. However, autumn die-back may also have contributed. the success of the planting is unlikely to be completely clear until next summer.

6.3 Experiment 2: The influence of wetland plant species-richness on the species-richness of macroinvertebrate communities

One of the commonest aims of conservation management is to maximise plant and animal species-richness. Vascular plants are easily recorded, so success in maintaining species-rich plant communities can be readily judged. In contrast, invertebrate richness is much more difficult to record and it is therefore often assumed that species-rich macroinvertebrate communities will occur if plant species-richness is high. In practise there is very little direct experimental evidence to show that this is true.

The aim of this experiment is to investigate whether more invertebrate species are present in ponds if there are more species of emergent and aquatic plants. The results should give a preliminary indication of how much effort should be directed towards the maintenance of vegetation diversity for the benefit of aquatic invertebrates.

6.3.1 Experimental Design

Planting scheme

The experiment involves two pairs of replicate ponds (ie four ponds). One pair of ponds will be maintained as 'species-poor' sites, supporting only one stand-forming emergent plant (*Glyceria maxima*) and one submerged plant (*Potamogeton pusillus*). The other pair of ponds will be maintained as 'species-rich' sites, and have been planted with five stand-forming emergent species (*G.maxima, Sparganium erectum, Phragmites arundinacea, Schoenoplectus lacustris, Carex riparia*) and five submerged species (*P. pusillus, Ceratophyllum demersum, Myriophyllum spicatum, Elodea nuttallii, Ranunculus trichophyllus*).

All four ponds will be managed to maintain the original number of species planted. Other colonising species will be removed.

Removal of invertebrates introduced on plant material

In order that all the ponds start from the same base-line position as far as invertebrate colonisation is concerned, it may be necessary to treat the four ponds with a non-persistent pesticide to 'set the system to zero'. Pesticide applications are currently being planned in discussion with local NRA Thames staff, and with the Ministry of Agriculture Fisheries and

Food.

The ideal pesticide for the job would be broad-spectrum and non-persistent. Insects (larvae and adults), crustaceans, leeches and molluscs all need to be killed. Very few pesticides kill such a broad spectrum of animals, but possible candidates include:

(i) Carbaryl. A contact carbamate insecticide, which kills worms, and may therefore have some effect on leeches (of the compounds reviewed the only one that does). It is non-toxic to plants. We currently have no information on its environmental persistence, but it does not accumulate in animal tissues and is available as an "amateur" product. The longest harvest interval recommended for horticultural applications is six weeks but we have not yet found any data about its persistence in the environment.

(ii) Chlorpyrifos. An organophosphate insecticide which is also toxic to crustaceans. It is not clear whether molluscs and leeches would be killed. Chlorpyrifos degrades relatively slowly in the soil (half life 80-100 days) so may be too persistent to be applied at Pinkhill.

(iii) Cypermethrin. A pyrethroid insecticide. No data on its toxicity to non-insects and environmental persistence.

(iv) Malathion. A broad-spectrum organophosphate insecticide. No data on its toxicity to non-insects and environmental persistence but the harvest interval on crops is four to seven days.

(v) Methiocarb. A carbamate molluscicide and insecticide. No data on its toxicity to leeches and crustaceans and its environmental persistence but the harvest interval on crops is seven days.

(vi) Permethrin. A broad spectrum pyrethroid insecticide. No data on environmental57 persistence or non-insect invertebrate toxicity. Harvest interval zero days.

(vii) Rotenone. A natural insecticide of low persistence. No data available on its toxicity to non-insect invertebrates. Harvest interval is one day.

If applied, pesticides should be used in the autumn to leave as long as possible for breakdown before the next main period of invertebrate colonisation in the spring.

Survey and analytical methods

The effects of vegetation species-richness on the macroinvertebrate community will be assessed using standard National Pond Survey sampling techniques (Pond Action, 1989) and analytical methods (principally TWINSPAN and DECORANA analysis).

Vegetation will be mapped, and abundance of individual plant species recorded, annually or once every six months as appropriate.

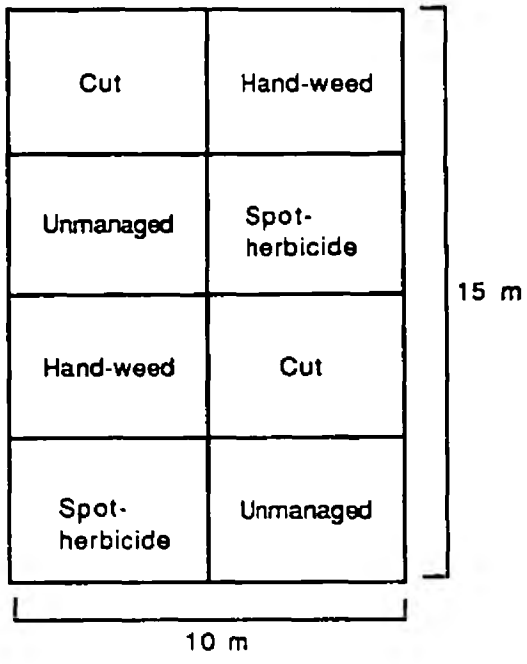
6.3.2 Work to date

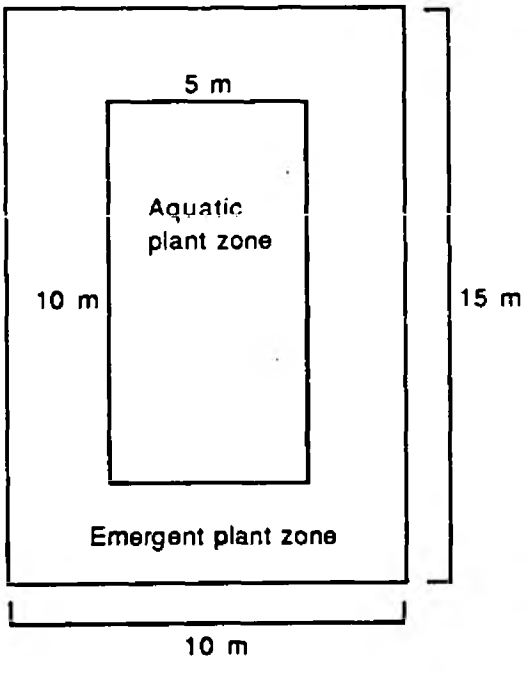
The ponds were planted up with marginal plants in late June /early July. Emergent plants were put in at a density of five plants per square metre. Aquatic plants were put in at the density of two small bunches per square metre.

Discussions and information-gathering are currently in progress over potential use of pesticides in ponds to kill invertebrates before beginning experimental monitoring.

Figure 6.1 Experimental Ponds: Plan view

(a) Experiment 1
(1 of 3)



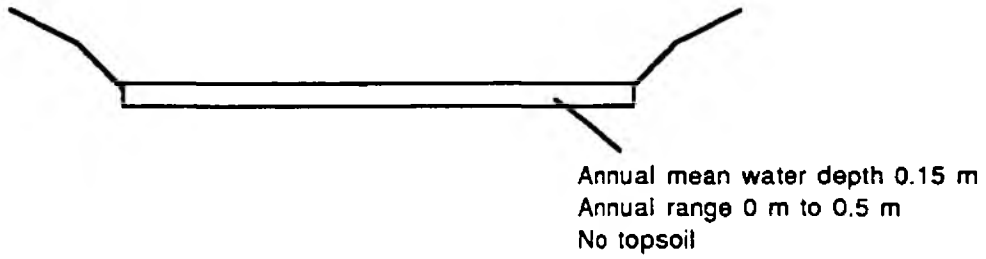


(b) Experiment 2
(1 of 4)

Figure 6.2 Experimental Ponds: Cross section

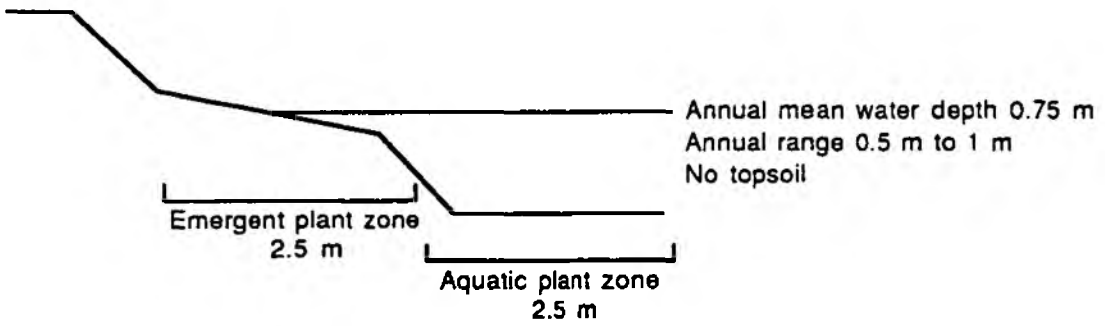
Experiment 1

Establishment of species-rich plant communities



Experiment 2

Establishment of species-rich macroinvertebrate communities



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APPENDIX 1

INTRODUCTORY INFORMATION

Appendix Table 1.1 Summary of the proposed programme of work at Pinkhill Meadow 1990-1993

SURVEY WORK	1990-91	1992	1993
Water quality	Samples taken monthly from May 1991	Samples taken monthly till March, then in July and September	Samples to be taken bi-monthly (except during Little Ringed Plover's nesting season)
Plants	All ponds surveyed twice annually	All ponds mapped in July Surveys conducted twice	All ponds mapped in July. Surveys conducted twice
Invertebrates	4 ponds sampled in July 1990, then in 4 seasons in 1991(17 samples).	4 ponds sampled in July (4 samples).	4 ponds sampled in July (4 samples)
Birds	Known-effort survey work	Spring and autumn habitat preference survey	Spring and autumn habitat preference survey
EXPERIMENTAL WORK			
Plant management		Set up plots in 3 ponds and plant-up vegetation plots bi-monthly	Record permanent quadrats in vegetation plots bi-monthly.
Plant species-richness versus macroinvertebrate species-richness		Plant-up 4 ponds (2 species-rich, 2 species-poor)	Hand-net aquatic macroinvertebrates using National Pond Survey techniques. Map vegetation annually (or more frequently if required).

Appendix Table 2. List of Pond Action reports relating to Pinkhill Meadow

March 1990	Pinkhill Meadow Wetland Enhancement Project - Farmoor Consultant's Report. 40pp.	TWU
July 1990	Meadow Wetland Enhancement Project - Farmoor. Diary of Events During the Construction Phase. A report to Thames Water Utilities. 14pp.	TWU
January 1991	A photographic record of Phase 1 of the Pinkhill Meadow Wetland Enhancement Project. TWU. 5pp. plus folder of photographic slides.	TWU
June 1991	Progress report of biological monitoring at Pinkhill Meadow: Autumn 1990-Winter 1991. 12pp.	NRA (Thames)
July 1991	Monitoring the Pinkhill Meadow wetlands: summer-1990 - spring 1991. A progress report for the National Rivers Authority. 43 pp.	NRA (Thames)
February 1992	Pinkhill Meadow wetland enhancement project - Farmoor. Phase 2: 1991/92. Diary of events during the construction phase. 14pp.	TWU
February 1992	Recommendations given for the Pinkhill Meadow wetland enhancement scheme: Phase 2. 4pp.	TWU
February 1992	Pinkhill Meadow Wetland Enhancement Project - Farmoor. Phase 2 1991/92. Diary of events during the construction phase. 14pp.	TWU

APPENDIX 2

WATER CHEMISTRY

APPENDIX 2. WATER CHEMISTRY

2.1 Water chemistry methods

Water chemistry samples in each of the ponds were taken monthly for the first year of the survey (April 1991 - March 1992). Sampling recommenced on 29th July 1992 and will continue, with one exception, at two-monthly intervals for all further monitoring. The exception is the May sample which will not be taken because of the likely disturbance to wading birds nesting on the site during the spring.

Water chemistry sampling has focussed on the four waterbodies created during Phase 1 of the project (ie the Main Pond, Scrape, Groundwater Pond and Surfacewater Pond).

Each set of samples was taken at the same location and depth, with sampling position judged in reference to markers. Sampling positions in each of the waterbodies are described in Table 2.1.

To minimise disturbance and contamination, most samples were taken using a remotely controlled device operated from the shore. In the scrape the very shallow water prohibited the use of this method and the sampling was done by hand.

One litre of water was collected on each occasion, in a clean plastic bottle, rinsed thoroughly with pond water before use. Bottles were sealed with no air inside the bottle, before being delivered to Denton House (NRA) and transported to the NRA chemical analysis laboratories in Reading for analysis next day.

The following determinands were measured:

pH
Total suspended solids
Conductivity
Total oxidised nitrogen (TON)
Ionised ammoniacal nitrogen (NH_4-N)
Unionised ammoniacal nitrogen (NH_3-N)
Soluble reactive phosphate (SRP-P)
Biochemical Oxygen Demand (BOD)

Appendix Table 2.1 Sites in the Pinkhill Meadow ponds from which water samples are collected for water quality analyses

SITE	SAMPLE TYPE	SAMPLING SITES	DEPTH
Main pond	Single	North and South	100 cm
Ground water pond	Duplicate	Middle	50 cm
Surface water pond	Duplicate	Middle	50 cm
Scrape	Single	North and South	Mid-Column

APPENDIX 3

WETLAND PLANTS

APPENDIX 3. WETLAND PLANTS

3.1. Wetland plants: survey and assessment methods

Wetland plant surveys have been undertaken in two years:

(i) Summer 1991 (between Phase 1 and Phase 2)
(ii) Summer 1992 (after Phase 2 had been completed)

3.1.1 Wetland plant species list

Wetland plant species lists were compiled for the site as a whole. In addition individual species lists were made for each of the four original ponds constructed during Phase 1. In order to give a comprehensive species list for the site, two survey visits were undertaken in each year, one in early summer (June-July,) and one in late summer (August-September).

The National Pond Survey Wetland Plant list was used to define the species of wetland plants which were recorded during the survey (Biggs et.al. 1989). A copy of this list is given in Appendix 3.4.

Critical species (eg fine-leaved *Potamogetons*, *Chara* spp.) were identified in the laboratory using a binocular microscope.

3.1.2 Abundance

Plant abundance was assessed broadly, by eye, in 1991 and in greater detail in 1992 when accurate maps of the site became available from NRA (Thames). The total abundance of vegetation was assessed using a modified DAFOR scale:

Abundance category	Total plant cover
6	81%-100%
5	61%-80%
4	41%-60%
3	21%-40%
2	1%-20%
1	0%-1%

In 1992 plant abundance was assessed for every five square metres of the site. This was done by assigning every 5 m^2 grid square of the NRA base map an Abundance Category (1-6) according to the total plant cover in that square (see above). The 5 m^2 grid was chosen to coincide with the grid used for bird recording on the site.

3.1.3 Wetland plant communities

As with plant abundance, the plant communities present on the site were broadly assessed in 1991 and mapped in greater detail in Summer 1992 when accurate maps of the site became available.

Plant communities were only mapped where there was sufficient plant cover to allow the community to be identified with confidence. In practice this meant that communities were not mapped where total cover was less than 5%.

3.1.4 Conservation value

The conservation value of the plant community was assessed on the basis of:
(i) the **number** of wetland plant species
(ii) the presence of nationally **uncommon** plant species.

Assessing the number of wetland plant species

There are currently no systematic surveys of ponds for Britain as a whole so that the 'number of plant species' cannot be used as part of a **national** assessment of conservation value. However Pond Action holds systematically collected plant data for ponds in Oxfordshire. A graphical representation of the numbers of emergent and aquatic plant species found in Oxfordshire ponds is given in Appendix Table 3.1 overpage (Pond Action 1992, unpublished data). This data can be compared with data from the Pinkhill ponds to give a **regional** assessment of how species-rich the Pinkhill ponds are compared to other ponds in Oxfordshire.

3.4.2 Assessing the number of nationally uncommon plant species

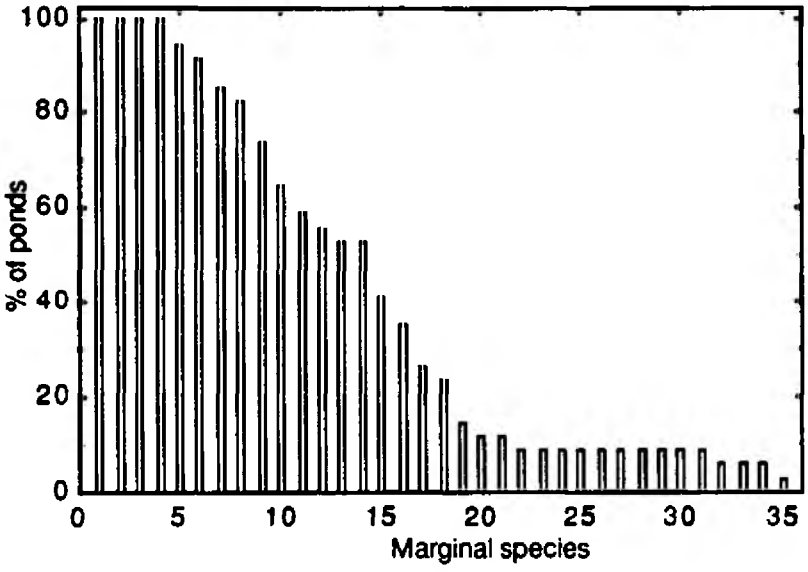
The conservation value of the Pinkhill ponds was also assessed on the basis of the presence of nationally uncommon species (ie local, nationally scarce or Red Data Book species). Definitions of these terms are given in Appendix Table 3.2.

To allow comparisons with other ponds, the Pinkhill ponds were given a Conservation Score according to the number of uncommon species present. A Conservation Index (Conservation Score/number of species recorded), which allowed ponds of different sizes to be compared, was also calculated.

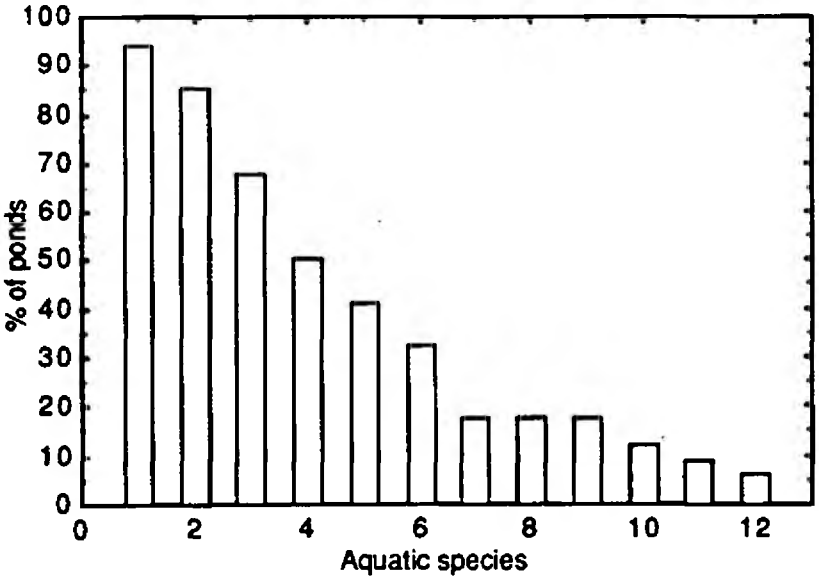
This information was used to place each of the Pinkhill ponds in one of four national conservation categories: low, moderate, high or very high. Descriptions of these categories are given in Appendix Table 3.3.

Appendix Table 3.1 Numbers of species of wetland plants recorded from Oxfordshire Ponds

1. Marginal plants: Numbers of species recorded from Oxfordshire ponds.



2. Aquatic plants: Numbers of species recorded from Oxfordshire ponds.



Appendix Table 3.2 Definition of terms used for plant and invertebrate species in this report and conservation scores for each category.

Description	Score	Plants	Invertebrates
Common	1	Recorded from >700 10x10km grid squares in Britain.	Generally regarded as commom.
Local	2	Recorded from between 101 and 700 grid squares in Britain.	Generelly regarded as local.
Nationally Scarce B	4	Nationally Scarce. Recorded from 31-100 grid squares in Britain.	Nationally Notable B. Recorded from 31-100 grid squares in Britain.
Nationally Scarce A	8	Nationally Scarce. Recorded from16-30 grid squares in Britain.	Nationally Notable A. Recorded from16-30 grid squares in Britain.
RDB 3	16	Red Data Book: Category 3 (rare), Perring and Farrell (1977).	Red Data Book: Category 3 (rare), Shirt (1987), Bratton (1991).
RDB 2	32	Red Data Book: Category 2 (vulnerable), Perring and Farrell (1977).	Red Data Book: Category 2 (vulnerable), Shirt (1987), Bratton (1991).
RDB 1	64	Red Data Book: Category 1 (endangered), Perring and Farrell (1977).	Red Data Book: Category 1 (endangered), Shirt (1987, Bratton (1991).

Notes:

Plant distribution information should be derived from the following sources:

Aquatic plants: Croft, Preston and Forrest (1991)
Emergent wetland plants: Palmer and Newbold (1983), Perring and Farrell (1983) Perring and Walters (1990).
Aquatic macroinvertebrates: Ball (1986). See also Appendix 4 for distribution data of individual taxa

Appendix Table 3.3. Provisional system for assessing the nature conservation value of plant and aquatic macroinvertebrate communities

CONSERVATION CATEGORY	DESCRIPTION OF TYPE OF COMMUNITY
VERY HIGH	Typically supporting a very rich community of plant and/or macro-invertebrate species, including local and rare (RDB) species (though note that some sites with rare species can be relatively species-poor). Sites in this category would normally have National Conservation Indices in excess of 1.5.
HIGH	Supporting a rich community of common plants and/or macro-invertebrate species. Generally an above-average number of local species recorded . No RDB species. Sites in this category would normally have National Conservation Indices between 1.2 and 1.5
MODERATE	Supporting a moderately-rich or rich community of common plant and/or macroinvertebrate species with at least one local species. Sites in this category would normally have National Conservation Indices between 1.01 and 1.19.
LOW	Supporting a species-poor community of common plants and macro-invertebrates. No rare or local species. Sites in this category will have National Conservation Indices of 1.00.

Appendix 3.2. Wetland plants recorded from Pinkhill Meadow.

Abbreviations:

MP - Main Pond SW - Surfacewater Pond GW - Groundwater Pond S - Scrape TS - Total Site
Survey : 91- Summer 1991 92 - Summer 1992
Bold text: Aquatic species

SPECIES NAME	MP		GW		SW		SC		TS	
	91	92	91	92	91	92	91	92	91	92
Agrostis stolonifera	+	+	+	+	+	+	+	+	+	+
Alisma plantago-aquatica	-	+	-	+	-	-	+	+	+	+
Alopecurus geniculatus	+	+	+	+	+	+	+	+	+	+
Angelica sylvestris	-	+	-	-	-	-	-	-	+	+
Apium nodiflorum	-	+	-	-	-	-	-	-	-	+
Bidens tripartita	-	-	-	-	-	-	-	-	-	+
Callitriche sp*	+	+	-	-	-	-	-	-	+	+
Carex flacca	-	+	-	-	-	+	-	+	+	+
Carex riparia	-	+	-	+	+	+	-	-	+	+
Cardamine pratensis	+	+	-	-	-	-	+	-	+	+
Chara vulgaris	+	+	+	+	-	+	+	+	+	+
Deschampsia caespitosa	+	+	+	+	+	+	+	+	+	+
Epilobium hirsutum	+	+	+	+	+	+	+	+	+	+
Filipendula ulmaria	+	+	+	-	+	+	+	+	+	+
Glyceria plicata	-	-	-	-	-	-	-	-	+	-
Glyceria fluitans	-	+	-	-	-	-	-	+	+	+
Glyceria maxima*I	-	-	-	-	-	-	+	-	+	+
Hypericum tetrapterum	-	-	+	-	-	-	-	-	+	+
Iris pseudacorus*I	-	-	-	-	-	-	-	-	+	+
Juncus bufonis agg	-	+	-	+	-	-	-	+	-	+
Juncus articulatus	+	+	+	+	+	+	+	+	+	+
Juncus effusus	-	-	-	-	-	-	-	-	+	+
Juncus inflexus	+	+	+	+	+	+	+	+	+	+
Lycopus europaeus	-	+	-	+	-	-	-	+	-	+
Lythrum salicaria	-	-	-	-	-	+	-	-	-	+
Mentha aquatica	-	-	-	-	-	-	-	-	-	+
Mimulus guttatus*I	-	-	-	-	-	-	-	-	-	+
Myriophyllum spicatum	-	+	-	-	-	-	-	-	-	+
Myosoton aquaticum	-	+	-	-	-	-	-	+	+	+
Nasturtium officinale	-	+	-	-	-	-	-	-	-	+
Phalaris arundinacea	-	+	-	-	-	-	-	+	+	+
Phragmites australis*I	-	-	-	-	-	-	-	-	+	+
Polygonum amphibium	+	+	-	-	-	-	-	-	+	+
Polygonum lapathifolium	-	+	-	-	-	-	-	-	-	+
Polygonum persicaria	-	+	-	-	-	-	-	+	+	+
Potamogeton obtusifolius	-	+	-	-	-	-	-	-	-	+
Potamogeton perfoliatus	-	+	-	-	-	-	-	-	-	+
Potamogeton pusillus	-	+	-	-	-	-	-	-	-	+
Ranunculus sceleratus	-	+	-	+	-	-	-	+	+	+
Ranunculus trichophyllus	+	+	-	+	-	+	-	+	+	+
Rorippa palustris	+	+	+	-	+	-	+	+	+	+

SPECIES NAME	MP		GW		SW		SC		TS	
	91	92	91	92	91	92	91	92	91	92
Schoenoplectus lacustris*1	-	-	-	-	-	-	-	-	+	+
Scrophularia auriculata	+	+	+	-	-	-	+	-	+	+
Sparganium erectum*1	-	-	-	-	-	-	-	-	+	+
Stachys palustris	+	+	-	+	-	-	-	-	+	+
Typha latifolia	+	+	-	-	-	-	-	+	+	+
Veronica anagallis-aquatica	+	+	+	+	-	-	+	+	+	+
Veronica beccabunga	+	+	+	+	+	-	+	+	+	+
Veronica catenata	+	+	-	-	-	-	+	+	+	+
Zannichellia palustris	-	-	-	-	-	-	-	-	-	+
TOTAL SPECIES*2	19	37	13	16	10	12	16	23	36	49
TOTAL MARGINAL SPECIES	15	29	12	14	10	10	15	21	32	40
TOTAL AQUATIC SPECIES	4	8	1	2	0	2	1	2	4	9

NOTES:

* - Fruiting material not available during the surveys

*1 - 5 species introduced during planting the site with *Phragmites*

*2 - 1991 species totals include results from both early and late summer surveys and may therefore be greater than totals given in Pond Action's 1991 progress report to NRA (Thames Region)

Appendix 3.3. Common names of wetland plants recorded from Pinkhill Meadow

SPECIES NAME	COMMON NAME
Agrostis stolonifera	Creeping Bent
Alisma plantago-aquatica	Water-plantain
Alopecurus geniculatus	Marsh Foxtail
Angelica sylvestris	Wild Angelica
Apium nodiflorum	Fool's Water-cress
Bidens tripartita	Trifid Bur-marigold
Callitriche sp.	Starwort
Carex flacca	Glaucous Sedge
Carex riparia	Greater Pond-sedge
Cardamine pratensis	Cuckoo flower
Chara vulgaris	Common Stonewort
Deschampsia caespitosa	Tufted Hair-grass
Epilobium hirsutum	Great Willowherb
Filipendula ulmaria	Meadowsweet
Glyceria fluitans	Floating Sweet-grass
Glyceria plicata	Plicata Sweet-grass
Glyceria maxima	Reed Sweet-grass
Hypericum tetrapterum	Square-stalked St John's-wort
Iris pseudacorus	Yellow Flag
Juncus articulatus	Jointed Rush
Juncus bufonis agg	Toad Rush
Juncus effusus	Soft Rush
Juncus inflexus	Hard Rush
Lycopus europaeus	Gipsywort
Lythrum salicaria	Purple-loosestrife
Mentha aquatica	Water Mint
Mimulus guttatus	Monkeyflower
Myosoton aquaticum	Water Chickweed
Myriophyllum spicatum	Spiked Water-milfoil
Nasturtium officinale	Water-cress
Phalaris arundinacea	Reed Canary-grass
Phragmites australis	Common Reed
Polygonum amphibium	Amphibious Bistort
Polygonum lapathifolium	Pale Persicaria
Polygonum persicaria	Redshank
Potamogeton obtusifolius	Blunt-leaved Pondweed
Potamogeton perfoliatus	Perfoliate Pondweed
Potamogeton pusillus	Long-stalked Pondweed
Ranunculus sceleratus	Celery-leaved Buttercup
Ranunculus trichophyllus	Thread-leaved Water-crowfoot
Rorippa palustris	Marsh Yellow-cress
Schoenoplectus lacustris	Common Club-rush
Scrophularia auriculata	Water Figwort
Sparganium erectum	Branched Bur-reed
Stachys palustris	Marsh Woundwort
Typha latifolia	Bulrush
Veronica anagallis-aquatica	Blue Water-speedwell
Veronica beccabunga	Brooklime
Veronica catenata	Pink Water-speedwell
Zannichellia palustris	Horned Pondweed

Appendix 3.4 National Pond Survey Wetland plant list

SUBMERGED AND FLOATING PLANTS

Apium inundatum
Aponogeton distachyos
Azolla filiculoides
Callitriche hamulata
Callitriche hermaphroditica
Callitriche obtusangula
Callitriche platycarpa
Callitriche stagnalis
Callitriche truncata
Callitriche sp. (undetermined)
Ceratophyllum demersum
Ceratophyllum submersum
Crassula helmsii
Egeria densa
Elatine hexandra
Floating Club-rush
Elodea canadensis
Elodea nuttallii
Glyceria fluitans
Groenlandia densa
Hippuris vulgaris
Hottonia palustris
Hydrocharis morsus-ranae
Isoetes lacustris
Juncus bulbosus
Lagarosiphon major
Lemna gibba
Lemna minor
Lemna minuscula
Lemna polyrhiza
Lemna trisulca
Littorella uniflora
Lobelia dortmann
Luronium natans
Menyanthes trifoliata
Myriophyllum alterniflorum
Myriophyllum aquaticum
Myriophyllum spicatum
Myriophyllum verticillatum
Nuphar lutea
Nymphaea alba
Nymphoides peltata
Oenanthe aquatica
Oenanthe fluviatilis
Potamogeton alpinus
Potamogeton berchtoldii
Potamogeton coloratus
Potamogeton crispus
Potamogeton friesii
Potamogeton gramineus
Potamogeton lucens
Potamogeton natans
Potamogeton obtusifolius
Potamogeton perfoliatus
Potamogeton pectinatus
Potamogeton polygonifolius
Potamogeton praelongus
Potamogeton pusillus
Potamogeton trichoides
Potamogeton hybrid(s)
Ranunculus aquatilis
Ranunculus baudotii
Ranunculus circinatus
Ranunculus fluitans
Ranunculus hederaceus
Ranunculus omiophyllus
Ranunculus peltatus
Ranunculus penicillatus
Ranunculus trichophyllus
Sagittaria sagittifolia
Sparganium angustifolium
Sparganium emersum
Sparganium minimum
Stratiotes aloides
Subularia aquatica
Utricularia australis
Utricularia intermedia
Utricularia minor
Utricularia vulgaris
Wolffia arriza
Zannichellia palustris

Bryophytes:
Fontinalis antipyretica
Riccia fluitans
Ricciocarpus natans
Sphagnum sp.

Algae:
Chara sp.
Nitalla sp.
Tolypella sp.

EMERGENT AND OTHER WETLAND PLANTS

Acorus calamus
Agrostis stolonifera
Alisma lanceolatum
Alisma plantago-aquatica
Alopecurus aequalis
Alopecurus geniculatus
Anagallis tenella
Andromeda polifolia
Angelica archangelica
Angelica sylvestris
Apium nodiflorum
Baldellia ranunculoides
Barbarea intermedia
Barbarea vulgaris
Berula erecta
Bidens cernua
Bidens tripartita
Blysmus compressus
Butomus umbellatus
Calamagrostis canescens
Calamagrostis epigejos
Caltha palustris
Cardamine amara
Cardamine pratensis
Carex acuta
Carex acutiformis
Carex curta
Carex demiss
Carex diandra
Carex disticha
Carex flacca
Carex hostinana
Carex laevigata
Carex lasiocarpa
Carex lepidocarpa
Carex nigra
Carex otrubae
Carex panicea
Carex paniculata
Carex pendula
Carex pseudocyperus
Carex pulicaris
Carex riparia
Carex rostrata
Carex spicata
Carex vesicaria
Catabrosa aquatica
Cicuta virosa
Cirsium dissectum
Cirsium palustre
Cladium mariscus
Conium maculatum
Crepis paludosa
Cyperus longulus
Dactylorhiza fuchsii
Damasonium alisma
Deschampsia caespitosa
Drosera rotundifolia
Eleocharis acicularis
Eleocharis multicaulis
Eleocharis palustris
Eleocharis quinqueflora
Equisetum fluviatile
Equisetum palustre
Epilobium hirsutum
Epilobium nerteroides
Epilobium obscurum
Epilobium palustre
Epilobium parviflorum
Epilobium tetragonum
Epipactis palustris
Erica tetralix
Eriophorum angustifolium
Eriophorum latifolium
Eriophorum vaginatum
Eupatorium cannabinum
Filipendula ulmaria
Galium boreale
Galium palustre
Galium uliginosum
Geum rivale
Glyceria declinata
Glyceria fluitans
Glyceria maxima
Glyceria plicata
Hydrocotyle vulgaris
Hypericum elodes
Hypericum tetrapterum
Impatiens capensis
Impatiens glandulifera
Impatiens noli-tangere
Iris pseudacorus
Isolepis cernua
Isolepis setacea
Juncus acutiflorus
Juncus articulatus
Juncus bufonis agg.
Juncus compressus
Juncus conglomeratus
Juncus inflexus
Juncus subnodulosus
Juncus effusus
Lotus uliginosus
Lychnis flos-cuculi
Lycopus europeaus
Lysimachia nemorum
Lysimachia nummularia
Lysimachia vulgaris
Lythrum hyssopifolia
Lythrum portula
Lythrum salicaria
Mentha aquatica
Mimulus guttatus
Mimulus luteus
Molinia caerulea
Montia fontana
Myosotis laxa
Myosotis scorpioides
Myosotis secunda
Myosoton aquaticum
Myrica gale
Narthecium ossifragum
Nasturtium microphyllum
Nasturtium officinale
Oenanthe aquatica
Oenanthe crocata
Oenanthe fistulosa
Oenanthe lachenalii
Osmunda regalis
Parnassia palustris
Pedicularis palustris
Petasites hybridus
Phalaris arundinacea
Phragmites australis
Pilularia globulifera
Pinguicula vulgaris
Polygonum amphibium
Polygonum hydropiper
Polygonum lapathifolium
Polygonum persicaria
Potentilla erecta
Potentilla palustris
Pulcaria dysenterica
Ranunculus flammula
Ranunculus lingua
Ranunculus sceleratus
Rhynchospora alba
Rorippa amphibia
Rorippa palustris
Rorippa sylvestris
Rumex hydrolapathum
Rumex maritimus
Rumex palustris
Sagina procumbens
Saggitaria sagittifolia
Schoenoplectus lacustris
ssp lacustris
ssp tabernaemontani
Schoenus nigricans
Scrophularia auriculatas
Scutellaria galericulata
Senecio aquaticus
Senecio fluviatilis
Sium latifolium
Solanum dulcamara
Sparganium erectum
Stachys palustris
Stellaria alsine
Stellaria palustris
Symphytum officinale
Thalictrum flavum
Thelypteris palustris
Tofieldia pusilla
Tricophorum cespitosum
Triglochin palustris
Typha angustifolia
Typha latifolia
Valeriana dioica
Veronica anagallis-aquatica
Veronica beccabunga
Veronica catenata
Veronica scutellata
Viola palustris

Trees and shrubs:
Alnus glutinosa
Frangula alnus
Populus sp.l
Salix sp.

APPENDIX 4

AQUATIC MACROINVERTEBRATES

APPENDIX 4. AQUATIC MACROINVERTEBRATES

4.1 Methods

4.1.1 Sampling methods, July 1990, November 1990 and February 1991.

The sampling strategy followed the habitat-dependent, time-limited method developed by Pond Action for the National Pond Survey (Biggs et.al. 1989).

On each occasion, the number of microhabitats present in the pond was assessed. A microhabitat was defined as an area of distinctively different substrate or vegetation cover. This might include gravelly or muddy banks, stands of different marginal plants or stands of submerged plants.

A total sampling effort of three minutes of hand-netting was allotted to each pond, and this time was divided equally between the microhabitats present. For a pond with four microhabitats, each microhabitat would be hand-netted for 45 seconds whereas for a pond with three microhabitats each microhabitat would be hand-netted for 60 seconds.

In most of the ponds the microhabitats either covered large areas or were present in more than one part of the pond (e.g. extensive, apparently uniform gravel banks, large stands of charophytes, etc). Because of this, the sampling time was usually further divided between several areas of each microhabitat (eg six 10-second samples might be taken in different areas of a microhabitat in order to a produce a cumulative 60-second sample).

All microhabitat samples were pooled to give a single three-minute sample.

Microhabitats were sampled by vigorous sweeping with a pondnet (GB Nets, 1 mm square mesh). Samples were taken back to the laboratory where macroinvertebrates were removed from the samples, counted and identified. Samples were sorted live in large white trays and specimens preserved in 70% ethanol (except for leeches and flatworms which were identified from live material).

Macroinvertebrates were mainly identified to species level. Table 4 lists the taxa removed from the samples, and the taxonomic levels to which they were identified. Keys and guides used to identify species are listed in Section 7 .

4.1.2 Sampling methods in May 1991 and July 1992

On these occasions the sampling method was made slightly more complex in order to provide information about the value of individual microhabitats in each pond. The pooled results from this sampling method also gave results comparable with those from other seasons.

Note. The first sample was taken in the spring of 1991. It had been intended that the second sample would be taken in the spring of 1992. However, due to concern about possible disturbance to the nesting Little Ringed Plovers, it was decided to delay the sampling until the summer of 1992.

For the microhabitat sampling programme the total sampling time of three minutes was divided between 16 separate hand-nettings (11.25 seconds each). In practice, all four ponds could be represented by either two, four or eight microhabitats. This allowed eight, four or two replicates (respectively) to be collected from each microhabitat.

Examples of the procedure adopted for sampling macroinvertebrates in the microhabitats are given in Appendix Table 4.1.

As with sampling at other times of the year, the total time for each sample was further broken down where necessary: e.g 2 x 5.6 seconds of netting to form a composite 11.25-second sample.

In contrast to the samples from other seasons, each 11.25-second microhabitat sample was kept separate during laboratory sorting and analysis.

4.1.3 Sampling Methods in September 1992

On September 25th and 28th 1992, the Pinkhill site, including all water-bodies except for the experimental ponds, was surveyed for macroinvertebrates. The aim of the survey was to record as many species of macroinvertebrate as possible in order to obtain an idea of the total value of the whole site for macroinvertebrates. It was also possible, within this broad remit, to obtain an impression of trends in macroinvertebrate community composition across the site.

For convenience, the site was divided into 14 areas representing different bodies of water or areas of water representing different potential habitats: e.g. the undulating margins in the northern area of the site.

Each of the areas was searched for invertebrates for approximately one hour. Searching consisted of hand-netting all different microhabitats within the area. The results of the hand-nettings were sorted in the field in white trays, and species either recorded in the field or returned to the laboratory for identification. In addition to the hand-netting, some time was spent searching in marginal areas by eye, particularly for the small hydrophilid beetles.

Lists of macroinvertebrates were drawn up for each of the areas of the site; results are presented in Appendix Table 4.4.

4.1.4 Use of the National Conservation Index to assess conservation value

A National Conservation Index (NCI) was used in order to achieve a relatively objective comparison of the Pinkhill sites with sites in other areas. The NCI as described below should be regarded as an **aid** to assessing conservation value and not as an **absolute** measure of conservation value without further consideration of all available information.

The NCI is a measure of the 'average rarity' of the species in a community and is derived in the following way:

(i) All species present are given a numerical value depending on their rarity.

Common species are given the value of 1, local species the value of 2 and so on up to the most endangered species (RDB1), which are given a value of 64. Appendix Table 3.2 gives the values ascribed to different categories of rarity.

Within this system, a level of discretion is required when interpreting the literature on species distribution. For example, the small diving beetle, *Coelambus nigrolineatus*, which is recorded from the Main pond and the Scrape at the Pinkhill meadows site, is provisionally a rare (RDB3*) species. However, the species has been recorded only recently in Britain having, presumably, migrated from the continent. Though the species is as yet recorded from only a few localities it is obviously expanding in range and its interest in terms of nature conservation is not as yet certain. Accordingly the species is not given the same value as other RDB3 species (16) but is given a value of 4, placing it in the same category as the Nationally Notable B species.

(ii) The values of all the species present are totalled to give a National Conservation Score (NCS).

If the communities being assessed were of exactly the same type, then it would be valid to use this score to assess the relative merits of the sites. However, different types of site would be expected to have different species-richnesses. For example, new sites of high quality would be expected to have less species than more mature sites of a similar quality, and acidic sites of high quality would be expected to have less species than alkaline sites of a similar quality etc. However, the **average** rarity of the species in these sites would be expected to be similar irrespective of species numbers and site type.

(iii) The NCS is divided by the number of species present to give the NCI.

The NCI should, in theory, give a good comparison between sites of any type. It should also be relatively independent of sampling effort.

In sites with low numbers of species the presence of one or two local or notable species can have a large effect on the NCI. This would be a valid effect if **all** species were recorded. However, surveys are never this efficient and so it is desirable to use as much data as possible to derive the NCI. So, NCI's derived from relatively exhaustive sampling will tend to produce more consistent results than those derived from smaller amounts of sampling. In addition, NCI's calculated for communities of low species richness (for example the relatively immature communities of the ponds on Pinkhill Meadows) will tend to be inherently prone to variation, and so it will be particularly important in these cases to use as complete a species list as possible.

To summarise:

(i) All species present are given a numerical value depending on their rarity.
(ii) The values of all the species present are totalled to give a National Conservation Score (NCS).
(iii) The NCS is divided by the number of species present to give the NCI.

4.1.5 Statistical analysis using DECORANA

Macroinvertebrate species and abundance data, obtained from the spring 1991 and summer 1992 microhabitat sampling, was analysed using the ordination technique Detrended Correspondence Analysis, running as the Fortran programme DECORANA. The data-set consisted of 128 samples from 4 sites in two seasons.

DECORANA assesses the variation within a set of samples. The major variation in community composition in a sample set is described by the first axis of DECORANA. The second axis describes the major variation in community composition not already described by the first axis. The first two axes of DECORANA are independent of each other. The amount of variation is represented in terms of units of standard deviation. In data sets with a strong first axis, samples separated by 4 standard deviations on the first axis have about 25% of their species in common (Hill, 1979b).

An ordination diagram showing the relationships of the macro-invertebrate communities of the ponds was plotted (using Axes 1 and 2 of DECORANA). The diagram was built-up from ordination plots of individual microhabitat samples from each pond in a given season. The polygons enclose the ordination co-ordinates of all the microhabitats within a single pond in one season and illustrate the relationships between the macroinvertebrate communities of the ponds (see Figures 4.1 and 4.2).

Appendix table 4.1 Examples of the procedure adopted for spring and summer sampling of macro-invertebrates at Pinkhill Meadow

For a pond with 8 microhabitats

Eight replicate samples of 11.25 seconds from each microhabitat

Total sampling time 16 x 11.25 seconds =180 seconds

For a pond with 4 microhabitats

Four replicate samples of 11.25 seconds from each microhabitat

Total sampling time 16 x 11.25 seconds =180 seconds

For a pond with 2 microhabitats

Eight replicate samples of 11.25 seconds from each microhabitat

Total sampling time 16 x 11.25 seconds =180 seconds

Appendix 4.2. Numbers of macroinvertebrates in major groups recorded from ponds on Pinkhill Meadows

Sites
MP = Main Pond GW = Groundwater Pond SW = Surfacewater Pond
SC = Scrape

Dates
a = July 1990 b = November 1991 c = February 1991
d = May 1991 e = July 1992

GROUP	MP					GW					SW					SC				
	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
GASTROPODA	0	0	0	0	3	0	0	0	0	1	0	0	0	0	1	0	0	0	0	2
Five-season total					3					1					1					1
HIRUDINEA	0	1	0	1	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
Five-season total					2					2					0					2
CRUSTACEA	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Five-season total					2					0					0					0
EPHEMEROPTERA	0	2	2	3	6	1	4	2	4	3	1	3	3	3	4	2	3	3	3	4
Five-season total					6					5					4					4
ODONATA	0	0	0	1	3	0	0	0	1	3	0	1	0	1	3	0	0	0	0	3
Five-season total					4					3					3					3
MEGALOPTERA	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Five-season total					0					1					0					0

(Continued)

Appendix 4.2.
(Continued)

GROUP	MP					GW					SW					SC				
	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
HETEROPTERA	1	4	3	9	11	3	8	5	9	7	0	7	8	7	5	3	5	6	4	8
Five-season total					14					15					15					11
TRICHOPTERA	0	1	3	2	3	0	1	2	1	0	0	2	1	2	0	0	1	0	4	1
Five-season total					4					3					4					4
COLEOPTERA	3	6	3	17	17	3	4	4	11	10	5	8	11	17	15	3	2	3	7	10
Five-season total					28					19					26					16
TOTAL	4	14	11	35	46	7	17	13	26	27	6	21	23	30	28	8	11	12	18	30
Five-season total					63					49					53					42
NATIONAL CONSERVATION SCORE	4	19	12	45	56	8	23	14	31	32	6	25	33	40	31	9	14	14	25	36
Five-season score					80					60					66					54
NATIONAL CONSERVATION INDEX	1	1.36	1.09	1.29	1.22	1.14	1.35	1.08	1.19	1.19	1	1.19	1.43	1.33	1.11	1.13	1.27	1.17	1.39	1.2
Five-season index					1.27					1.22					1.25					1.29

Appendix 4.3. Macroinvertebrates recorded from the main survey ponds on Pinkhill Meadow

Sites
MP = Main Pond GW = Groundwater Pond SW = Surfacewater Pond
SC = Scrape

Dates
a = July 1990 b = November 1991 c = February 1991
d = may 1991 e = July 1992

Abundance Categories:
1 = 1 - 5; 2 = 6 - 25; 3 = 26 - 125; 4 = 126 - 625; 5 = 626 - 4000

	MP					GW					SW					SC				
	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
GASTROPODA																				
Gyraulus albus	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lymnaea peregra	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Lymnaea truncatula	-	-	-	-	4	-	-	-	-	1	-	-	-	-	3	-	-	-	-	3
HIRUDINEA																				
Helobdella stagnalis	-	1	-	-	3	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Theromyzon tessulatum	-	-	-	1	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
MALACOSTRACA																				
Asellus aquaticus	-	-	-	1	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crangonyx pseudogracilis	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPHEMEROPTERA																				
Caenis horaria	-	-	-	-	3	-	-	-	-	2	-	-	3	-	1	2	-	2	-	2
Caenis luctuosa	-	3	1	5	3	-	5	4	5	4	-	4	2	4	1	-	4	2	5	2
Caenis robusta	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Cloeon dipterum	-	3	3	3	4	1	5	3	5	3	1	5	5	4	3	3	3	2	3	3
Cloeon simile	-	-	-	3	2	-	3	-	1	-	-	-	-	-	-	-	3	-	2	2
Ephemera vulgata	-	-	-	-	1	-	1	-	3	-	-	1	-	1	-	-	-	-	-	-

Appendix 4.3.
(Continued)

	MP					GW					SW					SC				
	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
ODONATA																				
Aeshna cyanea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anax imperator	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coenagrion puella/pulchellum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Enallagma cyathigerum	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ischnura elegans	-	-	-	-	2	-	-	-	-	1	-	-	-	-	1	-	-	-	-	2
Libellula depressa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthetrum cancellatum	-	-	-	1	-	-	-	-	2	2	-	-	-	-	3	-	-	-	-	2
Sympetrum striolatum	-	-	-	-	2	-	-	-	-	3	-	1	-	1	3	-	-	-	-	3
MEGALOPTERA																				
Sialis lutaria	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
HETEROPTERA																				
Arctocorisa germari	-	-	-	2	2	-	1	-	2	-	-	1	1	1	-	-	1	1	1	-
Callicorixa praeusta	-	1	1	1	-	1	1	1	-	-	-	-	1	-	-	1	1	1	-	1
Corixa panzeri	-	-	-	-	2	-	1	-	1	-	-	1	1	1	-	-	-	1	-	-
Corixa punctata	-	-	-	-	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Cymatia bonsdorffii	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cymatia coleoptrata	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Gerris lacustris	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-
Gerris thoracicus	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Microvelia reticulata	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Notonecta glauca	-	-	-	-	2	-	-	-	1	2	-	-	-	-	1	-	-	-	-	2
Notonecta maculata	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Notonecta marmorea	-	-	-	-	2	-	-	-	-	1	-	-	-	-	1	-	-	-	-	2
Sigara concinna	-	1	-	2	1	-	-	-	1	-	-	1	1	1	-	-	1	-	1	-
Sigara distincta	-	-	-	1	2	-	1	1	-	-	-	-	1	1	-	-	-	-	-	-
Sigara dorsalis	-	-	-	1	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	1
Sigara falleni	-	-	1	3	1	-	2	1	1	-	-	-	1	-	1	-	-	1	-	1
Sigara fossarum	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-
Sigara lateralis	1	3	2	5	2	1	3	2	2	1	-	2	3	1	2	1	3	3	3	2
Sigara nigrolineata	-	1	-	1	1	1	3	1	2	1	-	1	1	-	-	1	1	1	1	1

Appendix 4.3.
(Continued)

	MP					GW					SW					SC				
	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
TRICHOPTERA																				
Agrypnia varia	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anabolia nervosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Athripsodes cinereus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Leptocerus tineiformis	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Limnephilus affinis/incisus	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-
Mystacides longicornis	-	-	1	2	3	-	1	-	-	-	-	1	-	1	-	-	-	-	1	-
Oecetis lacustris	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oecetis ochracea	-	1	1	3	1	-	-	1	2	-	-	-	-	2	-	-	1	-	1	1
COLEOPTERA																				
Agabus bipustulatus	-	-	-	-	1	-	1	-	1	1	-	-	-	-	1	-	-	-	-	-
Agabus nebulosus	-	-	-	1	2	-	-	-	-	1	-	1	-	1	2	-	-	-	-	1
Anacaena limbata	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Coelambus confluens	-	1	-	1	-	-	-	-	-	-	-	1	-	-	1	1	-	-	-	-
Coelambus impressopunctatus	-	-	-	1	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
Coelambus nigrolineatus	-	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Colymbetes fuscus	1	-	-	1	1	-	-	-	1	-	1	-	-	1	-	-	-	-	-	-
Dryops sp. (fem.)	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Elmis aenea	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Gyrinus substriatus	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Haliplus confinis	-	-	-	1	1	-	-	-	-	-	-	-	-	-	1	-	-	-	1	1
Haliplus flavicollis	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-
Haliplus fluviatilis	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Haliplus lineatocollis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Haliplus obliquus	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helochares lividus	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-
Helophorus brevipalpis	-	-	-	2	1	1	-	-	1	-	1	1	1	2	2	-	-	1	-	2
Helophorus grandis	-	-	-	-	-	-	-	-	1	-	-	1	2	2	-	-	1	-	1	-
Helophorus granularis	-	-	-	-	-	-	-	-	-	-	-	-	2	3	-	-	-	-	2	-
Helophorus minutus	-	-	-	-	1	-	-	-	1	-	-	-	-	2	1	-	-	-	-	-
Helophorus obscurus	-	-	1	1	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-
Heterocerus fenestratus	-	-	-	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
Hydrobius fuscipes	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-
Hydroglyphus pusillus	-	2	2	3	3	1	2	2	4	2	-	3	3	3	2	1	1	1	3	3

Appendix 4.3.
(Continued)

	MP					GW					SW					SC				
	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
COLEOPTERA (continued)																				
Hydroporus palustris	1	-	-	-	-	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-
Hydroporus planus	-	-	-	-	-	-	-	1	-	-	1	1	1	-	1	-	-	1	-	-
Hydroporus pubescens	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydroporus tesselatus	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hygrotus inaequalis	-	-	-	-	1	-	-	-	-	1	-	1	-	-	1	-	-	-	-	1
Hygrotus inaequalis	-	-	-	-	1	-	-	-	-	1	-	1	-	-	1	-	-	-	-	1
Hyphydrus ovatus	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Laccobius minutus	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	1
Laccobius sinuatus	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Laccobius striatulus	1	1	1	2	2	1	1	1	1	2	-	-	1	3	1	1	-	-	2	1
Laccophilus minutus	-	1	-	1	2	-	-	1	-	1	-	1	3	2	1	-	-	-	-	2
Ochthebius dilatatus	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ochthebius minimus	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Oulimnius tuberculatus	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-
Potamonectes depressus	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhantus suturalis	-	-	-	1	-	-	1	-	-	-	-	-	1	1	-	-	-	-	-	-

Appendix 4.4 Macroinvertebrates recorded from Pinkhill Meadows on 25 and 28 September 1992

KEY

MPE =Main Pond, East Section
MPW = Main Pond, West Section
GW = Groundwater Pond
SW = Surface Water Pond
SC = Scrape
PHN = Phragmites Bed , North
NIP = Northern Isolated Ponds
UNN = Undulating Margins, North
DFP = Dragonfly ponds
SN = South Pond, North Section
SS = South Pond, South Section
PHO = Phragmites Bed, Old
PHS = Phragites Bed, South
UNS = Undulating Margins, South
NUM = Number of records

	MPE	MPW	GW	SW	SC	PHN	NIP	UNN	DFP	SN	SS	PHO	PHS	UNS	NUM
TRICLADIDA															
Dendrocoelum lacteum	-	-	-	-	-	-	-	-	-	-	-	+	-	-	1
Dugesia lugubris	+	-	-	-	-	-	-	-	-	-	-	+	-	-	2
GASTROPODA															
Anisus vortex	-	-	+	-	-	-	-	-	-	-	+	+	+	+	5
Bathyomphalus contortus	-	-	-	-	-	-	-	-	-	-	-	+	-	-	1
Lymnaea peregra	+	+	-	+	+	-	-	+	+	+	+	+	+	+	11
Lymnaea stagnalis	-	-	-	-	-	-	-	-	-	+	-	+	-	-	2
Lymnaea truncatula	+	+	+	+	+	+	+	+	+	+	+	-	+	+	13
Physa acuta	-	-	-	-	-	-	-	-	-	-	-	-	+	+	2
HIRUDINEA															
Erpobdella octoculata	-	-	-	-	-	-	-	-	-	+	-	-	-	-	1
Helobdella stagnalis	+	+	+	+	-	-	-	+	-	-	-	+	-	-	6
Theromyzon tessulatum	+	+	-	+	+	+	-	+	-	-	-	+	+	+	9
CRUSTACEA															
Asellus aquaticus	+	+	+	+	+	-	-	+	+	+	+	+	-	+	11
Crangonyx pseudogracilis	-	-	-	-	-	-	-	-	-	+	+	+	-	-	3
EPHEMEROPTERA															
Caenis luctuosa	+	+	+	-	-	+	-	-	-	+	-	-	+	-	6
Cloeon dipterum	+	+	-	+	+	+	+	+	+	-	+	-	-	-	9
Cloeon simile	+	+	+	+	+	+	-	+	-	+	+	-	+	+	11
Ephemera vulgata	+	+	-	-	-	+	-	-	-	+	+	-	-	-	5

Appendix 4.4 (continued)

	MPE	MPW	GW	SW	SC	PHN	NIP	UNN	DFP	SN	SS	PHO	PHS	UNS	NUM
ODONATA															
Aeshna cyanea	-	-	-	-	-	-	-	-	-	-	-	+	-	-	1
Anax imperator	-	-	-	-	-	+	-	-	-	-	-	-	-	-	1
Coenagrion puella/pulchellum	+	-	-	-	-	+	-	-	-	-	-	-	-	-	2
Enallagma cyathigerum	+	+	-	-	+	-	-	-	+	+	+	-	+	+	8
Ischnura elegans	+	+	+	+	+	+	+	+	+	+	+	+	+	+	14
Libellula depressa	+	-	+	-	+	+	+	-	-	-	+	-	+	+	8
Orthetrum cancellatum	+	+	+	+	+	+	+	+	-	+	+	-	+	+	12
Sympetrum striolatum	-	-	-	-	-	-	-	-	-	-	-	+	+	-	2
MEGALOPTERA															
Sialis lutaria	-	-	-	-	-	-	-	-	-	+	+	-	-	-	2
TRICHOPTERA															
Agraylea multipunctata	+	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Agrypnia varia	-	-	-	-	-	-	-	-	-	-	-	-	+	-	1
Mystacides longicornis	-	+	-	-	-	-	-	-	-	-	-	-	-	-	1
Oecetis ochracea	+	+	-	-	-	-	-	-	-	-	+	-	-	-	3
Phryganea bipunctata	-	-	-	-	-	-	-	-	-	-	-	-	+	-	1
HEMIPTERA															
Arctocorisa germari	+	+	-	-	-	-	-	-	-	-	-	-	-	-	2
Callicorixa praeusta	-	-	-	-	+	-	+	-	-	-	+	-	-	-	3
Corixa panzeri	+	+	+	+	+	+	-	+	+	+	+	-	+	+	12
Corixa punctata	+	-	-	-	+	+	+	-	+	-	+	-	+	+	8
Gerris lacustris	-	-	-	+	-	-	-	+	-	-	+	-	+	-	4
Gerris thoracicus	-	-	+	+	+	-	+	+	+	+	+	-	+	+	10
Hesperocorixa sahlbergi	-	-	-	-	-	-	-	-	-	-	-	+	-	-	1
Microvelia reticulata	-	-	-	-	-	-	-	-	-	+	-	-	-	-	1
Notonecta glauca	+	-	+	+	+	+	+	+	+	+	+	+	+	+	13
Notonecta maculata	-	-	-	-	-	+	-	-	-	-	-	-	+	-	2
Notonecta marmorea	+	-	+	+	+	+	+	+	+	+	+	+	+	+	13

Appendix 4.4 (continued)

	MPE	MPW	GW	SW	SC	PHN	NIP	UNN	DFP	SN	SS	PHO	PHS	UNS	NUM
HEMIPTERA (continued)															
Sigara concinna	-	+	-	-	-	-	-	-	-	-	-	-	-	-	1
Sigara distincta	+	-	+	+	+	+	-	+	+	+	+	-	+	+	11
Sigara dorsalis	+	-	-	-	+	+	-	-	+	+	+	-	+	+	8
Sigara falleni	+	-	+	-	+	+	-	-	-	+	-	-	-	+	6
Sigara fossarum	-	-	-	-	-	-	-	-	-	+	+	-	-	-	2
Sigara lateralis	+	+	+	+	+	+	+	+	-	+	+	-	+	+	12
Sigara nigrolineata	-	+	+	+	+	-	+	+	-	+	+	-	+	+	10
COLEOPTERA															
Agabus bipustulatus	-	-	-	+	-	-	+	+	-	-	-	-	-	+	4
Agabus nebulosus	-	+	+	+	+	+	+	+	+	+	-	+	+	-	11
Anacaena limbata	-	-	+	-	-	-	-	-	-	-	-	+	-	-	2
Coelambus confluens	-	-	-	-	+	+	-	-	+	+	-	-	-	-	4
Coelambus impressopunctatus	-	+	+	+	+	-	-	+	+	+	+	+	+	+	11
Coelambus nigrolineatus	-	+	-	-	-	+	-	-	+	-	-	-	-	-	3
Colymbetes fuscus	-	+	-	+	-	-	+	+	+	+	+	+	-	-	8
Gyrinus substriatus	-	-	-	-	-	+	-	-	-	-	-	-	-	-	1
Haliplus confinis	-	-	-	-	-	-	+	-	+	-	-	-	-	-	2
Haliplus flavicollis	-	-	-	+	-	-	+	+	-	-	-	-	-	+	4
Haliplus lineatocollis	-	-	-	-	-	+	-	-	+	-	-	-	-	-	2
Haliplus obliquus	-	-	-	-	-	-	-	-	-	-	-	-	+	-	1
Haliplus ruficollis	-	-	-	-	-	-	+	-	+	-	-	-	-	-	2
Helochares lividus	+	-	+	-	+	-	-	-	-	+	-	-	+	+	6
Helophorus brevipalpis	-	+	-	-	-	-	+	-	+	-	-	-	-	-	3
Helophorus grandis	-	-	-	-	-	-	+	-	-	-	-	-	-	-	1
Helophorus granularis	-	-	-	-	-	-	+	-	-	-	-	-	-	-	1
Helophorus obscurus	-	-	-	-	-	-	+	-	-	-	-	-	-	-	1
Hydrobius fuscipes	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Hydroglyphus pusillus	-	+	+	+	+	+	+	+	+	+	+	+	+	+	13
Hydroporus palustris	-	-	+	+	-	-	-	+	-	-	-	+	-	-	4
Hydroporus planus	-	-	-	+	-	-	-	-	+	-	-	-	-	-	2
Hygrotus inaequalis	+	-	+	+	+	+	-	+	+	+	+	+	+	+	12
Hygrotus versicolor	-	-	-	-	-	-	-	-	-	-	+	-	-	-	1
Hyphydrus ovatus	-	-	-	-	-	-	-	-	-	-	+	-	-	-	1
Ilybius fuliginosus	-	-	-	-	+	-	+	-	-	+	-	-	+	+	5

Appendix 4.4 (continued)

	MPE	MPW	GW	SW	SC	PHN	NIP	UNN	DFP	SN	SS	PHO	PHS	UNS	NUM
COLEOPTERA (continued)															
Laccobius bipunctatus	-	-	-	-	-	-	-	-	-	-	-	+	-	-	1
Laccobius minutus	+	-	-	+	+	-	-	+	+	+	+	+	+	+	10
Laccobius sinuatus	+	+	+	-	+	-	+	-	+	-	+	-	+	+	9
Laccobius striatulus	+	-	+	+	+	+	+	+	+	+	+	+	+	+	13
Laccophilus minutus	+	+	+	+	+	+	+	+	+	+	+	+	+	+	14
Noterus clavicornis	+	-	+	+	+	-	-	+	-	+	+	-	-	+	8
Ochthebius minimus	-	+	-	-	-	-	-	-	-	-	-	-	-	-	1
Potamonectes depressus	-	+	-	-	-	-	-	-	+	-	-	-	-	-	2
Rhantus suturalis	-	-	-	-	-	-	+	-	+	-	-	-	-	-	2
Scarodytes halensis	-	-	-	-	-	+	-	-	-	-	+	-	-	-	2

Appendix 4.5 Rare and local species recorded from the Pinkhill Meadow ponds

Main Pond	EPHEMEROPTERA	Caenis robusta
		Cloeon simile
	ODONATA	Orthetrum cancellatum
	HEMIPTERA	Corixa panzeri
		Cymatia bonsdorffii
		Sigara concinna
	COLEOPTERA	Coelambus confluens
		Coelambus nigrolineatus
		Haliplus obliquus
		Hydroglyphus pusillus
		Laccobius sinuatus
		Rhantus suturalis
Groundwater Pond	EPHEMEROPTERA	Cloeon simile
	ODONATA	Orthetrum cancellatum
	HEMIPTERA	Corixa panzeri
		Sigara concinna
	COLEOPTERA	Hydroglyphus pusillus
		Laccobius sinuatus
		Rhantus suturalis
Surfacewater Pond	EPHEMEROPTERA	Caenis robusta
	ODONATA	Orthetrum cancellatum
	HEMIPTERA	Corixa panzeri
		Cymatia coleoptrata
		Sigara concinna
	COLEOPTERA	Coelambus confluens
		Helochares lividus
		Helophorus granularis
		Hydroglyphus pusillus
		Rhantus suturalis

(continued)

Appendix 4.5 (continued)

Scrape	EPHEMEROPTERA	Cloeon simile
	ODONATA	Orthetrum cancellatum
	HEMIPTERA	Corixa panzeri Sigara concinna
	COLEOPTERA	Coelambus confluens Coelambus nigrolineatus Helophorus granularis Hydroglyphus pusillus Laccobius sinuatus

Appendix 4.6. The national distribution of rare and local species of macroinvertebrate recorded from four ponds on Pinkhill Meadow

RARE SPECIES

Coelambus nigrolineatus: (Dytiscidae: COLEOPTERA)

A diving beetle. The species is RDB3 *. The exact status of the species is not known. It appears to be a recent arrival from the continent and is likely to increase in range over the next few years. The most favourable habitat for the species is thought to be mature gravel pits. Determination by G.N.Foster.

The species was first recorded from the Main Pond in the autumn and is now present in the Main Pond (several specimens) and the Scrape.

Shirt (1987)
G.N.Foster pers. comm.

LOCAL SPECIES

Cloeon simile: (Baetidae: EPHEMEROPTERA)

The lake olive. Widespread but locally distributed. Favouring larger water bodies and new sites.

The species is recorded from all but the Surfacewater pond. It showed a dramatic decline (to no specimens recorded) after the winter, but is now present in large numbers in the Main pond and the Scrape.

Elliott, J.M. et al.(1988)
Pond Action (unpublished results)

Orthetrum cancellatum: (Libellulidae: ODONATA)

The Black-tailed Skimmer. Locally common in Southern England. An early coloniser of gravel-pit lakes in the Thames Valley.

Recorded from the Main pond and the Groundwater pond in the spring sample. 7 specimens, the most mature being in, approximately, the antepenultimate instar were recorded from the Groundwater pond. The species was subsequently recorded from all for ponds in the summer 1992 survey.

J.Campbell pers. comm.

Corixa panzeri: (Corixidae: HETEROPTERA)

A lesser water boatman. A species local to South East England but rare elsewhere.

Recorded from all but the Main pond. Single specimens have been recorded in autumn, winter and spring samples from one or more of the ponds.

J.Bratton, pers. comm.
Savage (1989)

(continued)

Appendix 4.6 (Continued)

Cymatia bonsdorffii. (Corixidae: HETEROPTERA)

A lesser water boatman. Quite common in the north of England but very locally distributed in the south. The species normally prefers ponds and lakes with a large amount of plant cover.

Recorded from the Main Pond in summer 1992.

J.Campbell (pers. comm.)
Savage (1989)

Cymatia coleoptrata. (Corixidae: HETEROPTERA)

A lesser water boatman. Locally common in the south of England and regionally notable in the north. Locally the species normally prefers wooded sites.

Recorded from the surface pond in the autumn 1991 survey.

Savage (1989)
Pond Action (unpublished data)

Sigara concinna: (Corixidae: HETEROPTERA)

A lesser water boatman. A local and scarce species often associated with new or disturbed sites. .

The species was first recorded, casually, from the Surfacewater pond, two weeks after its construction. It is now present in all the ponds.

J.Bratton (pers. comm.)
Pond Action, unpublished results)

Coelambus confluens. (Dytiscidae: COLEOPTERA)

A diving beetle. Locally distributed throughout Britain, a species of temporary water, quarries and subsidence ponds.

The species has been recorded in several of the surveys in all but the Groundwater pond.

Foster (1981)

Haliplus obliquus. (Haliplidae: COLEOPTERA)

A haliplid water beetle. Widespread but locally distributed. The species s usually associated with charophytes and with alkaline water.

A single record from the Main Pond in the 1992 summer survey.

(continued)

Appendix 4.6 (Continued)

Helochares lividus: (Hydrophilidae: COLEOPTERA)

A water scavenger beetle. Locally common in South East England. The species is Nationally Notable B.

The species was recorded from the Surfacewater pond in the winter and spring samples.

Ball (1986)

Helophorus granularis: (Hydrophilidae: COLEOPTERA)

A water scavenger beetle. A widespread but local species, favouring grassy margins of standing water.

Several specimens were recorded from the Surfacewater pond in the winter and spring surveys and the Scrape in the spring survey.

Friday (1987)

Hydroglyphus pusillus: (Dytiscidae: COLEOPTERA)

A diving beetle. Found mainly in man-made silt ponds and often in new ponds. The species is Nationally Notable B.

The species was recorded from all four sites. Over the course of the study it has increased in numbers and is now very common in all sites, particularly in the Groundwater pond (231 specimens in the Msy 1991 sample).

Foster (1981)

Hydroporus marginatus: (Dytiscidae: COLEOPTERA)

A diving beetle. A local species of southern England which has an association with interstitial water in gravels. The species is Nationally Notable A.

The species was recorded from the Surfacewater pond two weeks after its construction and has not been recorded since in any of the main survey ponds. It was, however recorded from the *Phragmites* pit prior to the spring planting. This particular specimen may have come from the population known to exist in the vicinity of Stanton Harcourt.

Foster (1984)
Ball (1986)

Laccobius sinuatus. (Hydrophilidae: COLEOPTERA)

A water scavenger beetle. Locally distributed throughout England with a strong preference for new ponds with inorganic substrates.

Recorded from all but the Surface water Pond in the summer 1992 survey. the species is Nationally Notable B.

Friday (1987)
Ball (1986)
Pond Action (unpublished data)

(continued)

Appendix 4.6 (Continued)

Rhantus suturalis. (Dytiscidae: COLEOPTERA)

A diving beetle. Locally distributed throughout England. The species is considered to be a warmth-loving species often found in shallow silty ponds. The species is Nationally notable B.

The species was first recorded from the Groundwater pond in the November 1991 sample and then subsequently in the Main pond and the Surfacewater pond.

Foster (1985)
Ball (1986)

APPENDIX 5

BIRDS

APPENDIX 5 BIRDS

5.1 Bird monitoring methods

5.1.1 Methods used to determine whether numbers of waders using the Farmoor site have increased following the creation of the Pinkhill wetlands

Collection of 'log-book' data by birdwatchers

Birdwatchers visit Farmoor reservoir on most days of the year and dates of visits, together with birds seen, are recorded in the Farmoor log-book. However, most people visiting the site do not record all birds seen systematically, concentrating on noting the birds which they find most interesting, and if common species are noted, their abundance is frequently omitted.

For purposes of comparison, numbers of birds visiting the site daily were estimated from the log-book. On any one day the largest single number of each species recorded was counted as the total for that day. As visiting birdwatchers do not generally list counts for the three areas of the site separately the counts referred to the whole of the Farmoor site.

Note that in the account below the following nomenclature is used:

(i) Log-book data: data gathered by birdwatchers visiting Farmoor reservoir, and recorded in the Farmoor log-book, are referred to as 'log-book data'. No other casual records gathered by birdwatchers have been included in the analysis.

(ii) Known-effort data: wader survey data gathered for this study by Pond Action during the migration months of 1991. Referred to as 'known-effort data' throughout the report.

Duration of surveys for log-book recording and known-effort recording

Between 68 and 98 birdwatchers recorded observations in the log-book each month.

Counts for known-effort recording took about 2 hrs/day during the spring and autumn, giving about 48 hours recording during the two months (excluding two all-day sessions)

Survey methods for gathering known-effort data

1. Timing of daily counts

As only 10 days (c80 hrs) were initially available for survey work it was necessary to determine how best to make use of this time. Preliminary work was undertaken to determine whether a reliable estimate of the birds present on any one day could be made with a relatively short visit (of 2-3 hrs) to the site.

Observations to investigate the timing of counts were made on 1 and 2 April and 18 May 1991. The results showed that:

(i) counts of most waterfowl and other wetland birds (excluding waders) could be made at any time of day.

(ii) numbers of waders varied during the course of the day (mainly due to variations in the numbers flying over the site). Peaks of activity appeared to occur in both the morning and evening.

In the light of these results it was decided to count in the morning between about 0600 and 0900.

Two further all-day counts were made, on 27 August 1991 and 30 September 1991, to study the way in which the bird population of the site varied during the course of the day.

2. Frequency of visits to the site

It was decided in advance to make approximately 12 visits each month to the site, on randomly selected days. The adequacy of this sample size was tested at the end of the survey period for counts of all species combined, for all waders combined and for selected species (see Appendix 5). In all cases the sample size was large enough to make a reasonable estimate of the mean numbers of birds visiting the site. Waterfowl could be counted reliably with considerably fewer visits, because their overall numbers changed slowly, but waders needed twenty or more visits for a reliable assessment of their abundance to be made, because their numbers often changed rapidly.

Duration of surveys for log-book recording and known-effort recording

Between 68 and 98 birdwatchers recorded observations in the log-book each month. Counts for known-effort recording took about 2hrs/day during the spring and autumn, giving about 48 hours recording during the two months (excluding two all-day sessions).

Days for counts were chosen randomly with 14 visits made in April and 10 in May. 12 visits were made in August, 12 in September and 4 during the first 11 days of October. Birds were counted in the three areas of the Farmoor site twice on each of these days if the weather allowed. Counts of the two halves of reservior generally took 15-25 minutes each (occasionally longer if large numbers of birds were present). The reservoir was counted by driving right around the perimeter of the basin (to check for waders on the edges) and by scanning with telescope and binoculars. The Pinkhill Main Pond and Scrape were watched for 20 minutes during each circuit.

Most Spring recording was undertaken by Dr J Biggs. On three days recording was undertaken by Dr A Gosler. Autumn recording was undertaken by Dr. S. R. Goss.

Analytical methods

A preliminary assessment of the attractiveness of the three areas of the Farmoor site (north and south halves of the reservior and Pinkhill) was made using known-effort data from spring and autumn 1991. There was insufficient time to continue this analysis after 1992.

The significance of differences in the numbers of waders using the three areas of the site was assessed with chi-square tests. In each case the hypothesis tested was that the number of birds observed was proportional to the length of shoreline. In other words birds would be expected in the ratio of roughly 8:39:53 on Pinkhill Meadow, Farmoor North and Farmoor South respectively, this being the percentage of total shoreline on the site in each of these three areas (see Appendix 9). Only known-effort data was analysed in this way, because log-book data rarely locates birds within the Farmoor site.

A preference for an area was suggested if the number of birds observed was significantly greater than expected with the chi-square test.Preliminary inspection of both the known-effort data and the log-book data showed that it was not normally distributed. Because of this all comparisons were made using non-parametric statistics with ranked data. Analytical methods are described in Methods.

1. The total number of bird-days recorded for all species

The total number of bird-days for each species was calculated from the known-effort data and from the log-book data. The totals were ranked and the Spearman's rank correlation between the two sets of ranked data calculated. The existence of a significant correlation between the two sets of data would indicate that log-book data was at least describing the general trend of species abundance correctly.

Comparisons were made in two ways:

(i) between the known-effort data and the log-book data for the same days during the survey period.

(ii) between the known-effort data and the log-book data for all days of the survey period.

2. The total numbers of bird-days recorded for all wader species

The above procedure was repeated for waders alone as these appeared to be more reliably recorded than other species.

3. The number of bird-days recorded per individual species

The abundance of all species was compared individually using the above method. This was the most stringent test of the three comparisons.

5.1.2 Habitat-preference monitoring

Habitat-preference monitoring started in spring 1992 and will continue every spring and autumn. Some additional observations have also been made at other periods (for example of Lapwings and Little Ringed Plover during the breeding season). Days and times were chosen at random. Time of day was selected by dividing the day into four equal portions and then choosing at random in which of these periods to carry out the two-hour survey. The starting time within this four-five hour window was also selected at random although on some dates practical difficulties meant that surveys were not started exactly on time.

In autumn 1992 a limited survey was undertaken as September proved to be the 'worst' of the ten-year period for waders at Farmoor, and there were no species recorded during many visits.

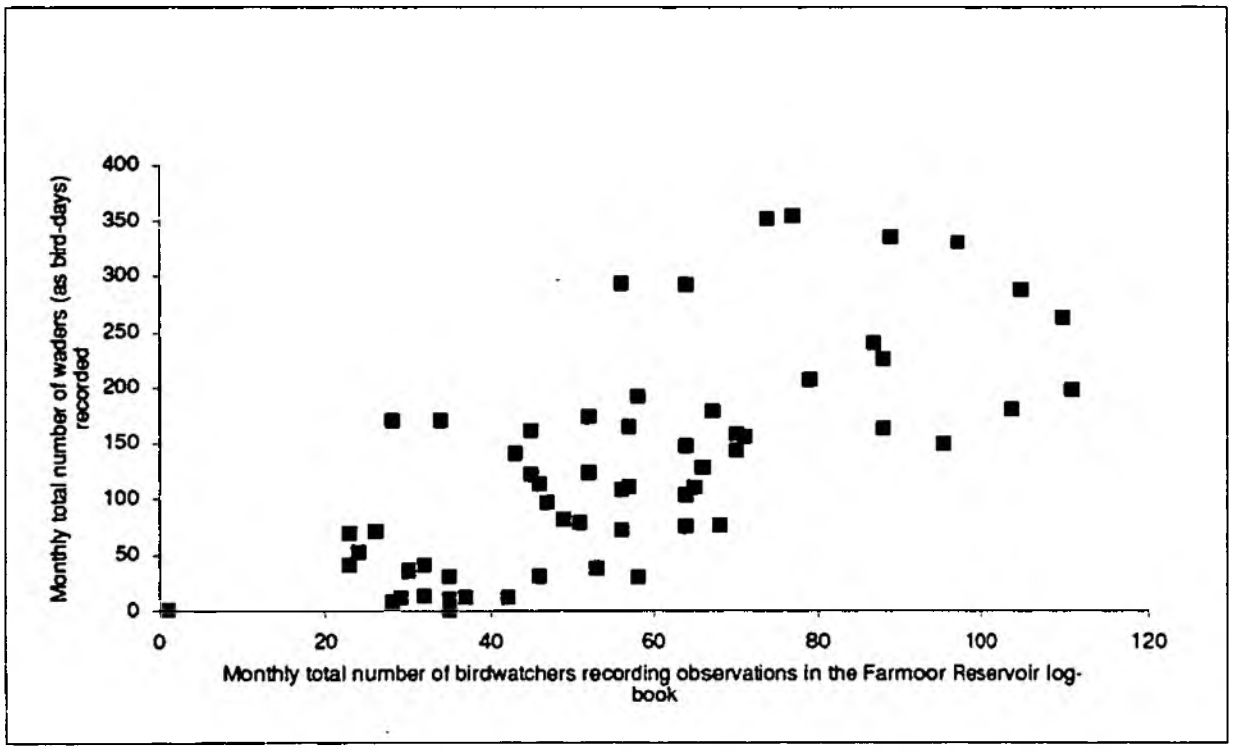
Recording procedure

During spring 1991 all locations of birds were plotted by hand onto large-scale site maps. In the autumn this procedure was modified and bird locations and activities were recorded on a dictaphone for logging later. This system was much easier to use when larger numbers of birds were present.

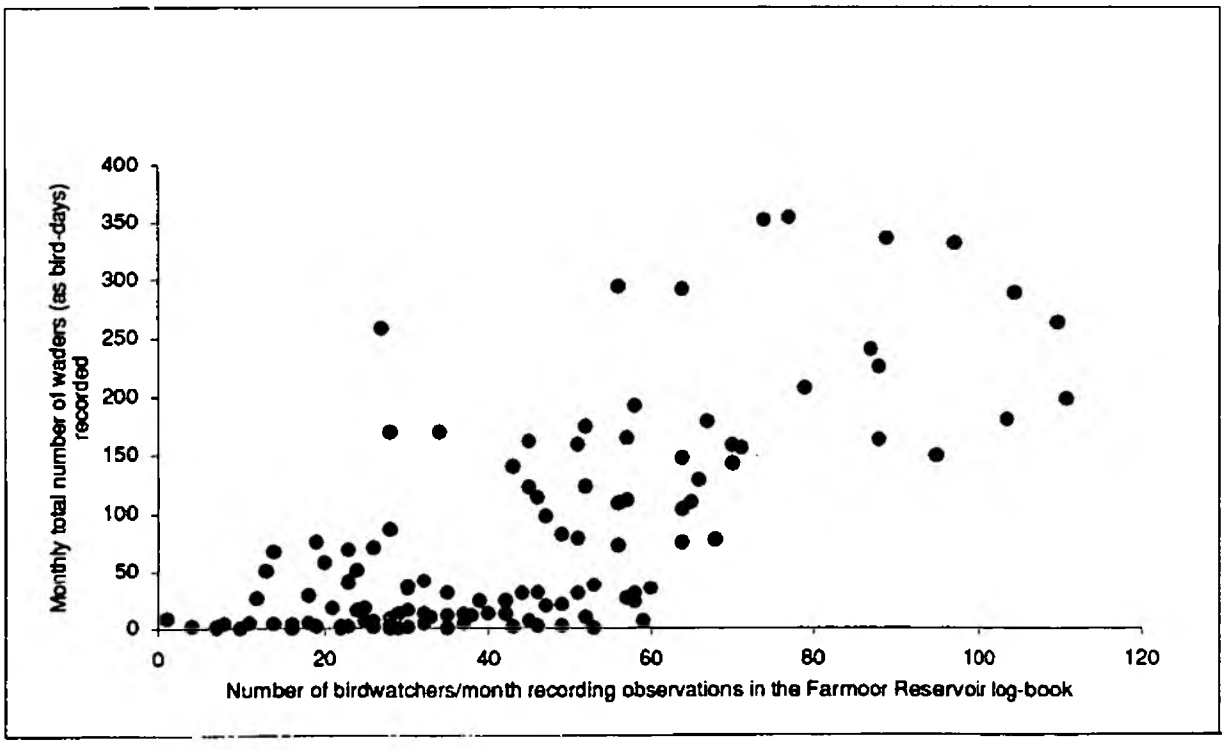
Habitat preference has been assessed in terms of number of visits by individual birds to different areas of the site. The position of individual birds was described on a 5 m x 5 m grid (based on the NRA topographical survey of the site which was has a 50 m x 50 m grid). The positions and activities of all birds on the site are logged every five minutes, so for each bird a maximum of 12 observation/hour can be made. All observation is undertaken from the Pinkhill Meadow hide which allows viewing of most of the site.

Physical and vegetation features are also being recorded on a 5 m x 5 m grid. Results are currently being input into a data-base and it is intended to plot the results on GIS. Vegetation community and density will be added later this autumn. Other environmental factors will include water depth and substrate type.

APPENDIX FIGURE 5.1a. The correlation between numbers of birdwatchers and numbers of waders recorded (as bird-days) at Farmoor Reservoir between 1982 and 1991. $r2 = 0.51^{***}$.



Appendix figure 5.1b. The correlation between numbers of birdwatchers and numbers of waders recorded (as bird-days) at Farmoor Reservoir during migration months (March, April, May, August, September, October), 1982-1 $r2 = 0.534^{***}$.



Appendix Table 5.1. Numbers of waders recorded at Farmoor Reservoir, January 1982 to October 1991. Original log-book records, uncorrected for birdwatcher effort.

KEY:
- Total — Total number of wader-days recorded in the month.
- Total 2 — Total number of wader-days recorded in the month, excluding Golden plover (Pa) and Lapwing (Vv).
- BW — Number of birdwatchers recording observations in the Farmoor log-book in that month.
- Spp — Number of wader species recorded in the month.

BIRDS.

Ho	Oystercatcher	*Haematopus ostrlaegus*	To	Green Sandpiper	*Tringa ochropus*
Pa	Golden Plover	*Pluviatilis apricalis*	Na	Curlew	*Numenius arquata*
Cd	Little Ringed Plover	*Charadrius dubius*	Np	Whimbrel	*Numenius phaeopus*
Ch	Ringed Plover	*Charadrius hiaticula*	Lla	Bar-tailed Godwit	*Limosa lapponica*
Ps	Grey Plover	*Pluvialis squatarola*	Lli	Black-tailed Godwit	*Limosa limosa*
Ai	Turnstone	*Arenaria interpres*	Te	Spotted Redshank	*Tringa erythropus*
Cap	Dunlin	*Calidris alba*	Ra	Avocet	*Recurvirostra avosetta*
Ct	Temminck's Stint	*Calidris temminckii*	Lm	Jack Snipe	*Lymnocryptes minimus*
Cm	Little Stint	*Calidris minuta*	Tg	Wood Sandpiper	*Tringa glareola*
Cc	Knot	*Calidris canutus*	Pf	Grey Phalarope	*Phalaropus fulicarius*
Cab	Sanderling	*Calidris alba*	Cf	Curlew Sandpiper	*Calidris ferruginea*
Tt	Redshank	*Tringa totanus*	Cma	Purple sandpiper	*Calidris maritima*
Tn	Greenshank	*Tringa nebularia*	Am	Spotted sandpiper	*Actitis macularia*
Ah	Common Sandpiper	*Actitis hypoleucos*	Pp	Ruff	*Philomachus pugnax*
Vv	Lapwing	*Vanellus vanellus*	Gg	Snipe	*Gallinago gallinago*

DATE	Month	Total	Total 2	BW	Spp	Ho	Cd	Ch	Pa	Ps	Ai	Vv	Cap	Ct	Cm	Cc	Cab	Tt	Tn	Ah	To	Pp	Na	Np	Lla	Lli	Gg	Te	Ra	Lm	Tg	Pf	Cf	Cma	Am
82 JAN	1	338	4	37	3	0	0	0	134	0	0	200	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82 FEB	2	19	18	25	4	2	0	0	0	0	0	1	12	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
82 MAR	3	49	35	30	3	1	0	0	0	0	0	14	5	0	0	0	0	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82 APR	4	202	179	67	11	1	8	2	0	0	0	23	32	0	0	0	1	100	0	19	0	1	3	0	9	0	3	0	0	0	0	0	0	0	0
82 MAY	5	223	192	58	8	0	0	19	0	1	7	31	51	0	0	0	27	32	0	54	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
82 JUN	6	4	4	14	2	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82 JUL	7	64	16	24	6	1	1	0	0	0	0	48	4	0	0	0	0	0	0	8	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
82 AUG	8	309	164	57	8	1	4	43	0	0	0	145	35	0	0	0	1	2	0	77	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
82 SEP	9	109	108	56	9	3	0	32	0	0	0	1	15	0	0	0	0	0	1	45	0	1	0	0	1	0	9	0	0	0	0	0	0	1	0
82 OCT	10	227	41	32	5	0	0	5	0	0	0	186	26	0	3	0	0	1	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82 NOV	11	4	3	28	2	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
82 DEC	12	178	6	45	2	0	0	0	0	0	0	172	5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83 JAN	13	70	0	53	0	0	0	0	0	0	0	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83 FEB	14	168	3	16	1	0	0	0	3	0	0	162	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83 MAR	15	74	52	24	4	1	0	0	0	0	0	22	6	0	0	0	0	44	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
83 APR	16	188	128	66	13	2	4	3	60	0	1	0	45	0	0	0	4	48	1	16	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0
83 MAY	17	72	72	56	8	0	0	2	0	0	4	0	16	0	0	0	10	13	2	21	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
83 JUN	18	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83 JUL	19	30	29	18	4	0	0	2	0	0	1	1	3	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Appendix Table 5.1. Numbers of waders recorded at Farmoor Reservoir, January 1982 to October 1991. Original log-book records, uncorrected for birdwatcher effort.

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Spp	Number of wader species recorded in the month.

DATE	Month	Total	Total 2	BW	Spp	Ho	Cd	Ch	Pa	Pv	Al	Vv	Cap	Ct	Cm	Cc	Cab	Tl	Tn	Ah	To	Pp	Na	Np	Lla	Ll	Gg	Te	Ra	Lm	Tg	Pf	Cf	Cma	Am
83 AUG	20	161	161	45	9	2	7	12	0	0	1	0	36	0	0	0	0	12	9	79	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
83 SEP	21	83	82	49	10	1	0	2	0	0	0	1	35	1	0	0	0	3	6	31	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
83 OCT	22	90	13	32	6	0	0	3	0	0	0	77	5	1	0	0	0	0	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
83 NOV	23	318	19	47	6	1	0	0	16	0	0	283	5	0	0	2	0	0	0	7	0	0	3	0	0	0	1	0	0	0	0	0	0	0	0
83 DEC	24	145	16	30	3	0	0	0	0	0	0	129	3	0	0	0	0	6	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84 JAN	25	18	13	40	2	0	0	3	0	0	0	5	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84 FEB	26	205	5	18	1	0	0	0	0	0	0	200	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84 MAR	27	41	41	23	5	6	0	0	0	0	0	0	2	0	0	0	0	27	0	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
84 APR	28	113	110	85	10	0	5	2	0	0	9	3	11	0	0	0	0	65	1	14	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0
84 MAY	29	128	123	52	10	0	0	5	0	1	11	5	8	0	0	2	27	38	0	28	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0
84 JUN	30	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84 JUL	31	26	26	12	3	12	0	0	0	0	0	0	3	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84 AUG	32	237	170	34	10	0	14	12	1	0	1	68	17	0	0	0	0	4	22	95	0	1	0	0	3	0	0	1	0	0	0	0	0	0	0
84 SEP	33	207	207	79	9	0	32	25	0	1	0	0	32	0	20	0	5	0	6	74	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0
84 OCT	34	326	31	35	3	0	0	15	0	0	0	295	13	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84 NOV	35	371	24	42	5	0	0	0	0	0	0	347	11	0	0	0	0	3	0	5	0	0	0	0	0	0	4	0	1	0	0	0	0	0	0
84 DEC	36	355	28	57	4	0	0	0	19	0	0	310	4	0	0	0	0	3	0	14	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
85 JAN	37	23	23	58	2	0	0	0	0	0	0	0	16	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85 FEB	38	0	0	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85 MAR	39	12	12	29	1	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85 APR	40	143	143	70	3	0	0	0	0	0	0	0	19	0	0	0	0	81	0	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85 MAY	41	122	122	45	10	2	0	9	0	0	9	0	8	0	2	0	12	12	0	59	0	0	0	8	1	0	0	0	0	0	0	0	0	0	0
85 JUN	42	4	4	8	1	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85 JUL	43	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85 AUG	44	294	294	58	9	0	2	22	0	0	6	0	93	0	1	0	0	13	6	141	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0
85 SEP	45	111	111	57	9	0	2	14	0	0	1	0	29	0	6	6	0	0	2	49	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
85 OCT	46	14	12	42	2	0	0	1	2	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85 NOV	47	127	21	49	4	0	0	0	106	1	0	0	7	0	0	0	0	12	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
85 DEC	48	3	3	28	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86 JAN	49	76	76	19	2	0	0	0	0	0	0	0	7	0	0	0	0	69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86 FEB	50	4	4	32	1	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86 MAR	51	37	37	30	3	0	0	2	0	0	0	0	15	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86 APR	52	147	147	64	4	0	13	0	0	0	0	0	23	0	0	0	0	81	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86 MAY	53	97	97	47	4	0	0	2	0	0	0	0	13	0	0	0	0	36	0	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86 JUN	54	1	1	7	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86 JUL	55	51	51	13	2	0	0	0	0	0	0	0	17	0	0	0	0	0	0	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86 AUG	56	355	354	77	14	3	9	17	1	0	5	0	63	0	3	0	3	5	6	223	1	6	9	0	0	0	0	1	0	0	0	0	0	0	0

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Appendix Table 5.1. Numbers of waders recorded at Farmoor Reservoir, January 1982 to October 1991. Original log-book records, uncorrected for birdwatcher effort.

KEY:
- Total — Total number of wader-days recorded in the month.
- Total 2 — Total number of wader-days recorded in the month, excluding Golden plover (Pa) and Lapwing (Vv).
- BW — Number of birdwatchers recording observations in the Farmoor log-book in that month.
- Spp — Number of wader species recorded in the month.

DATE	Month	Total	Total 2	BW	Spp	Ho	Cd	Ch	Pa	Pa	Al	Vv	Cap	Ct	Cm	Cc	Ceb	Tt	Tn	Ah	To	Pp	Na	Np	Lla	Ll	Gg	Te	Ra	Lm	Tg	Pf	Ct	Cma	Am
86 SEP	57	158	158	70	10	0	4	39	0	0	1	0	51	0	6	2	0	0	0	22	1	0	25	0	0	0	0	0	0	0	0	0	7	0	0
86 OCT	58	0	0	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86 NOV	59	6	6	26	1	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86 DEC	60	2	2	22	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87 JAN	61	24	24	39	6	3	0	0	0	0	0	0	4	0	0	0	2	11	0	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0
87 FEB	62	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87 MAR	63	8	8	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87 APR	64	69	69	23	4	0	5	0	0	0	0	0	27	0	0	0	0	17	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87 MAY	65	113	113	48	8	0	11	1	0	0	23	0	10	0	0	0	6	15	0	46	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
87 JUN	66	1	1	30	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87 JUL	67	40	40	23	7	0	1	0	0	0	2	0	6	0	0	0	3	2	1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87 AUG	68	170	170	28	8	0	0	13	0	0	0	0	62	0	1	0	2	0	0	86	0	0	0	1	0	0	2	0	0	0	0	0	3	0	0
87 SEP	69	79	79	51	3	0	0	3	0	0	0	0	17	0	0	0	0	0	0	59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87 OCT	70	11	11	35	2	0	0	0	0	0	0	0	6	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87 NOV	71	323	259	27	3	0	0	0	64	0	0	0	6	0	0	0	0	3	0	0	0	0	0	0	0	0	250	0	0	0	0	0	0	0	0
87 DEC	72	1	1	26	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88 JAN	73	2	2	23	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88 FEB	74	4	2	19	1	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88 MAR	75	8	8	28	1	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88 APR	76	140	140	43	9	0	27	3	0	0	4	0	21	0	0	0	0	50	1	13	0	0	3	18	0	0	0	0	0	0	0	0	0	0	0
88 MAY	77	71	71	26	9	1	1	2	0	0	0	0	21	0	0	1	5	5	0	31	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
88 JUN	78	2	2	4	2	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88 JUL	79	68	68	14	3	0	0	0	0	0	0	0	22	0	0	0	1	0	0	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88 AUG	80	174	174	52	4	0	0	16	0	0	0	0	76	0	0	0	0	6	0	76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88 SEP	81	240	240	87	13	1	0	16	0	2	0	0	99	0	32	0	1	4	17	37	0	22	4	0	0	0	0	0	0	0	0	4	1	0	0
88 OCT	82	30	30	58	2	0	0	0	0	0	0	0	25	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88 NOV	83	30	30	51	2	0	0	0	0	0	0	0	15	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88 DEC	84	30	30	44	2	0	0	0	0	0	0	0	15	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89 JAN	85	6	6	59	1	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89 FEB	86	6	6	25	2	0	0	0	0	0	0	0	4	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89 MAR	87	77	77	68	5	0	0	4	0	0	0	0	16	0	0	0	0	54	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0
89 APR	88	1261	180	104	11	0	43	10	1081		0	0	0	20	0	0	0	5	25	0	46	0	2	21	0	1	6	0	0	1	0	0	0	0	0
89 MAY	89	156	156	71	11	1	0	6	0	0	10	0	42	0	0	0	17	9	4	57	0	0	0	8	1	0	0	1	0	0	0	0	0	0	0
89 JUN	90	11	11	38	5	0	2	1	0	0	0	0	3	0	0	0	0	2	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
89 JUL	91	86	86	28	9	1	10	2	0	0	3	0	18	0	0	0	4	1	0	46	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
89 AUG	92	226	226	88	10	0	0	40	0	0	19	0	71	0	3	0	7	3	7	68	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0
89 SEP	93	169	163	88	13	0	13	34	6	0	3	0	36	0	12	2	11	0	14	32	0	2	2	1	0	0	0	0	0	0	0	1	0	0	0

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Appendix Table 5.1. Numbers of waders recorded at Farmoor Reservoir, January 1982 to October 1991. Original log-book records, uncorrected for birdwatcher effort.

KEY:

Total	Total number of wader-days recorded in the month.
Total 2	Total number of wader-days recorded in the month, excluding Golden plover (Pa) and Lapwing (Vv).
BW	Number of birdwatchers recording observations in the Farmoor log-book in that month.
Spp	Number of wader species recorded in the month.

DATE	Month	Total	Total 2	BW	Spp	Ho	Cd	Ch	Pa	Pe	Al	Vv	Cap	Ct	Cm	Cc	Cab	Tt	Tn	Ah	To	Pp	Ne	Np	Lla	Ll	Gg	Te	Re	Lm	Tg	Pf	Cf	Cme	Am
89 OCT	94	12	12	37	2	0	0	1	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89 NOV	95	10	10	33	2	0	0	0	0	0	0	0	9	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89 DEC	96	12	0	29	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90 JAN	97	2	2	49	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90 FEB	98	3	3	28	2	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90 MAR	99	227	75	64	5	0	0	0	115	0	0	37	1	0	0	0	0	67	0	0	0	3	3	0	0	1	0	0	0	0	0	0	0	0	0
90 APR	100	288	288	105	14	1	33	3	0	0	2	0	26	0	0	0	11	157	2	39	0	0	8	2	2	1	1	0	0	0	0	0	0	0	0
90 MAY	101	331	331	97	11	0	6	39	0	4	63	0	61	0	0	0	17	0	28	66	0	10	0	27	10	0	0	0	0	0	0	0	0	0	0
90 JUN	102	5	5	11	3	0	1	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90 JUL	103	159	159	51	8	1	18	15	0	0	4	0	33	0	0	0	0	2	0	86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
90 AUG	104	338	336	89	14	1	17	29	0	0	20	0	118	0	0	0	4	4	8	109	3	16	1	1	0	0	5	0	0	0	0	0	0	0	0
90 SEP	105	367	352	74	12	3	2	111	15	0	0	0	140	0	31	0	5	3	11	33	9	0	0	0	0	0	2	0	0	0	0	0	2	0	0
90 OCT	106	31	31	46	5	3	0	0	0	0	0	0	16	0	9	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
90 NOV	107	9	9	52	1	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90 DEC	108	1	1	43	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91 JAN	109	134	2	46	1	0	0	0	0	0	0	132	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91 FEB	110	77	35	60	5	0	0	1	0	1	0	42	23	0	0	0	0	7	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
91 MAR	111	581	38	53	6	1	1	3	513	0	0	30	13	0	0	0	0	19	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
91 APR	112	198	198	111	11	0	59	9	0	1	0	0	70	0	0	0	3	11	0	27	0	0	2	5	2	9	0	0	0	0	0	0	0	0	0
91 MAY	113	269	263	110	15	4	19	17	0	4	19	6	51	1	0	3	27	7	3	77	0	0	8	11	12	0	0	0	0	0	0	0	0	0	0
91 JUN	114	18	18	21	8	0	1	6	0	0	1	0	2	0	0	1	1	1	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91 JUL	115	58	58	20	7	0	1	0	0	0	2	0	17	0	0	1	0	2	0	34	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
91 AUG	116	293	292	64	13	7	5	24	0	0	3	1	120	0	6	0	0	11	9	97	0	1	2	0	0	0	5	0	0	0	0	0	2	0	0
91 SEP	117	449	149	95	13	0	2	9	0	7	0	300	39	0	8	11	38	2	13	15	0	3	1	1	0	0	0	0	0	0	0	0	0	0	0
91 OCT	118	123	103	64	8	1	0	1	20	0	0	0	74	0	6	0	0	0	0	10	4	0	0	0	0	0	2	0	0	0	0	5	0	0	0

Appendix Table 5.2. Numbers of waders recorded at Farmoor Reservoir, January 1982 to October 1991. Corrected for birdwatcher effort, values are given as numbers of bird-days per birdwatcher record (Total 2/number of birdwatchers).

KEY TOTAL Total number of bird-days/birdwatcher (excluding Golden Plover and Lapwing)

BIRDS

Ho	Oystercatcher	*Haematopus ostralegus*	Na	Curlew	*Numenius arquata*
Cd	Little Ringed Plover	*Charadrius dubius*	Np	Whimbrel	*Numenius phaeopus*
Ch	Ringed Plover	*Charadrius hiaticula*	Lla	Bar-tailed Godwit	*Limosa lapponica*
Pa	Grey Plover	*Pluvialis squatarola*	Lli	Black-tailed Godwit	*Limosa limosa*
Ai	Turnstone	*Arenaria interpres*	Te	Spotted Redshank	*Tringa erythropus*
Cap	Dunlin	*Calidris alba*	Ra	Avocet	*Recurvirostra avosetta*
Ct	Temminck's Stint	*Calidris temminckii*	Lm	Jack Snipe	*Lymnocryptes minimus*
Cm	Little Stint	*Calidris minuta*	Tg	Wood Sandpiper	*Tringa glareola*
Cc	Knot	*Calidris canutus*	Pf	Grey Phalarope	*Phalaropus fulicarius*
Cab	Sanderling	*Calidris alba*	Cf	Curlew Sandpiper	*Calidris ferruginea*
Tt	Redshank	*Tringa totanus*	Cma	Purple Sandpiper	*Calidris maritima*
Tn	Greenshank	*Tringa nebularia*	Am	Spotted Sandpiper	*Actitis macularia*
Ah	Common Sandpiper	*Actitis hypoleucos*			
To	Green Sandpiper	*Tringa ochropus*			
Pp	Ruff	*Philomachus pugnax*			

DATE	Ho	Cd	Ch	Pa	Ai	Cap	Ct	Cm	Cc	Cab	Tt	Tn	Ah	To	Pp	Na	Np	Lla	Lli	Te	Ra	Lm	Tg	Pf	Cf	Cma	Am	TOTAL	DATE
82 JAN	0	0	0	0	0	0.03	0	0	0	0	0.03	0	0	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0.11	82 JAN
82 FEB	0.08	0	0	0	0	0.48	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	82 FEB
82 MAR	0.03	0	0	0	0	0.17	0	0	0	0	0.97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.17	82 MAR
82 APR	0.01	0.12	0.03	0	0	0.48	0	0	0	0.01	1.49	0	0.28	0	0.01	0.04	0	0.13	0	0	0	0	0	0	0	0	0	2.6	82 APR
82 MAY	0	0	0.33	0.02	0.12	0.88	0	0	0	0.47	0.55	0	0.93	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0	3.32	82 MAY
82 JUN	0	0	0	0	0	0	0	0	0	0	0.21	0	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.28	82 JUN
82 JUL	0.04	0.04	0	0	0	0.17	0	0	0	0	0	0	0.33	0	0.04	0.04	0	0	0	0	0	0	0	0	0	0	0	0.66	82 JUL
82 AUG	0.02	0.07	0.75	0	0	0.61	0	0	0	0.02	0.04	0	1.35	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	2.88	82 AUG
82 SEP	0.05	0	0.57	0	0	0.27	0	0	0	0	0	0.02	0.8	0	0.02	0	0	0.02	0	0	0	0	0	0	0	0.02	0	1.77	82 SEP
82 OCT	0	0	0.16	0	0	0.81	0	0.09	0	0	0.03	0	0.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.28	82 OCT
82 NOV	0	0	0	0	0	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0.11	82 NOV
82 DEC	0	0	0	0	0	0.11	0	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.13	82 DEC
83 JAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	83 JAN
83 FEB	0	0	0	0	0	0	0	0	0	0	0.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.19	83 FEB
83 MAR	0.04	0	0	0	0	0.25	0	0	0	0	1.83	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0	2.16	83 MAR
83 APR	0.03	0.06	0.05	0	0.02	0.68	0	0	0	0.06	0.73	0.02	0.24	0.02	0	0.02	0.02	0	0	0.02	0	0	0	0	0	0	0	1.97	83 APR
83 MAY	0	0	0.04	0	0.07	0.29	0	0	0	0.18	0.23	0.04	0.38	0	0	0	0	0.07	0	0	0	0	0	0	0	0	0	1.3	83 MAY
83 JUN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	83 JUN
83 JUL	0	0	0.11	0	0.06	0.17	0	0	0	0	0	0	1.28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.62	83 JUL
83 AUG	0.04	0.16	0.27	0	0.02	0.8	0	0	0	0	0.27	0.2	1.76	0	0	0.07	0	0	0	0	0	0	0	0	0	0	0	3.59	83 AUG
83 SEP	0.02	0	0.04	0	0	0.71	0.02	0	0	0	0.06	0.12	0.63	0.02	0.02	0.02	0	0	0	0	0	0	0	0	0	0	0	1.66	83 SEP
83 OCT	0	0	0.09	0	0	0.16	0.03	0	0	0	0	0	0.06	0	0.03	0.03	0	0	0	0	0	0	0	0	0	0	0	0.4	83 OCT
83 NOV	0.02	0	0	0	0	0.11	0	0	0.04	0	0	0	0.15	0	0	0.06	0	0	0	0	0	0	0	0	0	0	0	0.38	83 NOV
83 DEC	0	0	0	0	0	0.1	0	0	0	0	0.2	0	0.23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.53	83 DEC
84 JAN	0	0	0.08	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33	84 JAN
84 FEB	0	0	0	0	0	0	0	0	0	0	0	0	0.28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.28	84 FEB
84 MAR	0.26	0	0	0	0	0.09	0	0	0	0	1.17	0	0.22	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0	1.78	84 MAR
84 APR	0	0.08	0.03	0	0.14	0.17	0	0	0	0	1	0.02	0.22	0	0.02	0.02	0	0.02	0	0	0	0	0	0	0	0	0	1.72	84 APR
84 MAY	0	0	0.1	0.02	0.21	0.15	0	0	0.04	0.52	0.73	0	0.54	0	0	0	0.04	0.02	0	0	0	0	0	0	0	0	0	2.37	84 MAY
84 JUN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	84 JUN
84 JUL	1	0	0	0	0	0.25	0	0	0	0	0	0	0.92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.17	84 JUL
84 AUG	0	0.41	0.35	0	0.03	0.5	0	0	0	0	0.12	0.65	2.79	0	0.03	0	0	0.09	0	0.03	0	0	0	0	0	0	0	5	84 AUG
84 SEP	0	0.41	0.32	0.01	0	0.41	0	0.25	0	0.06	0	0.08	0.94	0	0.15	0	0	0	0	0	0	0	0	0	0	0	0	2.63	84 SEP
84 OCT	0	0	0.43	0	0	0.37	0	0.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.89	84 OCT
84 NOV	0	0	0	0	0	0.26	0	0	0	0	0.07	0	0.12	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0.47	84 NOV
84 DEC	0	0	0	0	0	0.07	0	0	0	0	0.05	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.37	84 DEC
85 JAN	0	0	0	0	0	0.28	0	0	0	0	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	85 JAN
85 FEB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85 FEB
85 MAR	0	0	0	0	0	0	0	0	0	0	0.41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.41	85 MAR

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Appendix Table 5.3. Differences between daily log-book wader counts and known-effort wader counts during spring an autumn 1991 migration periods.

	Date	Known-effort counts	Log-book counts	Number of birdwatchers recording observations	Difference between log-book and known-effort counts
April 1991	1	1	0	1	-1
	2	10	0	1	-10
	5	1	1	4	0
	7	0	3	6	3
	8	1	0	3	-1
	11	6	2	2	-4
	13	1	5	5	4
	14	4	0	1	-4
	16	2	0	1	-2
	17	1	4	2	3
	18	9	0	3	-9
	22	24	33	5	9
	23	8	5	3	-3
	24	25	12	4	-13
May 1991	1	6	5	5	-1
	4	19	6	4	-13
	6	6	9	4	3
	16	11	13	2	2
	17	9	22	2	13
	18	8	10	5	2
	19	13	10	2	-3
	22	2	7	2	5
	23	5	10	4	5
	31	0	0	2	0
August 1991	2	15	0	0	-15
	5	7	0	0	-7
	7	16	9	3	-7
	8	14	15	2	1
	12	13	16	4	3
	14	8	4	1	-4
	16	13	0	0	-13
	19	4	7	3	3
	20	9	11	2	2
	22	13	10	4	-3
	24	21	25	5	4
	27	18	18	2	0
September 1991	2	9	11	7	2
	7	7	8	5	1
	10	6	6	2	0
	12	51	21	3	-30
	13	18	21	2	3
	18	8	0	0	-8
	19	4	2	0	-2
	20	2	5	3	3
	23	7	1	4	-6
	25	4	2	1	-2
	27	36	13	2	-23
	30	17	6	3	-9

Appendix Table 5.4. Climatic data for spring and autumn migration period, 1982-1990. Data from Oxford University Meterological Station.

MONTH	DATE	WIND DIRECTION (days/month)								WIND SPEED (average kph/month)								CLOUD	VISIB	TEMP	RAIN	SUN
		N	NE	E	SE	S	SW	W	NW	N	NE	E	SE	S	SW	W	NW					
3	Mar 82	3	2	2	0	8	6	7	2	9.67	8	2	0	8.13	17.33	12.57	13	380	690	620	310	470
4	Apr 82	9	5	0	2	3	2	3	6	9.44	10.4	0	7.5	10.33	11	6.33	10	480	670	930	90	550
5	May 82 5	1	4	3	2	7	6	1	7.2	8	8	7.33	3.5	10.29	9.33	16	360	690	1330	120	600	
8	Aug 82	2	3	1	0	4	10	8	2	8	3.33	3	0	10.25	13.7	11.38	9.5	500	740	1710	120	520
9	Sep 82	2	3	0	6	8	5	3	1	10	3.67	0	5.17	13.75	11.4	5.33	10	510	670	1500	170	470
10	Oct 82	4	0	0	4	11	2	2	8	10.25	0	0	6.5	10.27	15	6	7.88	680	610	1040	270	210
15	Mar 83	3	0	0	1	6	10	7	3	8.33	0	0	10	11.5	12.6	10.57	6	610	630	630	140	290
16	Apr 83	5	3	0	4	2	6	7	3	14	3.33	0	10.5	13.5	9	9.14	7.67	580	720	750	300	500
17	May 83 2	3	4	2	10	6	3	1	7.5	5.67	6.25	8.5	10.6	6.33	10.33	5	690	680	1100	340	410	
20	Aug 83	1	14	3	0	4	2	4	2	11	8.5	8	0	9.5	9	9	12	490	720	1770	80	690
21	Sep 83	0	2	2	2	7	8	7	2	0	2	8.5	9	10.29	12.13	12.71	21	540	680	1430	200	310
22	Oct 83	5	0	0	2	4	13	6	1	5.6	0	0	6.5	14	11.38	11.67	7	560	680	1050	170	390
27	Mar 84	11	4	1	2	2	1	6	3	5.91	10.5	12	12	6.5	4	9.17	7	800	600	470	160	160
28	Apr 84	8	6	2	2	7	1	2	2	6.38	7.5	10	9.5	8.14	11	6	10	400	700	870	10	790
29	May 84 12	8	1	2	2	0	1	5	8.08	11.38	10	5	5	0	5	9.6	600	600	1020	230	460	
32	Aug 84	6	4	5	0	4	5	4	2	4.33	4.75	5.6	0	6.5	8.8	5.5	7.5	500	600	1790	110	640
33	Sep 84	3	0	0	1	5	7	10	4	10.33	0	0	5	8.6	11.14	8.9	11.75	600	700	1420	300	330
34	Oct 84	1	0	1	1	10	12	5	0	16	0	7	2	10.6	11.17	9.6	0	500	700	1150	180	290
39	Mar 85 2	1	5	1	9	7	4	2	17.5	5	7.6	15	17.67	22.57	27.75	31	600	600	510	120	360	
40	Apr 85	2	4	2	2	4	6	9	1	12	16.5	4	14	18.5	11.33	11.78	12	600	700	910	110	460
41	May 85 10	5	1	3	5	1	1	5	10.7	11	2	8.33	11.8	10	5	14	600	700	1220	260	580	
44	Aug 85 0	0	0	3	7	15	4	2	0	0	0	10	11.57	12.67	10.75	12	600	700	1550	220	530	
45	Sep 85	2	1	0	1	9	11	5	1	1.5	2	0	6	4.89	12.45	10.4	10	600	700	1490	60	480
46	Oct 85	9	6	2	2	6	3	3	0	3.89	4.83	4.5	5.5	11	12.33	8.67	0	700	600	1070	90	330
51	Mar 86 0	3	0	6	6	8	6	2	0	2	0	4	5	6	7	8	600	600	540	190	410	
52	Apr 86	9	2	0	3	3	7	3	3	12.22	12	0	9.33	8	10.71	9.67	6	700	700	660	230	470
53	May 86 0	1	0	4	10	14	0	2	0	5	0	6.25	13.3	13.79	0	8.5	700	700	1220	230	660	
56	Aug 86 2	5	2	3	3	7	4	5	2	7	9.5	7.33	14.67	12.71	10	10	600	800	1490	370	470	
57	Sep 86	6	8	1	0	1	5	7	2	8.5	9.5	5	0	9	5.8	8.29	13.5	500	700	1140	130	550
58	Oct 86	7	0	0	3	9	7	5	0	2.14	0	0	6.67	10.78	9.43	9.6	0	500	600	1150	240	390
63	Mar 87 1	6	0	5	3	5	5	6	8	7.67	0	6.4	5.33	11.8	13.6	11.17	700	600	440	170	360	
64	Apr 87	5	2	2	5	4	5	5	2	4.8	4	7	4.2	10	9.4	9.4	13.5	600	600	1070	170	530
65	May 87 11	6	0	0	1	4	3	6	8.09	6.33	0	0	0	8	17.67	9.17	600	700	1090	160	540	
68	Aug 87 6	1	1	1	3	6	8	5	5	7	10	5	7.67	5	8.13	8.8	600	700	1660	110	510	
69	Sep 87	4	0	1	3	5	11	4	2	5	0	5	4	10	8.55	9.5	3	500	700	1470	80	460
70	Oct 87	4	2	1	6	7	8	2	1	5	6	11	5.17	9.71	11.25	11	2	500	700	990	450	350
75	Mar 88 2	0	2	0	0	7	12	8	9	0	5	0	0	12.86	12.83	9.75	600	700	680	190	270	
76	Apr 88	8	7	4	2	3	5	0	5	10.5	9.86	8.75	8	7	8	0		600	600	870	100	440
77	May 88 4	3	5	4	8	2	2	3	10.5	7.33	5.4	10.75	8.25	12	10.5	3.33	500	600	1250	100	570	
80	Aug 88 1	3	1	0	2	6	14	4	0	4.67	6	0	5.5	12.33	11.14	7.5	600	800	1600	130	580	
81	Sep 88	7	1	0	1	4	4	11	2	7.43	2	0	6	15.5	8	13.91	10.5	600	700	1410	130	460
82	Oct 88	2	2	8	3	7	1	7	1	3	5.5	10.88	6.67	8.29	5	14.14	2	500	600	1070	120	390
87	Mar 89 2	0	1	4	5	10	6	3	14	0	3	7.25	9.8	14.7	11.83	10	600	700	790	150	330	
88	Apr 89	6	4	3	2	5	1	5	4	8.83	12.5	14.33	5	10.6	6	8.8	5.75	600	600	730	210	450
89	May 89 4	11	2	0	2	7	4	1	7.75	8.82	7.5	0	4.5	9.14	11.5	5	400	700	1450	90	970	

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Appendix Table 5.4. Climatic data for spring and autumn migration period, 1982-1990. Data from Oxford University Meterological Station.

MONTH	DATE	WIND DIRECTION (days/month)								WIND SPEED (average kph/month)								CLOUD	VISIB	TEMP	RAIN	SUN
		N	NE	E	SE	S	SW	W	NW	N	NE	E	SE	S	SW	W	NW					
92	Aug 89 5	0	1	1	1	9	9	5	7	0	2	15	7	11.44	7.78	8.4	400	800	1800	140	870	
93	Sep 89	5	6	1	0	4	6	5	3	6.2	11.5	2	0	12.75	9.67	4	5.33	500	700	1570	80	470
94	Oct 89	3	1	1	3	7	4	11	1	8	2	6	5.33	8.29	14	10.45	7	600	600	1200	170	290
99	Mar 90 1	0	0	2	5	7	12	4	6	0	0	9	8.2	12.57	15.08	8.5	400	700	840	60	460	
100	Apr 90 5	6	1	1	1	5	8	3	6.8	12.5	3	5	2	8.6	13.38	11	400	700	910	70	780	
101	May 90 4	6	7	0	4	3	5	2	7.25	7.5	8.57	0	6.5	9.67	5	6	400	700	1440	30	920	
104	Aug 90 2	2	2	1	2	6	12	4	34.00	5.00	7.50	15.00	16.00	22.83	26.33	32.00	400	700	2020	90	760	
105	Sept 90 6	3	2	0	2	2	11	4.	4.33	6.00	6.00	0.00	5.50	9.00	9.73	8.75	500	700	1410	140	550	
106	Oct 90 3	0	4	5	3	10	6	0	6.67	0.00	8.75	6.80	9.33	13.30	11.67	0.00	500	600	1220	150	400	
111	Mar 91 4	4	3	7	6.	3	3	1	9.00	12.50	9.00	8.71	9.00	5.00	7.00	2.00	Data not yet analysed					
112	Apr 91 5	6	1	2	4	8	3	1	14.20	11.67	9.00	11.00	13.25	10.38	14.00	14.00	Data not yet analysed					
113	May 91 9	9	0	0	0	1	5	7	6.44	10.11	0.00	0.00	0.00	3.00	5.80	6.14	Data not yet analysed					
116	Aug 91 4	3	2	1	3	7	6	4	3.75	6.33	9.50	5.00	17.33	10.57	7.83	5.50	500	700	780	40	780	
117	Sep 91 9	6	1		3	6	0	1	8.78	6.67	25.00	5.00	10.67	16.83	0.00	5.00	500	600	1480	140	550	
118	Oct 91 5	3	2	3	5	3	5	3	2.60	11.00	1.50	9.00	8.60	11.00	10.20	7.67	600	600	1030	110	260	
128	Aug 92 2	0	1	2	5	13	5	1	5.5	0	4	5	19.2	10.07	11.6	8	600	700	1650	350	560	
129	Sep 92 Data not yet available from Oxford University Meteorological Station.																					
129	Oct 92 Data not yet available from Oxford University Meteorological Station.																					

Appendix Table 5.5 Autumn 1991 bird monitoring data

DATE	AUGUST												SEPTEMBER												OCTOBER				
	2	5	7	8	12	14	16	19	20	22	24	27	2	7	10	12	13	18	19	20	23	25	27	30	3	8	9	11	TOTAL
Great crested grebe	13	17	20	15	16	20	26	20	20	19	19	26	29	20	26	19	15	15	19	20	29	24	22	31	25	27	20	27	599
Little grebe	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	2	1	1	1	1	1	0	1	1	12
Black-necked grebe	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Gannet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cormorant	10	9	8	8	10	10	15	6	8	13	11	21	33	31	27	34	34	33	42	26	43	30	41	39	39	57	67	71	776
Heron	1	0	0	1	0	2	0	0	1	0	0	3	0	0	0	0	1	0	2	0	2	2	1	2	1	1	2	1	23
Mute swan	11	11	12	16	10	10	10	11	16	5	14	9	15	24	34	31	39	26	20	22	21	17	16	2	0	8	0	1	411
Greylag goose	0	0	0	0	0	0	0	36	0	0	0	0	52	0	0	0	120	100	113	100	100	100	100	107	100	0	0	100	1128
Canada goose	0	0	0	0	0	34	0	0	0	0	0	0	0	21	0	0	3	1	1	2	1	1	1	1	1	0	0	0	67
Shelduck	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mallard	30	65	55	54	74	82	64	85	85	32	58	24	74	117	120	134	159	109	127	111	114	95	119	88	94	107	116	146	2538
Gadwall	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wigeon	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	1	1	0	0	1	1	0	0	0	0	7
Teal	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	1	0	0	0	0	0	0	7
Garganey	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Shoveler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Tufted duck	115	103	126	125	143	150	147	155	146	162	159	229	246	240	287	284	257	231	275	275	340	301	258	269	259	328	339	324	6283
Pochard	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	7
Goldeneye	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Goosander	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ruddy duck	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood duck	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pintail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Osprey	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Marsh harrier	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Moorhen	0	0	0	1	0	0	0	1	2	0	1	1	2	1	0	0	0	1	0	0	1	11	2	0	0	0	0	1	25
Coot	0	0	0	0	12	0	0	0	3	7	2	16	9	23	37	39	38	61	67	65	69	56	76	63	61	65	33	96	918
Oystercatcher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little-ringed plover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ringed plover	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	7
Golden plover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Grey plover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Turnstone	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Lapwing	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	34	0	0	0	0	0	0	22	0	0	0	44	0	103
Dunlin	4	0	8	8	7	4	8	0	5	7	11	10	0	0	0	0	0	0	0	0	1	0	9	16	1	0	0	1	100
Temminck's stint	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little stint	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	2	1	0	0	0	0	0	0	0	0	0	1	7
Knot	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sanderling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	8	0	0	0	0	0	0	0	0	0	0	0	16
Redshank	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Greenshank	0	0	0	0	0	0	0	0	0	0	0	2	1	2	0	0	0	1	1	1	3	2	3	0	0	0	0	0	16
Common sandpiper	8	4	8	6	5	4	5	4	2	6	9	3	8	4	6	5	8	6	3	1	1	2	2	1	2	2	2	3	120
Green sandpiper	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3
Curlew sandpiper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ruff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Curlew	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Whimbrel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bar-tailed godwit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Black-tailed godwit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Snipe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grey phalarope	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Black-headed gull	2	9	8	15	87	65	7	212	42	707	102	482	32	208	12	7	20	4	22	2	7	14	41	8	0	2	314	17	2448
Little gull	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mediterranean gull	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Herring gull	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
L. black-backed gull	0	0	0	1	2	0	0	2	1	1	0	0	0	1	0	1	0	0	0	1	1	1	0	0	0	20	0	0	32
Imm. herring/Lbb	0	3	3	0	4	2	0	2	3	21	3	5	2	1	0	6	3	0	0	1	1	2	0	0	0	0	2	1	65
Great black-backed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Common gull	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Kittiwake	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sandwich tern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Common tern	18	13	8	11	8	9	6	8	10	11	10	7	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	128
Arctic tern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little tern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Black tern	0	0	1	1	0	0	0	0	1	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	12
Arctic skua	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Kingfisher	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
Water pipit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock pipit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	2	0	7
Pied wagtail	13	14	15	41	23	9	16	51	38	17	20	35	53	15	14	23	24	8	22	29	70	26	48	20	5	16	20	12	697
White wagtail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	9
Grey wagtail	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	5	
Yellow wagtail	11	3	10	8	16	26	25	35	22	99	39	93	40	33	14	54	25	41	44	41	43	20	5	1	0	0	0	1	749

Appendix table 5.6. Known-effort monitoring raw data: Spring 1991

DAY	1	2	5	7	8	11	13	14	16	17	18	22	23	24	1	4	6	16	17	18	19	22	23	31	TOTAL	
Great crested grebe	8	3	4	2	3	9	9	8	13	6	10	16	13	15	4	15	16	14	15	33	25	15	15	9	280	Great crested grebe
Dabchick	1	2	2	0	2	2	3	1	1	2	2	1	0	1	1	1	0	1	0	0	0	0	0	0	23	Dabchick
Gannet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Gannet
Cormorant	19	31	28	34	32	24	24	4	32	24	25	27	26	18	11	23	16	16	15	15	11	6	10	8	479	Cormorant
Heron	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	1	0	0	6	Heron
Mute swan	0	0	0	1	0	7	2	0	0	0	3	0	0	5	2	0	0	4	0	10	7	1	3	0	45	Mute swan
Greylag goose	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	Greylag goose
Canada goose	0	0	0	0	11	6	1	0	3	0	2	0	0	0	2	0	0	0	0	2	0	0	0	0	27	Canada goose
Shelduck	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	2	0	0	0	0	0	0	5	Shelduck
Mallard	73	91	37	30	42	34	20	53	27	46	39	55	42	54	22	35	27	28	25	74	27	36	28	49	994	Mallard
Gadwall	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Gadwall
Wigeon	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	Wigeon
Teal	0	0	0	0	0	0	0	0	0	2	0	3	0	0	0	0	2	0	0	0	0	0	0	0	7	Teal
Garganey	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Garganey
Shoveler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Shoveler
Tufted duck	139	118	37	38	50	50	57	56	53	59	46	52	68	64	38	39	34	24	18	54	15	16	7	13	1145	Tufted duck
Pochard	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Pochard
Goldeneye	31	35	26	14	16	11	14	5	9	11	13	2	2	3	0	0	0	0	0	0	0	0	0	0	192	Goldeneye
Goosander	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	Goosander
Ruddy duck	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	Ruddy duck
Wood duck	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	Wood duck
Osprey	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Osprey
Marsh harrier	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Marsh harrier
Moorhen	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	4	Moorhen
Coot	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	Coot
Oystercatcher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Oystercatcher
Little-ringed plover	0	0	0	0	0	5	1	2	2	1	6	4	3	2	4	0	2	0	0	1	2	0	2	0	37	Little-ringed plover
Ringed plover	0	1	0	0	1	0	0	0	0	0	0	2	0	1	0	0	0	0	0	1	0	1	0	0	7	Ringed plover
Golden plover	0	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52	Golden plover
Grey plover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	Grey plover
Turnstone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	0	4	Turnstone
Lapwing	0	4	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	3	0	0	1	0	10	Lapwing
Dunlin	0	8	0	0	0	0	0	0	0	0	0	15	2	4	0	0	0	5	2	8	0	0	1	0	45	Dunlin
Temminck's stint	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Temminck's stint
Little stint	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Little stint
Knot	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Knot
Sanderling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	4	Sanderling
Redshank	2	0	1	0	0	0	0	2	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	9	Redshank
Greenshank	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2	Greenshank
Common sandpiper	0	0	0	0	0	0	0	0	0	0	0	3	3	7	2	5	4	1	3	2	6	1	1	0	38	Common sandpiper
Green sandpiper	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	Green sandpiper
Ruff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Ruff
Curlew	0	1	0	0	0	1	0	0	0	0	0	0	0	10	0	0	0	0	0	1	0	0	0	0	13	Curlew
Whimbrel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	Whimbrel
Bar-tailed godwit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	2	0	4	0	0	0	0	0	17	Bar-tailed godwit
Black-tailed godwit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Black-tailed godwit
Snipe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Snipe
Black-headed gull	210	380	8	5	4	6	4	5	8	11	11	42	0	0	5	5	1	0	0	102	0	0	1	5	813	Black-headed gull
Little gull	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Little gull
Mediterranean gull	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Mediterranean gull
Herring gull	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Herring gull
L. black-backed gull	2	6	1	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	17	L. black-backed gull
G. black-backed gull	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	G. black-backed gull
Common gull	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Common gull
Kittiwake	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Kittiwake
Sandwich tern	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	Sandwich tern
Common tern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	13	6	6	6	13	4	2	5	6	77	Common tern
Arctic tern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	13	Arctic tern
Little tern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2	Little tern
Black tern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	17	19	Black tern
Kingfisher	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	Kingfisher
Rock pipit	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	3	Rock pipit
Pied wagtail	14	6	3	5	5	3	2	0	5	7	3	7	3	4	9	6	14	7	4	11	9	0	4	6	137	Pied wagtail
White wagtail	0	0	0	0	0	1	0	0	0	1	3	2	12	9	0	0	0	0	0	0	0	0	0	0	28	White wagtail
Yellow wagtail	0	0	0	0	1	0	5	24	9	24	16	15	6	7	26	11	13	4	4	11	4	0	1	1	182	Yellow wagtail
Reed bunting	2	1	1	1	1	1	1	1	1	0	1	2	2	1	4	1	1	0	0	1	1	1	2	0	27	Reed bunting