DEPARTMENT for ENVIRONMENT, FOOD and RURAL AFFAIRS **CSG 15**

Research and Development

Final Project Report

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Executive summary (maximum 2 sides A4)

INTRODUCTION

The potential consequences of environmental change, particularly those arising from global warming, continue to be a major environmental issue and a priority for government research. The Department for Environment and Rural Affairs (Defra) has a strong interest in the effects of climatic and other changes on agricultural systems and farmland biodiversity, and has funded ADAS at Defra Drayton as one of the founding sites within the UK Environmental Change Network (ECN) since April 1992. The ECN is the UK's integrated network for monitoring environmental change. It is funded by a consortium of sponsoring organisations and is managed by the Centre for Ecology and Hydrology (CEH), on behalf of the Natural Environment Research Council. The objectives of the network are to establish and maintain a set of UK sites at which variables identified as being of major environmental importance can be measured. Long-term data sets obtained are being, and will continue to be, analysed to identify and improve the understanding of the causes of environmental change. There are currently 54 ECN sites, located throughout the UK. Although most are fresh-water sites, Drayton has an important place among the 12 terrestrial sites - as the only site in the English Midlands and the only lowland, mixed-agriculture farm.

OBJECTIVES

The objectives of ECN are as follows:

1. To obtain uniform and comparable long-term datasets at selected sites by means of measurement at regular intervals of variables identified as being of major environmental importance.
2. To provide for the integration and analysis of these datasets so as to identify environmental changes and to improve understanding of the causes of such changes.
3. To make these long-term datasets available as a basis for research and for prediction of future changes.
4. To provide, for research purposes, a range of representative sites where there is good instrumentation and reliable environmental information.

The more specific objectives of the DEFRA Drayton ECN site are as follows:

1. To maintain Drayton as a participating site within the UK Environmental Change Network.
2. To undertake long-term recording of climate, air pollution, precipitation and soil solution chemistry, soil characteristics, vegetation and fauna as defined in the relevant ECN protocols (Sykes & Lane, 1996).
3. To maintain an up-to-date computerised data-base for the Drayton site, and provide data to the ECN Central Co-ordinating Unit at CEH Merlewood.
4. To participate in the analysis, interpretation and publication of the combined results from the ECN programme.

METHODS

Standardised methods of data collection are used within the ECN – with agreed protocols for all measurements (Sykes & Lane, 1996). Variables being recorded at Drayton include those pertaining to: meteorology, atmospheric NO_2, precipitation chemistry, vegetation, ground beetles, moths, butterflies, frogs, birds, deer and bats. The five-yearly soil sampling was completed in March 2003.

RESULTS

Meteorology

Rainfall totals at Drayton in 2002 were above the long-term average for the site, for the fifth year in succession. Wet autumns in 2000 and 2002 hampered the establishment of autumn-sown cereal crops, as it did for many farmers across England on similar heavy soils. In contrast, 2003 was a dry year, with total rainfall (429 mm) some 22% below the long-term mean. The total precipitation in August and September 2003 was only 37 mm, approximately 32% of the average for these two months. Analysis of Drayton rainfall data indicates that annual rainfall totals over the past 10 years have been more variable than in any 10-year period since 1944.

Atmospheric and precipitation chemistry

Results indicate that concentrations of several major atmospheric pollutants have declined in recent years. Mean annual atmospheric NO_2 concentrations between 1999 and 2003 were within the range 4.2-5.9 ppb, lower than in every year from 1993 to 1998 (range 6.5 – 8.6 ppb). The mean annual rainwater pH in 2003 (6.0) was the highest since ECN precipitation chemistry assessments began in 1993, after three years in which annual means were between 5.5 and 5.6. The annual mean water pH rose steadily from 5.1 in 1993 to 5.8 in 1998 and 1999. Mean annual sulphate sulphur (SO_4-S) concentrations in rainwater showed a corresponding decrease over the period from 1993 to 1997 and remained at a consistently low level (around 0.6 mg l^{-1}) from 1997 to 2003. Over the past four years, both mean annual rainwater conductivity and ammonium nitrogen concentrations have also been stable at relatively low levels (approx. 20 microSiemens l^{-1} and 0.5 mg l^{-1} respectively).

Vegetation

Most of the vegetation monitoring plots are located in improved grassland, where perennial rye-grass (*Lolium perenne*) is the dominant species (National Vegetation Classification class MG7b). Species diversity is relatively low and species are representative of a relatively high pH, nitrogen-rich vegetation type. The most frequently recorded species in 1993 and 2002 were perennial rye-grass and rough meadow-grass (*Poa trivialis*). Both species occurred in over 90% of coarse-grain plots in both years. Other commonly recorded species in 2002 included soft brome (*Bromus hordeaceus hordeaceus*), timothy (*Phleum pratense*), dandelions (*Taraxacum officinale* agg.) and sow-thistles (*Sonchus* spp.). Several species showed large changes between 1993 and 2002. Those showing big increases in their distribution included dandelions, sow-thistles, soft brome, timothy and Yorkshire-fog (*Holcus lanatus*). Species showing major decreases included annual meadow-grass (*Poa annua*), wall barley (*Hordeum murinum*), chickweed (*Stellaria media*) and creeping bent (*Agrostis stolonifera*). Most of the species which were recorded in fewer plots in 2002 are species typical of heavily disturbed grassland and decreases were probably a direct effect of reduced grazing pressures, including one year without any grazing livestock (i.e. 2001), when sheep were removed because of concerns about foot-and-mouth disease risks. The mean number of species recorded per cell increased from 2.5 in 1993 to 2.8 in 2002, but this difference was not statistically significant. Analysis of Ellenberg values, indicated an overall increase in reaction index and a decrease in nitrogen index. These changes, again, reflect the less intensive grassland management at Drayton in recent years.

Invertebrates

Populations of invertebrates (and many other taxonomic groups) fluctuate greatly between years, for numerous reasons. Results presented in this report clearly illustrate annual variations for a number of species, which can be extreme. In some instances, there is evidence of longer-term increases or decreases for particular invertebrate taxa, but all results should be interpreted with a degree of caution.

Total numbers of ground beetles captured in pitfall traps in 2001 and 2002 were lower than in any previous year since trapping began in 1993, and well below the 1993-2000 mean. This reduction in total numbers can be largely attributed to a major decline in numbers of the common farmland species *Pterostichus melanarius*. Only 184 beetles of this species were trapped in 2001, compared to a peak of 1196 in 1997, and totals of 400-800 in most other years. Some other previously abundant species, such as *Trechus quadristriatus*, were also recorded in very low numbers in 2001 and 2002.

A total of 157 moth species was recorded in 2002, the highest total for five years, and 20 species more than in 2001. The 137 species recorded in 2001 was the lowest since moth trapping commenced in 1992. 146 species were trapped in 2003. Over the 12-year period from 1992 to 2003, the mean number of species trapped per year was 153. Over the same period, the mean number of individual moths trapped per year was 2659. Total numbers of moths captured per year in the period 2001-03 increased from 1806 in 2001, to 2501 in 2002, and 3304 in 2003; although even the 2003 total was still well below the peak of 5286 moths recorded in 1996. Almost one third of the 2003 total was made up of three moth species: lunar underwing (*Omphaloscelis lunosa*), square-spot rustic (*Xestia xanthographa*) and Hebrew character (*Amathes c-nigrum*). For each of these species the total trapped at Drayton in 2003 was the highest recorded so far.

The total number of butterflies recorded in 2001 (652) was slightly above average. Almost 50% were meadow brown butterflies, with numbers of this species almost equalling the combined total of the previous eight years – probably due to the absence of sheep grazing in that year. In 2002, the estimated total for the year was 462, 20% below the mean for the preceding nine-year period (576). In 2003, butterfly numbers rose again to 626, slightly above the mean annual total.

Vertebrates

The first records of frogspawn occurred very early in 2002, 2003 and 2004 – all in the last week of February. The 2004 date (20th February) was the earliest in 11 years of recording. Prior to 2002, the only February record of frogspawn at Drayton was in 1998.

Since 2001, nine Red List and nine Amber List bird species have been recorded in the common birds census surveys at Drayton. Two of the Red List species, skylark (*Alauda arvensis*) and yellowhammer (*Emberiza citrinella*), were among the three most common breeding species at the site (the third being chaffinch, *Fringilla coelebs*). The estimated numbers of breeding pairs for both of these species in the period 2002-04 were, however, well below the 1993-2004 annual means. Initial analysis of bird territory data indicates a progressive decline in populations of several common bird species at Drayton, including chaffinch, skylark, yellowhammer, dunnock and whitethroat (*Sylvia communis*). Several warbler species have, however, become established as breeding species within the past four or five years – probably as a result of the short rotation coppice (SRC) willow planting around much of the farm.

Another species to benefit from the establishment of large areas of SRC has been the roe deer (*Capreolus capreolus*). Deer are now very frequently observed and droppings are regularly recorded in transects.

Pipistrelles (*Pipistrellus pipistrellus*) were by far the most frequently recorded bat species at Drayton over the period 1993-2003, and the only species noted since 1999. The total number of bats recorded in 2003 (42) was higher than in any other year and the mean per survey (10.5), was almost double the long-term mean.

Scientific report (maximum 20 sides A4)

THE UK ENVIRONMENTAL CHANGE NETWORK (DRAYTON)

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INTRODUCTION

The potential consequences of environmental change, particularly those arising from global warming, continue to be a major environmental issue and a priority for UK Government research. The need for a network for long-term, integrated environmental monitoring in the UK eventually led to the formation of the UK Environmental Change Network (ECN) in 1992. The ECN is funded by a consortium of sponsoring organisations and is managed by the Centre for Ecology and Hydrology (CEH), on behalf of the Natural Environment Research Council. The objectives of the network are to establish and maintain a set of UK sites at which variables identified as being of major environmental importance can be measured. Long-term data sets obtained are being, and will continue to be, analysed to identify and improve the understanding of the causes of environmental change.

There are currently 54 ECN sites, located throughout the UK. Most of these (42) are freshwater sites, but there are 12 terrestrial sites: Drayton, Rothamsted, North Wyke, Alice Holt, Wytham, Moor House, Porton Down (all in England), Snowdon (Wales), Sourhope, Glensaugh, Cairngorm (Scotland) and Hillsborough (Northern Ireland).

The Department for Environment, Food and Rural Affairs (Defra) has a strong interest in the effects of climatic and other changes on agricultural systems and farmland biodiversity. The possible consequences of climate change are numerous and potentially dramatic, not least for agriculture and the rural environment. The impact of climate change on UK agriculture was clearly recognised in the Ministry of Agriculture, Fisheries and Food's '*Research Strategy Document 1996-2000*' (MAFF, 1996), which stated that the principal objective of MAFF's '*Climate Change and Agriculture*' programme was "*to provide the scientific basis for the establishment of UK agricultural policy on climate change by assessing the impact and identifying adaptation strategies….*" This document also identified a need for better scientific knowledge to underpin the framing of future regulations in support of the Government's wildlife conservation policy.

MAFF/Defra has funded the ECN site at Drayton, one of the founding sites within the network, since April 1992. Drayton, in south Warwickshire, has an important place among the terrestrial sites - as the only site in the English Midlands and the only lowland, mixed-agriculture farm.

The long-term data from Drayton and other agricultural ECN sites contribute towards Defra's stated wildlife conservation scientific objective "*to identify the causes of declines in biodiversity on farmland*" (MAFF, 1996), and also provide further valuable information relating to particular Biodiversity Action Plan priority habitats and species for which Defra has specific responsibilities. The consultation document '*MAFF Research Strategy 2001-2005*', published in August 2000, re-emphasised the need for continued climate change related research (MAFF, 2000).

ECN data also contribute directly to other national monitoring networks (e.g. those relating to atmospheric pollution, birds, butterflies and moths) and are used by external researchers, in support of other projects. ECN is providing valuable reference data for research projects in several areas. Data will provide further quantification of annual fluctuations and longer-term population changes; and aid the understanding of the interactions between physical, chemical and biological variables that underlie these changes.

The general objectives of the ECN are as follows:

1. To obtain uniform and comparable long-term datasets at selected sites by means of measurement at regular intervals of variables identified as being of major environmental importance.
2. To provide for the integration and analysis of these datasets so as to identify environmental changes and to improve understanding of the causes of such changes.
3. To make these long-term datasets available as a basis for research and for prediction of future changes.
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The more specific objectives of the DEFRA Drayton ECN site are as follows:

1. To maintain Drayton as a participating site within the UK Environmental Change Network.
2. To undertake long-term recording of climate, air pollution, precipitation and soil solution chemistry, soil characteristics, vegetation and fauna as defined in the relevant ECN protocols (Sykes & Lane, 1996).
3. To maintain an up-to-date computerised database for the Drayton site, and provide data to the ECN Central Co-ordinating Unit at CEH Lancaster.
4. To participate in the analysis, interpretation and publication of the combined results from the ECN programme.

MATERIALS AND METHODS

Standardised methods of data collection are used at all ECN terrestrial sites, with agreed protocols for all measurements (Sykes & Lane, 1996). Variables being recorded at Drayton include those pertaining to: meteorology, atmospheric chemistry (NO_2, NH_3 and SO_2), precipitation chemistry, soil solution chemistry, soil survey, vegetation, butterflies (Lepidoptera: Papilionoidea), moths (Lepidoptera), ground beetles (Coleoptera: Carabidae), crane-flies (Diptera: Tipulidae), spittle bugs (Hemiptera: Cercopidae), birds, bats, rabbits, deer and frogs.

At Drayton, the ECN site comprises the whole of the farm (200 ha). Several regular assessments (e.g. weather recording, precipitation chemistry, soil solution chemistry, soil surveys, grass yields, atmospheric NO_2, crane-fly larvae and ground beetles) were, however, performed in or near a 100 x 100 m (1.0 ha) plot referred to as the ‘target sampling site’ (TSS). The TSS is located in a small (1.8 ha) field of permanent grassland, near the southern edge of the farm.

Meteorology

Weather data have been recorded manually at Drayton, for the Meteorological Office, since 1941. A Didcot automatic weather station was installed in May 1991, and this provides the much more detailed information demanded by ECN protocols. Data collected include sunshine hours and solar radiation; rainfall; soil, ground and air temperatures; maximum and minimum temperatures; and wind speed and direction.

Atmospheric chemistry

Atmospheric nitrogen dioxide (NO_2) concentrations at Drayton have been continuously monitored since 1993, using passive diffusion tubes. These tubes, containing 1 cm diameter stainless steel mesh discs coated with an NO_2 absorbent, were placed outside and exposed to the air for a period of 14 days before being closed and sent to the laboratory for analysis. In the laboratory, the weight of nitrite (µg NO_2) in the absorbent from each tube was calculated, using a calibration curve. This figure can then be used to calculate the mean concentration of NO_2 in the air over the 14-day exposure period.

Monitoring of atmospheric ammonia (NH_4), using an active denuder, also continued throughout the period of this report. All samples were analysed by CEH Edinburgh, who were also responsible for the overall management of this work. Data are not presented in this report.

Precipitation chemistry

Precipitation chemistry was measured by analysing water samples collected below a continuously open funnel (Sykes & Lane, 1996), so the number of samples collected was dependent on the frequency and amount of rainfall. Depending on the sample volume, up to 16 determinands were measured by the laboratory: pH, conductivity, alkalinity, total-N, dissolvable organic carbon (DOC) and dissolved Na^+, K^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, Al^{3+}, NH_4^+-N, NO_3^--N, Cl^-, SO_4^{2-} and PO_4^{3-}. Any obvious contamination of water samples (e.g. by bird droppings) was noted, using standardised QA codes.

Soil solution chemistry

Soil solution samples were collected fortnightly from soils beneath a long-term rye-grass ley, within the ECN ‘target sampling site’, using PTFE and quartz porous cups (suction lysimeters). Porous cups were located at two soil depths – one in the A horizon and one at the base of the B horizon (Sykes & Lane, 1996). Sampling commenced in April 1993, but both the number of samples collected and the volume of each sample were sometimes severely limited by dry soil conditions, particularly between summer 1995 and spring 1997. At the laboratory, water samples were analysed for the same 16 determinands measured in precipitation chemistry samples (see above).

Soil survey, characterisation and assessment of change

Soil physical, chemical and mineralogical properties are measured on 5 and 20 year cycles. The third five-yearly soil sampling was completed in March 2003. Sampling was undertaken under sub-contract by Mr Graham Beard of LandLook (Midlands) Ltd and laboratory analyses completed by Cranfield University. The first two ECN soil surveys at Drayton, in 1993 and 1998, were reported independently to MAFF/Defra by the Soil Survey and Land Research Centre (Cranfield University), with data for other ECN sites.

Vegetation

Vegetation monitoring is carried out at regular intervals, at two levels: coarse and fine-grain. The observed variation is characterised by reference to an existing descriptive system, that allows comparison of change across the network.

The main aim of the vegetation monitoring within ECN is to be able to map and monitor change among semi-natural vegetation types. However, at Drayton, most of the fields that are suitable for long-term botanical monitoring are permanent or semi-permanent grassland, as the site is predominantly a mixture of arable land and rye-grass (*Lolium perenne*) pasture (improved mesotrophic grassland). There are very few areas of vegetation that are not regularly subjected to agricultural management.

In 1993, initial mapping of National Vegetation Classification (NVC) types (Rodwell, 1991 *et seq.*) was undertaken in the selected long-term vegetation monitoring plots. This baseline dataset provided a framework for detailed monitoring of vegetation at the site i.e. the ‘coarse-grain’ and ‘fine-grain’ monitoring (Sykes & Lane, 1996).

Coarse-grain monitoring
Coarse-grain monitoring is carried out every nine years, and was undertaken at Drayton in 1993 and 2002. Fifty 2 x 2 m plots were randomly allocated to grid positions and each plot was divided into 25 40 x 40 cm cells. All vascular plant species present in each cell were recorded. Non-vascular plants were recorded in two groups - bryophytes and lichens. The presence of bare soil, bare rock, leaf litter and dead wood was recorded, along with physical factors such as topography, land use, etc.

Fine-grain vegetation monitoring
Fine-grain monitoring was initially scheduled to be carried out every three years, starting in 1994. However, thanks to additional funding, initially from the Department for Environment, Transport and the Regions (DETR) and subsequently from MAFF/Defra, fine-grain monitoring has been repeated annually since 1996. This change to annual monitoring was based on recommendations from an initial pilot study, which indicated that vegetation at several ECN sites showed significant changes between years.

The number of plots for assessment at each ECN site was determined on the basis of the number of vegetation types identified in the baseline survey i.e. ensuring that there were sufficient to give representative coverage of all of the main NVC classes. At Drayton, 12 10 x 10 m plots were randomly positioned, at line intersections on a grid overlaid on a map of the farm. Ten randomly selected 40 x 40 cm cells within each plot were used for recording all species of vascular plants, bryophytes and lichens. Other ground cover and physical factors were recorded as described above.

In addition to the fine-grain assessments carried out at each site in 1996, an independent Quality Assurance exercise was also undertaken, to assess the accuracy of vegetation recording and to highlight any problems in the application of the protocols. The QA assessment indicated that an acceptable standard of accuracy was being achieved in vegetation assessments at Drayton.

Results from the coarse and fine-grain vegetation assessments, like all other Drayton ECN data, are entered onto the ECN central database at CEH Lancaster. Detailed results from the repetition of the coarse and fine-grain monitoring will be sufficiently sensitive to detect change in any element of the vegetation. This ensures that a wide spectrum of the potential causes of environmental change can be assessed.

Grass yields
Annual yields of grass from the target sampling site (a permanent grass pasture, of predominantly *Lolium perenne*), continued to be estimated, by taking four cuts per year of grass from beneath ten 3 x 1 m ‘exclusion cages’ (in mid-May, early July, early September and late October).

Invertebrates

A number of indicator groups of invertebrates are sampled, concentrating on groups where national monitoring schemes already exist. The groups are moths, butterflies, ground predators (ground beetles and harvestmen), cranefly larvae and spittle-bugs.

Moths
The trapping of moths in a Rothamsted light trap continued throughout the three year period covered by this report, completing 11 years of continuous moth recording at the site. The killing jar was emptied of captured moths and refilled with tetrachloroethane on a daily basis, except at weekends. Moth identifications were carried out by staff at Rothamsted Research.

Butterflies
Annual butterfly recording continued according to standard ECN protocol requirements (Sykes & Lane, 1996), which follow the 'Pollard walk' method used by the Butterfly Monitoring Scheme (Hall, 1981). Weekly assessments were made from the beginning of April until the end of September, whenever the weather met certain pre-determined conditions (Hall, 1981). Monitoring in every year was undertaken along the same transect, approximately 2 km in length, which incorporates the majority of field margin/boundary habitat types present at Drayton. The transect is split into 12 sections, each representing a different field boundary, and contrasting habitat types and/or adjacent land use combinations.

The transect was walked at a regular pace and all butterflies coming within an imaginary 5 m^3 'box' in front of the recorder were recorded. Numbers and species of butterflies present each year would have been affected to some extent by adjacent crops (and, therefore, by the crop rotation) and the types of vegetation present in the field margin.

Data were analysed by Butterfly Monitoring Scheme (BMS) staff at CEH Monks Wood, using a standardised BMS methodology. Index values were calculated, using actual data and estimates for any missing weeks. In 2002, only 15 assessments were made, requiring an unacceptably high number of estimates. Consequently, for 2002 only, an alternative method was used to provide an approximate estimate of the annual total. The total number of butterflies actually recorded in the 15 assessments completed during 2002 was 81.8% of the long-term (10 year) mean value for those same 15 weeks. Therefore, the total number of individuals for 2002 was estimated as 81.8% of the long-term, mean annual total (581.3).

Ground predators
Ground beetles (Carabidae), which are important as predators of crop pests such as aphids and as biodiversity indicators, and harvestmen, have been monitored at Drayton since the start of the ECN project. Ground predators were caught in pitfall traps between May and October each year. The traps were located in areas relatively undisturbed by agricultural operations, 10 being adjacent to an intensively managed grass field grazed by sheep and a further 20 located in a coarse grass field margin, between a stream and an arable field (winter wheat). All captured ground beetles and harvestmen were removed from traps and preserved in alcohol, for subsequent identification to species.

Spittle bugs
The nymph density of two common spittle-bug species (*Philaenus spumarius* and *Neophilaenus lineatus*) was estimated annually in June, by sampling 40 0.25 m^2 quadrats. Spittles were collected from 20 quadrats in an area of coarse, 'semi-natural' grassland (uncropped field margin, near streamside) and 20 quadrats placed along the side of a hawthorn (*Crataegus monogyna*)-dominant hedgerow. Nymphs of *N. lineatus* (which feeds on monocotyledons) collected from the grass area, and nymphs of *P. spumarius* (which feeds on dicotyledons) collected from the hedgerow, were counted.

It is believed that the relative proportions of various colour morphs of *P. spumarius* adults are environmentally determined (Whittaker, 1968). Every August, up to fifty adults (depending on availablity in that year) were collected from the same hedgerow used for spittle-bug nymph sampling in June - for identification of the various colour morphs present. Results are not presented in this report.

Vertebrates

Population measurements were carried out on birds, bats, rabbits, deer and frogs.

Birds
Breeding bird populations were monitored annually, within a 64 ha plot of mixed agricultural land near the centre of the Drayton farm. Both common birds census (CBC) (Marchant, 1983) and breeding bird survey (BBS) (BTO, 1995) techniques were employed in tandem (Sykes & Lane, 1996). Data were analysed to determine the probable number of breeding pairs of each species present. BBS data were analysed by the British Trust for Ornithology (BTO). Up to and including 2002, the CBC territory analysis was also undertaken by the BTO.

Bats
Bat activity was monitored along two pre-determined, transects across the farm (approximately 1.6 km and 1.0 km in length), on four nights per year; using a tuneable, acoustic bat detector ('Batbox III' - Stag Electronics, Cornwall).

Rabbits and deer
In semi-natural or arable agricultural habitats rabbit (*Oryctolagus cuniculus*) grazing will have important impacts on vegetation. Consequently, it was considered important to monitor rabbit populations at every ECN site. At some sites, including some parts of the Drayton farm, livestock have a greater impact, especially where rabbits are actively controlled as part of the farm management policy.

Rabbit and deer droppings were counted twice per year (April and September/October) along a fixed transect, approximately 2 km in length.

Frogs
The main farm pond was monitored regularly during late winter and early spring for the first deposits of frog spawn. The dates of first observations of spawn, sizes of any patches and daily water temperatures were recorded.

Data analysis

All data (with the exception of those for moths, which were sent directly to CEH by Rothamsted Research) were entered onto computer, in a pre-determined format used by all ECN sites. Data were then checked, before electronic transfer to the ECN Central Co-ordinating Unit (CCU) at CEH Lancaster.

Drayton data are regularly summarised, for ADAS presentations and reports such as this – but the primary responsibility for analysis and reporting of data for the network as a whole lies with the CCU and the ECN statistician. ECN data summaries, and general information about the network, are made freely available on the ECN website (www.nmw.ac.uk/ecn). ECN data are also summarised in the annual *ECN Data Digests* (e.g. Scott *et al.*, 2002) and have been published in a large number of research papers throughout the period of this report. Drayton data have also been made available to various outside researchers, for related *bona fide* studies, after authorisation from Defra.

Common birds census (up until 2002) and breeding bird survey data were initially analysed by the British Trust for Ornithology, to determine breeding territories and numbers of nesting pairs for each species. Similarly, all butterfly data were first analysed by staff at CEH Monks Wood or Butterfly Conservation, responsible for the Butterfly Monitoring Scheme. Bird, butterfly and moth data all contribute to the appropriate UK national networks for these species groups.

RESULTS AND DISCUSSION

Significant land use changes at Drayton during the period covered by this report may have influenced some of the results recorded. These changes included the establishment of further areas of short rotation willow coppice (although outwith the ‘core’ assessment areas e.g. the bird census plot) and the construction of a new sheep experimental facility. Most importantly, there were no livestock grazing on grass fields during 2001, when sheep were housed throughout the year, because of concerns about foot and mouth disease risks. In 2001, most of the grassland area was utilised for hay production. Subsequently, sheep grazing was reintroduced to some grassland fields. However, numbers were significantly lower than they had been prior to the foot and mouth disease epidemic, and hay production continued to be the primary usage for some previously grazed fields (e.g. Fields 8 and 9).

Examples of some key 2001-2004 monitoring results from Drayton are given below.

Meteorology

Rainfall totals at Drayton in 2001 (708 mm) and 2002 (712 mm) were both more than 10% higher than the long-term (62 year) average of 627 mm (Table 1). 2002 was, in fact, the fifth consecutive year that higher than average precipitation was recorded. Total rainfall between September 2000 and April 2001, inclusive, was 60% above average for the period, resulting in major problems with farm management and many fields left uncropped. In 2001, there were five months when the rainfall total was more than 50% greater than the average for that month – February, March, April, July and October (Table 1). June was the only relatively dry month in 2001, with only 2.1 mm of rain, compared to a long-term mean of 51.2 mm. 2002 was similarly wet, with particularly high rainfall totals in February, July, October and November.

As the wet autumn of 2000 had done, the high rainfall in October and November 2002 caused serious problems for farmers who had not managed to drill their arable crops before the onset of the period of wet weather (in the dry September, when only 22.6 mm of rain fell). Autumn rainfall was consistently high between 1998 and 2002, with rainfall recorded between September and December in those five years some 33% above the long-term mean for this period of the year. The drilling of autumn crops was hampered by a series of wet Octobers. Mean monthly precipitation for October in the 1998-2002 period was 103 mm, compared to a 63-year mean of 57 mm. Very wet autumns are a particular problem on heavy soils, such as those at Drayton, as wet soil conditions may prevent seed-bed preparation and drilling of winter-sown arable crops.

In contrast, 2003 was a dry year (Table 1). The total annual rainfall was 492 mm, some 22% below the long-term average. There were no particularly wet months, none having a rainfall total more than 20% above the average. February, March, August and September were the driest months. The total precipitation in August and September was only 32% of the average for these two months. This lack of rainfall immediately before and after arable crop harvests resulted in very dry soils that were difficult to cultivate into good seed-beds for the drilling of crops for 2004.

Table 1. Monthly and annual rainfall totals recorded at Drayton, 2001-2003, and long-term (63 year) mean rainfall for the site.

Month	**Total rainfall (mm)**			
	2001	**2002**	**2003**	**63-year mean**
January	33.2	44.0	58.8	55.1
February	69.6	73.8	21.4	39.8
March	69.4	33.2	20.6	44.2
April	81.6	35.0	37.6	43.9
May	50.3	61.4	49.0	51.3
June	21.1	28.2	50.2	51.2
July	108.5	84.4	61.2	51.3
August	52.2	39.4	21.8	64.6
September	36.0	22.6	15.6	52.7
October	104.2	122.8	40.2	56.3
November	51.6	88.8	53.0	57.4
December	30.4	78.2	63.0	57.0
Totals	708.1	711.8	492.4	624.8

It has been predicted that one major effect of climate change in Britain will be an increase in frequency of ‘weather extremes’ e.g. summer droughts and storms, with strong winds and heavy rainfall. Analysis of Drayton rainfall data indicates that annual rainfall totals over the past 10 years have been more variable than in any 10 year period since 1944 (Figure 1). Interestingly, the past seven years (1996-2003) have provided five of the top 14 wettest years and two of the top six driest years since meteorological recording first began at the site in 1941. 1996 was the driest year (393 mm). 2000 (805 mm) and 1999 (783 mm) were the second and third wettest years, respectively.

Solar radiation levels were within +/- 20% of the average (for the previous nine years) in each month of 2001. Similarly, there were no extremely hot or cold months, when compared with the long-term means.

The mean annual air temperature for 2002 was 10.8^{o}C which, with 1999, was the equal warmest in the last ten years. The end of the year was mild, as well as wet, with only ten air frosts in the last four months of the year. Despite the wetter than average year, total solar radiation (3539 MJ) was almost exactly the same as the ten-year mean.

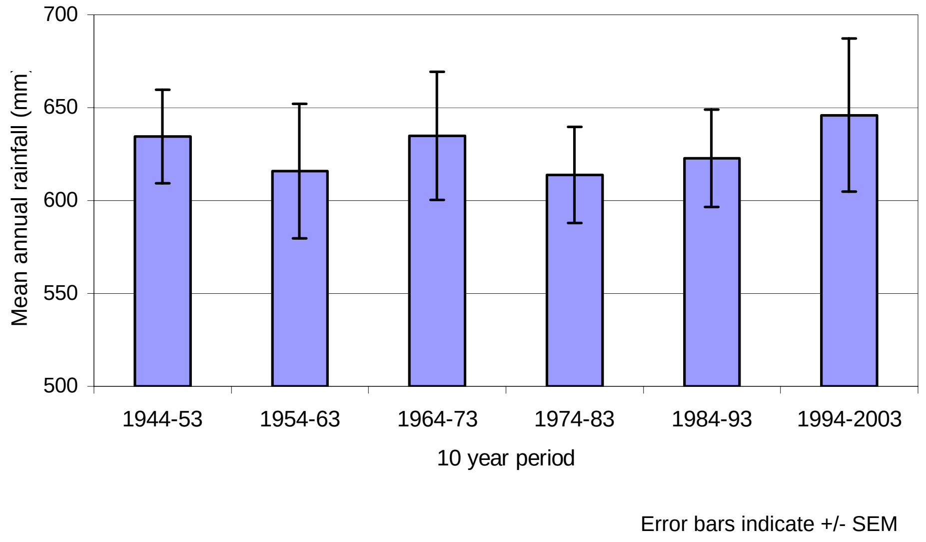

Figure 1. Mean annual rainfall at Drayton for 10 year periods from 1944 to 2003.

Total solar radiation in 2003 was 6% above the 11-year mean. Particularly high monthly totals were recorded in March (311 MJ), September (362 MJ) and October (234 MJ), each of these values being more than 15% above the long-term means for those months.

Atmospheric chemistry

The concentration of nitrogen dioxide (NO_2) in the air was lower than average during most of 2001, with a mean level of 5.5 ppb recorded, compared to the nine year average of 6.6 ppb (Figure 2). Mean monthly concentrations ranged between 4.1 and 8.6 ppb, in June and January respectively (Figure 3).

Atmospheric NO_2 concentrations were also lower than average throughout most of 2002, with a mean annual level of 5.0 ppb. This compares to a ten-year mean of 6.5 ppb. Mean monthly concentrations ranged between 2.3 ppb in June and 7.3 ppb in December.

Although NO_2 concentrations were slightly higher in 2003, the annual mean (5.9 ppb) was still well below those recorded at Drayton in the first four years of this research (1993-96), when annual means varied between 7.0 and 8.6. The 11-year mean was 6.4 ppb. Mean monthly concentrations ranged from 2.2 ppb in May to 10.2 ppb in January. The May 2003 figure was the lowest monthly mean recorded to date, but the January mean was the highest since January 1997.

NO_2 is a major atmospheric pollutant in urban areas. Estimates by the Department of the Environment's Critical Loads Advisory Group (DoE, 1996) suggested that some 29% of the UK, largely in southern and central England, had annual mean atmospheric NO_x concentrations above the critical level of 30 µg m^{-3} (as a NO_2 equivalent). Most atmospheric NO_2 arises from man-made sources, particularly through the oxidation of NO emissions from motor vehicles (approx. 50%), electricity generating stations (approx. 20-25%), domestic heating (approx. 3%) and various industrial processes (approx. 10-15%) (DoE, 1997). High concentrations can have significant negative effects on human health and the environment. NO_2 is a respiratory tract irritant, is toxic at high concentrations and is involved in the formation of photochemical smog and acid rain. It can also cause direct damage to crops and other vegetation and indirectly damage sensitive semi-natural habitats by increasing N deposition (DoE, 1996).

Published UK air quality data (Defra, 2004) indicate that there was a statistically significant downward trend in atmospheric NO_2 levels at rural test sites between 1992 and 2002, of approximately 5.1 to 5.6% per year. Data recorded at Drayton show a similar downward trend, particularly from 1995 to 2000. The average annual decrease between 1995, when the mean annual concentration peaked at 8.55 ppm, and 2003 was 4-5%.

In contrast to nitrogen oxides, the main source of ammonia emission to the atmosphere is the hydrolysis of animal excreta which, together with emissions from nitrogenous fertilisers are estimated to contribute over 85% of total UK emissions (DoE, 1997). Cattle represent the largest source of ammonia (approx. 50% of the total) and, consequently, atmospheric NH_3 concentrations are generally highest in counties with large numbers of cattle (DoE, 1997).

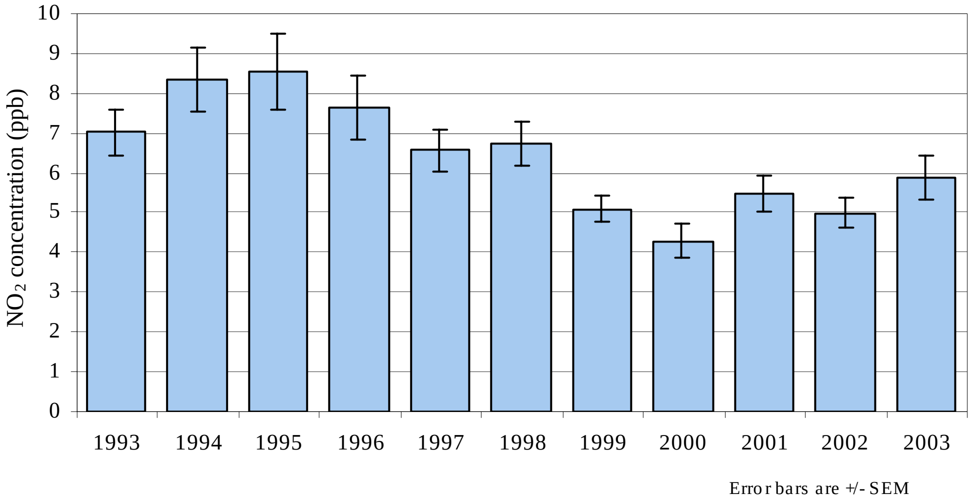

Figure 2. Mean annual atmospheric NO_2 concentrations (ppb) – 1993 to 2003.

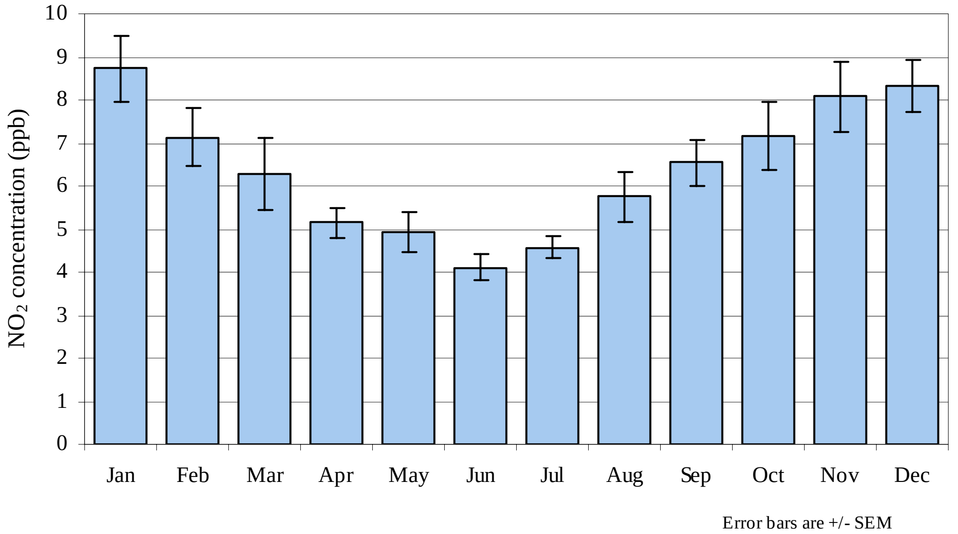

Figure 3. Mean monthly atmospheric NO_2 concentrations (ppb) – 1993 to 2003.

Precipitation chemistry

The high rainfall during late 2000 and early 2001 produced much higher than average numbers of samples during this period, whereas the relatively dry end to the year resulted in no autumn/winter soil solution samples at all until mid January 2002.

The mean pH of the year's rainwater samples (weighted to allow for variations in sample size) had shown a steady increase between 1993 and 1999, from 5.1 to 5.8 (Figure 4). In each year from 2000 to 2002 the mean annual rainwater pH was between 5.5 and 5.6 (Figure 4), almost exactly the same as the long-term average. In 2003, the mean pH rose again to a new high of 6.0. The new long-term mean pH (11 years) is 5.6.

Mean monthly rainwater pH, over this 11 year period, ranged from 5.21 (September) to 6.07 (December). Other months with a mean pH below 5.40 were April, May, June and August. Other months with a mean pH above 5.70 were January, March, October and November.

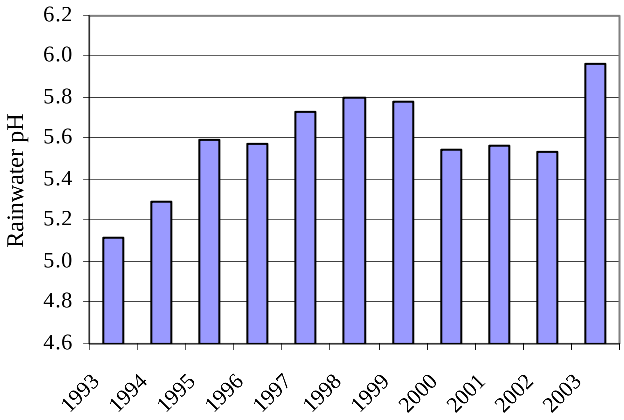

Figure 4. Mean annual rainwater pH – 1993 to 2003. Data weighted to allow for variations in sample volume. Data for all contaminated samples excluded.

The progressive increase in rainwater pH at Drayton, and the general pattern in mean annual pH values, over the period 1993-2003, were very similar to trends observed at other ECN sites in central and southern England (Figure 5). Rainwater pH at Drayton, however, was consistently higher than that at the Alice Holt (Surrey), Rothamsted (Hertfordshire) and Wytham (Oxfordshire) sites.

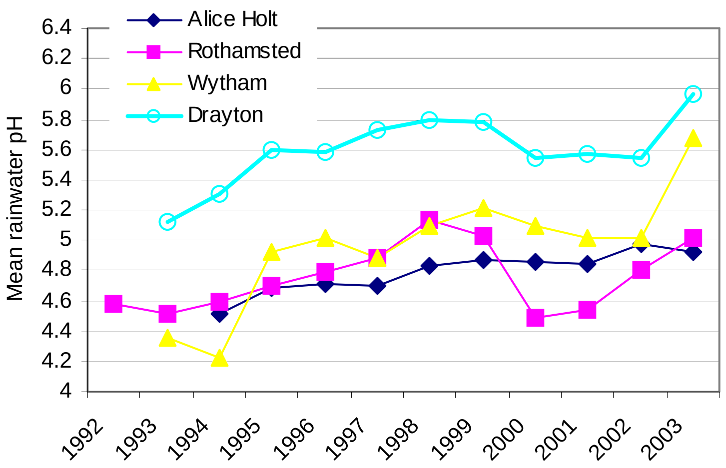

Figure 5. Mean annual rainwater pH at four ECN sites in central and southern England – Alice Holt (Surrey), Rothamsted (Hertfordshire), Wytham (Oxfordshire) and Drayton (Warwickshire). Data weighted to allow for variations in sample volume.

Data for mean annual rainwater conductivity (Figure 6) show that recorded levels have been relatively low since 2000, after an increase between 1996 and 1999. Over the last 11 years, the trend has been slightly downward.

The mean annual sodium (Na) concentration in rainwater (Table 7) increased steadily until 1999, then fell sharply. Na levels in 2002 and 2003 were similar to those in the four years immediately preceding the 1998-99 peak. Potassium levels (Figure 8) also peaked in 1998, increasing steadily before this and falling again subsequently. After an initial peak in 1993, mean annual sulphate sulphur concentrations declined sharply, before levelling off, at a relatively low level, between 1997 and 2003 (Figure 9).

The mean annual nitrate nitrogen (NO_3-N) concentration (Figure 10) was at a very high level (approx. 2.3 mg l^{-1}) in 1993, but then dropped very sharply to around 0.5 mg l^{-1}. Annual mean NO_3-N concentrations have remained at similarly low levels since then. Ammonium nitrogen levels declined over the first eight years (1993-2000), but have remained fairly stable at approximately 0.5 mg l^{-1} since then (Figure 11). The lowest mean annual total N concentration (0.7 mg l^{-1}) was recorded in 1997. Since then, there has been a steady increase, although levels have remained below the high points of 1994 and 1996 (Figure 12).

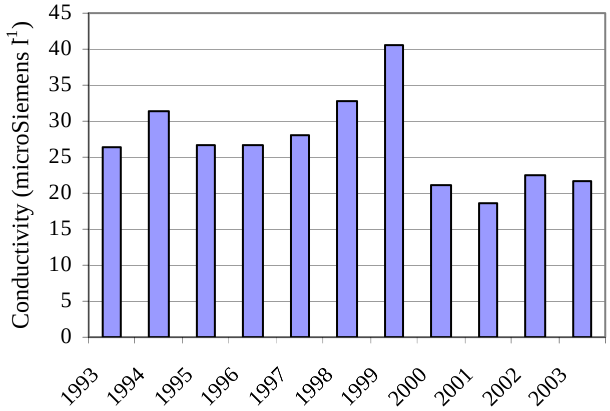

Figure 6. Mean annual rainwater conductivity (microSiemens l^{-1}) – 1993 to 2003. Data weighted to allow for variations in sample volume. Data for all contaminated samples excluded.

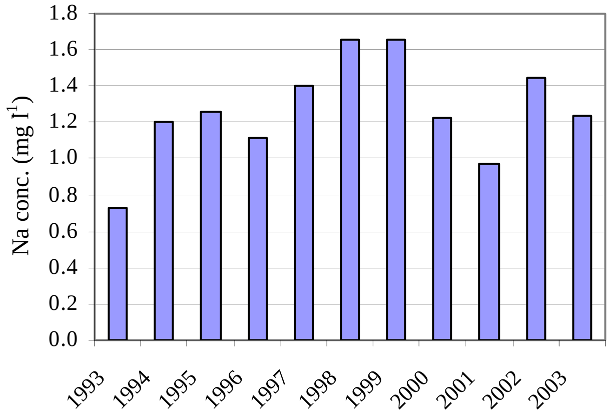

Figure 7. Mean annual sodium (Na) concentration (mg l^{-1}) in rainwater – 1993 to 2003. Data weighted to allow for variations in sample volume. Data for all contaminated samples excluded.

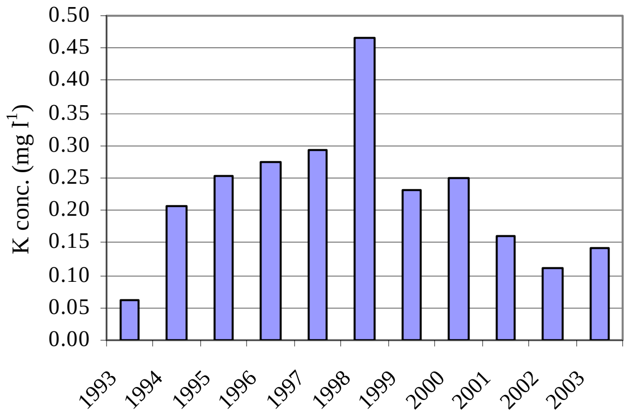

Figure 8. Mean annual potassium (K) concentration (mg l^{-1}) in rainwater – 1993 to 2003. Data weighted to allow for variations in sample volume. Data for all contaminated samples excluded.

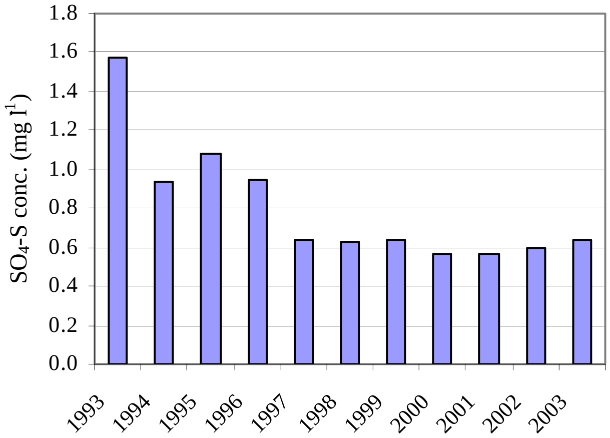

Figure 9. Mean annual sulphate sulphur (SO_4-S) concentration (mg l^{-1}) in rainwater – 1993 to 2003. Data weighted to allow for variations in sample volume. Data for all contaminated samples excluded.

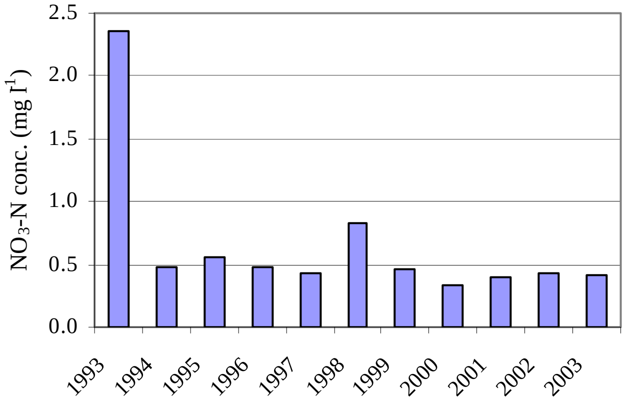

Figure 10. Mean annual nitrate nitrogen (NO_3-N) concentration (mg l^{-1}) in rainwater – 1993 to 2003. Data weighted to allow for variations in sample volume. Data for all contaminated samples excluded.

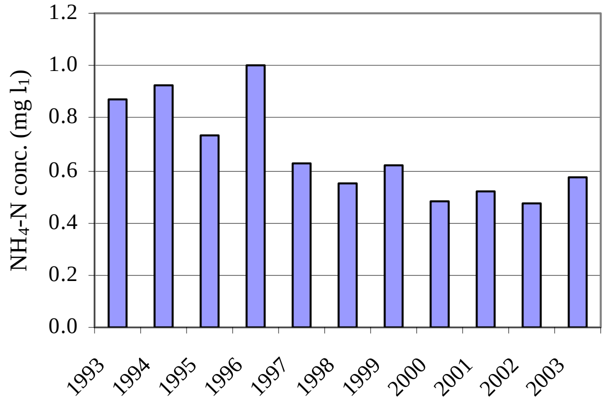

Figure 11. Mean annual ammonium nitrogen (NH_4-N) concentration (mg l^{-1}) in rainwater – 1993 to 2003. Data weighted to allow for variations in sample volume. Data for all contaminated samples excluded.

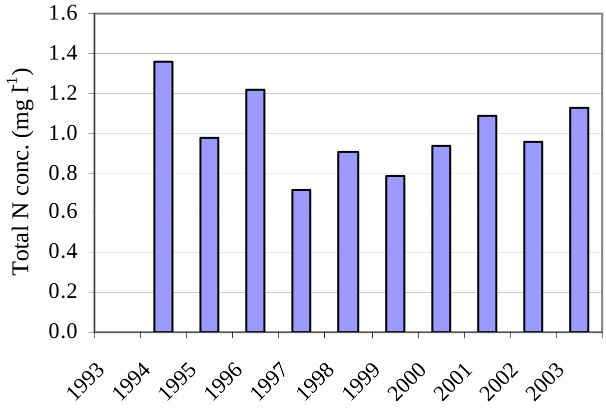

Figure 12. Mean annual total nitrogen (N) concentration (mg l^{-1}) in rainwater – 1993 to 2003. Data weighted to allow for variations in sample volume. Data for all contaminated samples exclude

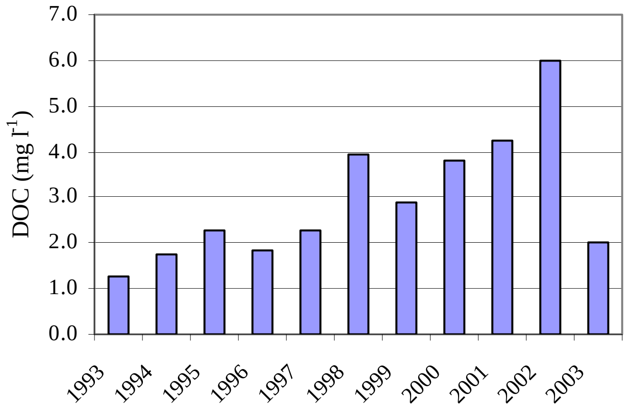

Figure 13. Mean annual dissolved organic carbon (DOC) concentration (mg l^{-1}) in rainwater – 1993 to 2003. Data weighted to allow for variations in sample volume. Data for all contaminated samples excluded.

Mean annual concentrations of dissolved organic carbon (DOC) rose steadily between 1993 and 2002, before falling very sharply in 2003 (Figure 13).

The analyses of water samples were affected by high rainfall during late 2000 and early 2001. Both the bulk precipitation chemistry and soil solution chemistry methods produced much higher than average numbers of samples during this period, whereas the relatively dry end to the year resulted in no autumn/winter soil solution samples at all until mid January 2002.

Vegetation

The initial mapping of NVC types, in 1993, showed that 84% were in perennial rye-grass (*Lolium perenne*) – rough meadow-grass (*Poa trivialis*) grassland (NVC Class MG7b) (Table 2).

Table 2. NVC vegetation types recorded at Drayton and percentage of all plots in each class.

NVC type	Description	% of all plots
MG7b	*Lolium perenne – Poa trivialis* ley	84
OV24	*Dactylis glomerata – Lolium perenne* community	4
MG1/WE25	Mosaic transition of MG1, *Arrhenatherum elatius* community and WE25, *Urtica dioica – Galium aparine* weed community	3
MG7b/W24b	Mosaic/transition of MG7b and W24b, *Rubus fruticosus – Holcus lanatus* under-scrub	9

Both fine- and coarse-grain vegetation monitoring were completed in 2002. This was the first scheduled repeat of the comprehensive, coarse-grain assessments, with measurements made in 1,250, predominantly grassland, fixed quadrats - nine years after the previous survey. All results from the coarse and fine-grain vegetation assessments (like other Drayton ECN data) have also been entered onto the central ECN database at CEH Lancaster, and will be reported with the results from other ECN sites. Some of the results summaries presented below are taken from detailed analyses undertaken by Dr Mike Morecroft of CEH.

Coarse-grain monitoring

Species diversity in the managed grassland at Drayton is relatively low. As in 1993, the most frequently recorded species were perennial rye-grass and rough meadow-grass (Table 3). Both species occurred in over 90% of coarse-grain plots in both years. Other commonly recorded species in 2002 included soft brome (*Bromus hordeaceus hordeaceus*), timothy (*Phleum pratense*), dandelions (*Taraxacum officinale* agg.) and sow-thistles (*Sonchus* spp.) (Table 3). Comparing data from those 46 2 x 2 m plots that were recorded in both years, perennial rye-grass, the dominant species across most of the Drayton grassland, was present in 98% of plots in 2003. This species had been present in all 46 quadrats in 1993. Simlarly, rough meadow-grass (*Poa trivialis*) was recorded in 98% of all quadrats, compared to 100% in 1993.

Several species appeared to show large changes between 1993 and 2002 (Table 3). Those showing big increases in their distribution included dandelions, sow-thistles, soft brome, timothy and Yorkshire-fog (*Holcus lanatus*). Species showing major decreases in the number of plots in which they were recorded included annual meadow-grass (*Poa annua*), wall barley (*Hordeum murinum*), chickweed (*Stellaria media*) and creeping bent (*Agrostis stolonifera*). Annual meadow-grass, wall barley and chickweed were recorded in very few plots in 2002, whereas these three species (all annuals associated with disturbed conditions) were found in 65%, 26% and 37% of quadrats, respectively, in 1993.

Most of these species which were recorded in fewer plots in 2002 are species typical of heavily disturbed grassland. The reductions in these species were probably a direct effect of reduced grazing pressures on grassland at Drayton over this period, including one year without any grazing livestock (i.e. 2001), when sheep were removed because of concerns about foot-and-mouth disease risks. There was also a consequent decrease in bare soil and dung/urine frequency (data not shown).

The mean number of species recorded per cell increased from 2.48 in 1993 to 2.81 in 2002, but this difference was not statistically significant ($P > 0.05$).

Analysis of Ellenberg values, indicated an overall increase in reaction index ($P < 0.001$) and a decrease in nitrogen index ($P < 0.001$). These changes, again, reflect the less intensive grassland management at Drayton in recent years.

Figures 14 and 15 put these changes in Ellenberg values in the context of the wider network, comparing Drayton data with other ECN sites that have comparable data. These illustrate the small changes in mean R and N values, and show how the plant species at Drayton are representative of a relatively high pH, nitrogen-rich vegetation type. These charts show the strong similarity with mean values for North Wyke (Devon) and Wytham (Oxfordshire), and the sharp contrast with the more acidic, nutrient-poor, upland sites at Glensaugh and Moorhouse.

Within the 2 x 2m coarse grain plots where they were present, both perennial rye-grass and rough meadow-grass were recorded in almost all of the 25 40 x 40 cm squares (Figure 16). Between 1993 and 2002, annual meadow-grass, chickweed, wall barley and mosses/liverworts all decreased in frequency within plots where they were present. Species to increase in frequency over this period included rough meadow-grass, creeping bent, smooth meadow-grass, common couch, sow-thistles and soft brome.

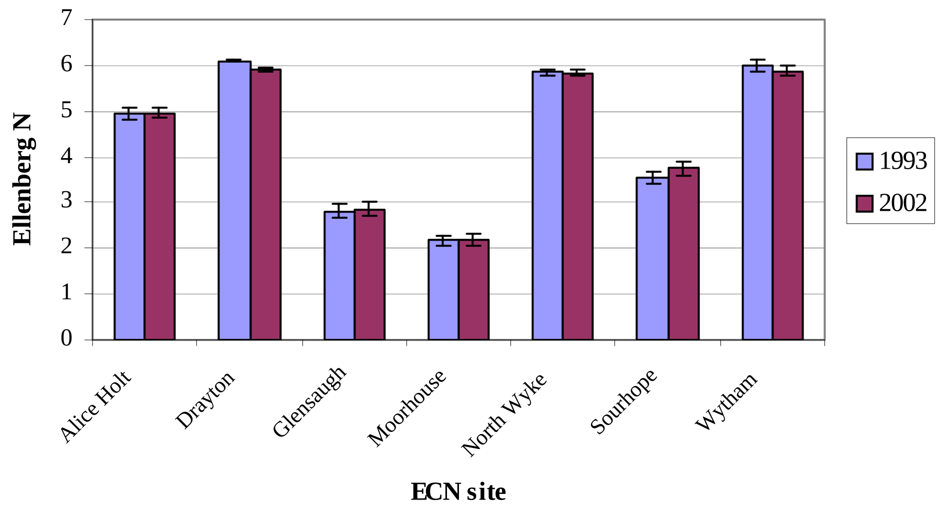

Figure 14. Mean Ellenberg N (Nitrogen) values at seven ECN sites, 1993 and 2002.

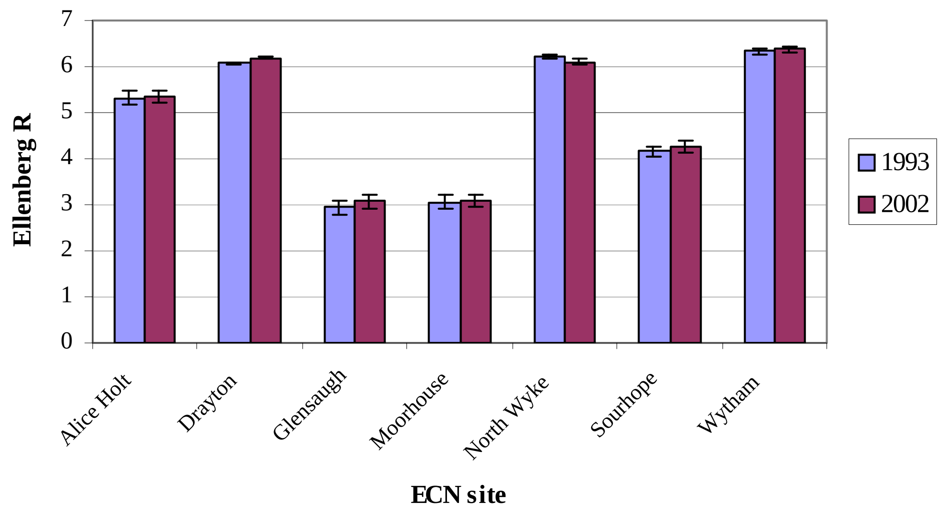

Figure 15. Mean Ellenberg R (Reaction) values at seven ECN sites, 1993 and 2002.

Table 3. Coarse-grain vegetation assessments at Drayton, 1993 and 2002. Number of plots in which plant species occurred. Only 15 most frequent species included.

Species	% of plots 1993	% of plots 2002	Change
Perennial rye-grass	100	98	-2
Rough meadow-grass	100	98	-2
Annual meadow-grass	65	2	-63
Chickweed	37	7	-30
Creeping bent	35	20	-15
Dandelion	28	50	+22
Wall barley	26	4	-22
Mosses & liverworts	22	11	-11
Smooth meadow-grass	13	24	+11
Timothy	11	35	+24
Cock’s-foot	11	22	+11
Sow-thistles	4	48	+44
Yorkshire-fog	2	22	+20
Common couch	0	15	+15
Soft brome	0	41	+41

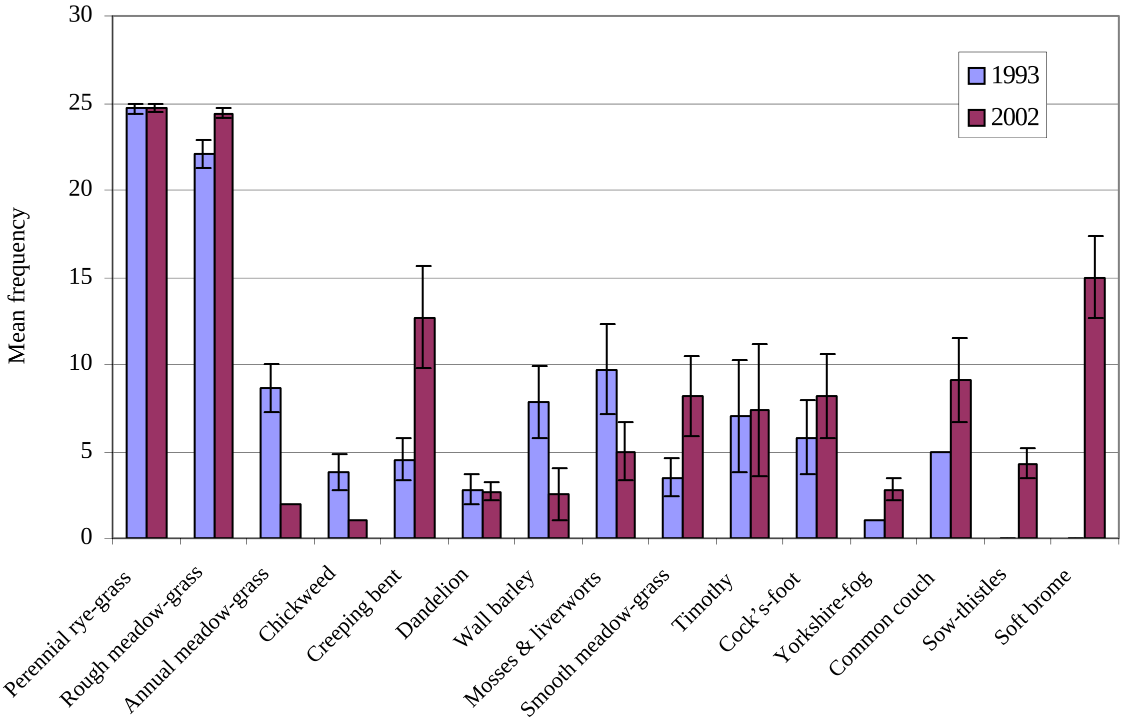

Figure 16. Mean frequencies (max. 25) of 15 plant species in coarse grain vegetation assessment plots at Drayton, for plots in which each species occurred – 1993 and 2002.

Fine-grain monitoring

The mean number of plant species recorded in fine-grain plots in 2002 (3.2 per plot) was similar to those recorded in the same plots in 1996 and 1999 (Table 4). The total numbers of species recorded in each of these three years were also similar (17, 15 and 15 respectively).

Table 4. Fine-grain vegetation assessments at Drayton, 1996, 1999 and 2002. Mean numbers of plant species recorded in all plots and in grazed or hay fields only.

	1996	1999	2002
All fields	3.5	3.4	3.2
Grazed fields only	2.9	3.4	2.4
Hay fields only*	4.0	3.5	3.7

* Refers to fields that were used for hay production, instead of sheep grazing, from 2001 onwards i.e. Fields 8 and 9 (approx. 14.9 ha). Before 2001 all fields were managed for sheep grazing.

Annual grass yields

2003 was the only year between 1997 and 2003 in which lower than average rainfall fell between April and the end of October, resulting in the lowest grass yield during this period (Fig. 17).

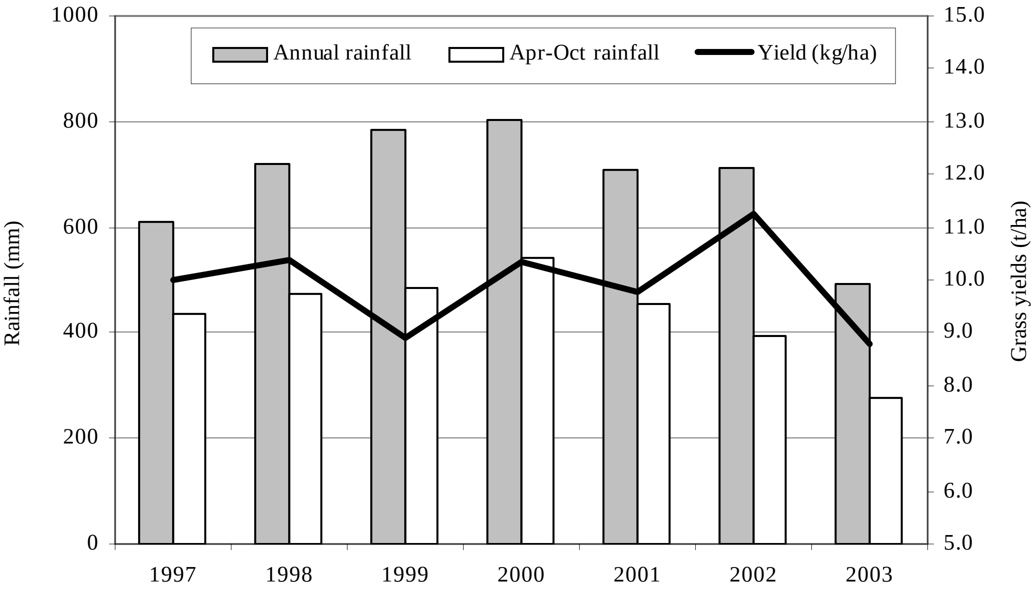

Figure 17. Annual grass yields (t ha^{-1}), 1997-2003 – in relation to annual and April to October rainfall totals.

Invertebrates

Ground beetles

The total number of individual ground beetles (Carabidae) captured in pitfall traps was at its lowest in 2001 – when only 526 beetles were trapped (Figure 18). This is only 26% of the number trapped in 2000 and only 17% of the 1998 peak. More individuals were trapped in 2002 than in the previous year, but the total was still lower than catches in any year prior to 2001. It has previously been noted that lower annual catches had tended to coincide with lower soil moisture levels in early summer, and that this was likely to have been detrimental to larval development. This was not, however, the explanation during 2001 and 2002, as May to July rainfall was above average in both years. Data for 2003 are currently unavailable, as identifications are incomplete.

For the first five years of the project, there was a decrease in the number of species of ground beetles trapped at Drayton, with the lowest number being recorded in 1997 (Figure 19). The number of species recorded then increased until 1999, before gradually decreasing again, up to 2002.

Figure 20 shows how numbers of some of the most commonly trapped individual species varied greatly from year to year. In most years, the most frequently captured species was *Pterostichus melanarius*, a common farmland species (Figure 20a). Numbers of this species varied between 400 and 800 in most years, but rose to 1196 in 1997 and fell to only 184 in 2001. Two other species that formed a large proportion of the total catch in certain years were *Agonum dorsale* (Figure 20b) and *Trechus quadristriatus* (Figure 20c). The total number of *Agonum dorsale* beetles caught was less than 100 in six of the 10 years, with a lowest total of 12 (1996), but more than 450 in the other four years. The highest total was 1168, in 1998. *Trechus quadristriatus* also showed considerable variation, although Figure 20c shows a more consistent pattern for this species. Numbers of this species captured increased to a maximum of 886 in 1998, but then fell sharply again. The lowest total, of only 19, was recorded in 2002. Although there appears to be no consistent pattern in the numbers of these different species captured in the 10 years of this study to date, relatively low numbers of each of these three species were recorded in 2001 – resulting in the very low overall total catch for that year.

As for most of the other ground beetle species, total numbers of *Nebria brevicollis* captured have fluctuated greatly from year to year, although totals recorded since 1994 have been consistently well below the 350 trapped in 1993. (Figure 20d). Numbers were particularly low in 2000 and 2001, but increased again (to almost 100) in 2002.

Microlestes maurus, a species that is common nationally, has been reported to be increasing in numbers across Warwickshire in recent years. This trend was repeated at Drayton, until numbers peaked in 1997 (Figure 20e). Numbers then dropped dramatically until 2000, when only one individual was recorded. None at all were trapped in 2001 or 2002.

Both *Demetrias atricapillus* (Figure 20f) and *Notophilius biguttatus* (Figure 20g) declined sharply over the past 3-4 years. None of the first species were trapped in 2002.

One of the few species captured more frequently in recent years, is *Badister bipustulatus* (Figure 20h). 43 individuals were caught between 2000 and 2002, more than had been trapped in the previous seven years combined (34 individuals).

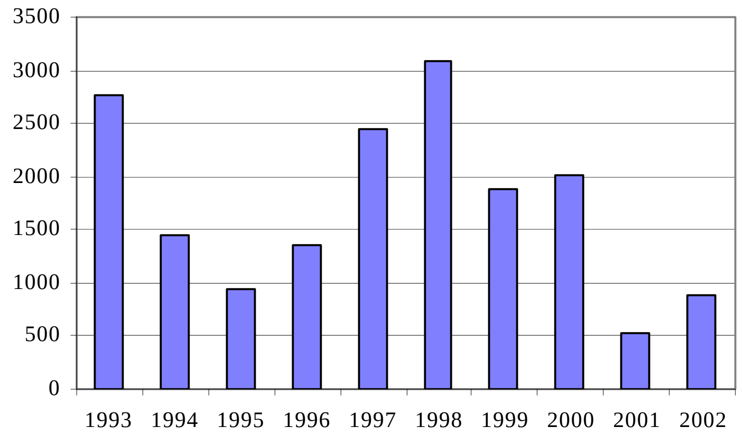

Figure 18. Total number of ground beetles (Carabidae) captured per year in pitfall traps, 1993 to 2002.

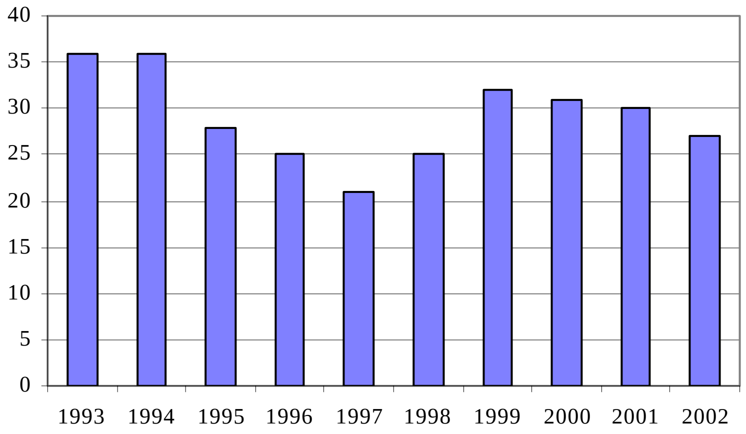

Figure 19. Total numbers of ground beetle species captured per year in pitfall traps, 1993 to 2002.

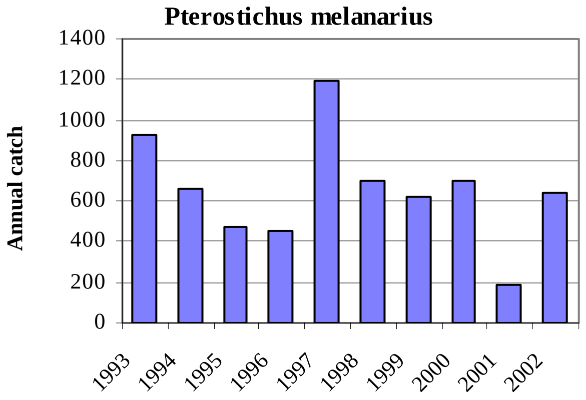

Fig. 20a

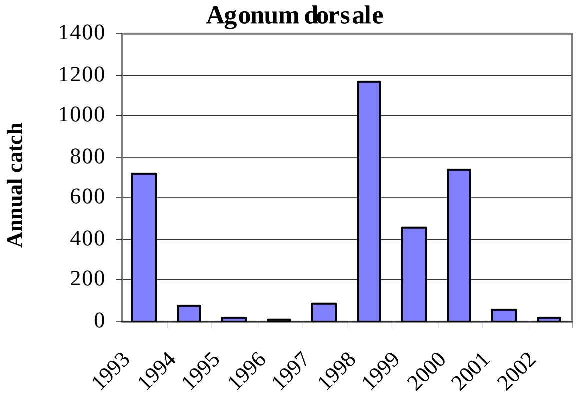

Fig. 20b

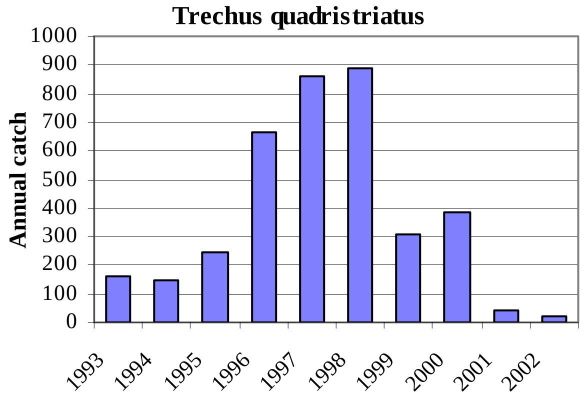

Fig. 20c

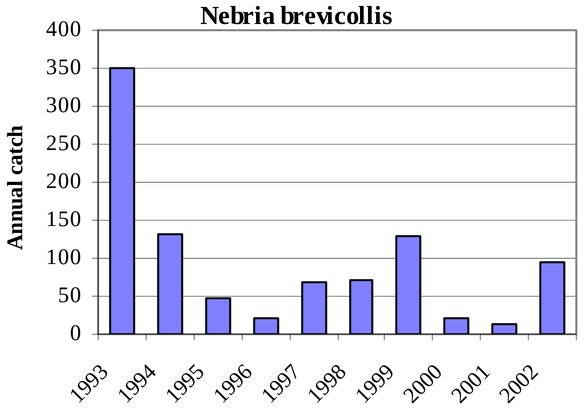

Fig 20d

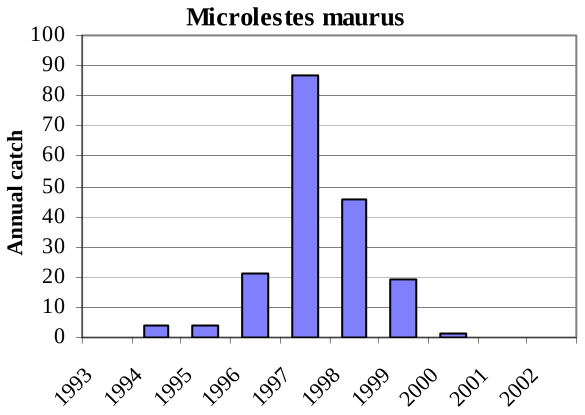

Fig 20e

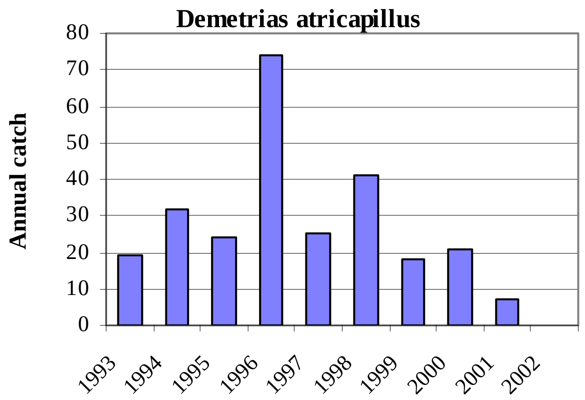

Fig 20f

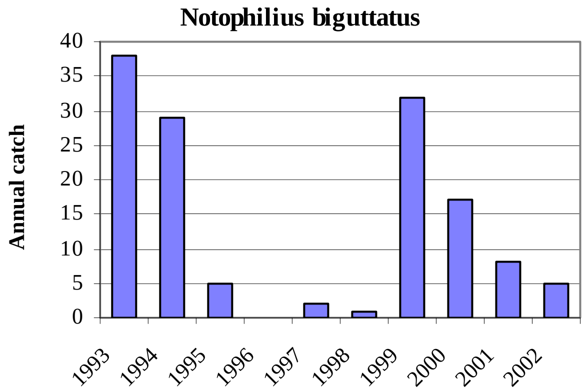

Fig 20g

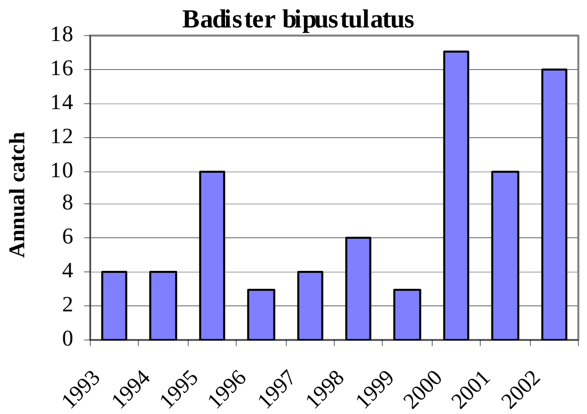

Figure 20h

Figure 20. Total numbers of eight indivdual species of ground beetle captured in pitfall traps, 1993 to 2002.

Moths

In 2001, 137 moth species were trapped; the lowest total in any year since recording began in 1992 (Figure 21). In the same year, a total of 1,806 adult moths were caught, the second lowest recorded. This total compares to a peak of 5,286 in 1996 and a 10-year mean of 2,610.

A total of 157 moth species were trapped in 2002; the highest number since 1997. A total of 2,501 individuals were caught and, although this was the highest number trapped since 1997, it was slightly below the 11-year mean (2,600).

In 2003, 146 moth species and 3,304 moths were trapped. The total number of individuals was well above the 12-year mean (2,659) and the third highest since trapping commenced at the site.

Over the period from 1993 to 2003, of the 12 ECN terrestrial sites, only Alice Holt consistently trapped more species of moths per year than Drayton, and only Porton Down regularly trapped more individual moths of the larger species (Macrolepidoptera) (www.ecn.ac.uk/database).

The three most commonly trapped species in 2001 and 2002 were the small square-spot (*Diarsia rubi*) (Figure 22), square-spot rustic (*Xestia xanthographa*) (Figure 23) and lunar underwing (*Omphaloscelis lunosa*) (Figure 24). All are common species, occurring in a range of habitats across most of Britain (although the lunar underwing is more local in the north – to central Scotland). In 2001, numbers of small square-spot moths (332) were the highest recorded in 12 years, some 21% above the previous highest annual total (in the previous year). Although the third most frequently trapped species in 2001, the total number of square-spot rustics trapped that year was the fourth lowest for this species.

Three common species were more abundant in 2003 than in any of the previous 11 years: lunar underwing (445 moths), square-spot rustic (343 moths) and setaceous Hebrew character (*Amathes c-nigrum*) (298 moths) (Figure 25). The other most frequently trapped species in 2003 were common wainscot (*Mythimna pallens*) (190), common footman (*Eilema lurideola*) (122) and common swift (*Hepialus lupulinus*) (103). Numbers of small square-spots dropped sharply, to just nine moths, after three years with very large totals (mean 282/year).

The population size of heart and dart moths (*Agrotis exclamationis*) remained small. For the seventh consecutive year, the total number of this species trapped was less than 20; following peaks of 609 and 842 in 1995 and 1996 respectively (Figure 26).

In the last six years of trapping at Drayton (1998-2003), the mean number of moths trapped per year was 2,267, compared to a mean of 3,051 per year over the preceding six years. This equates to a reduction of 26%.

Over the 12-year recording period from 1992 to 2003, the mean number of species trapped per year was 153 and the mean number of individual moths per year 2,659. The mean annual totals, over this 12-year period, were greater than 100 for six species: square-spot rustic (184), common wainscot (147), lunar underwing (147), flounced rustic (*Luperina testacea*) (144), heart and dart (142) and common footman (117).

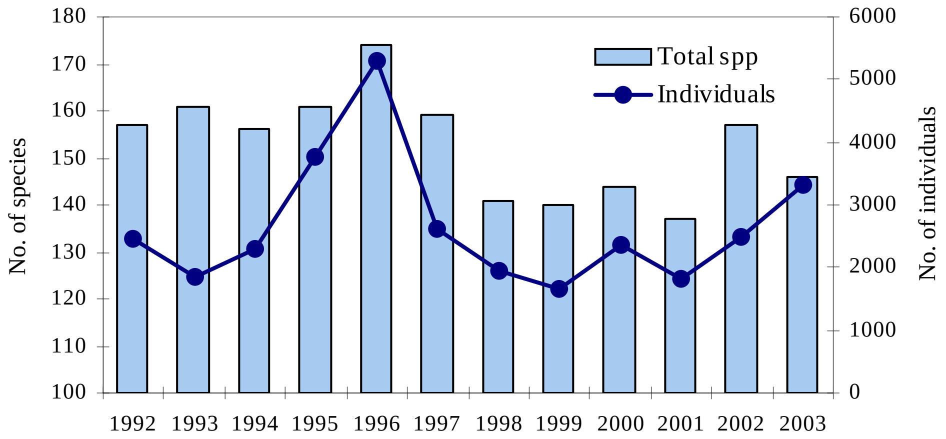

Figure 21. Total numbers of moth species and individual adults captured per year in Drayton light trap, 1992-2003.

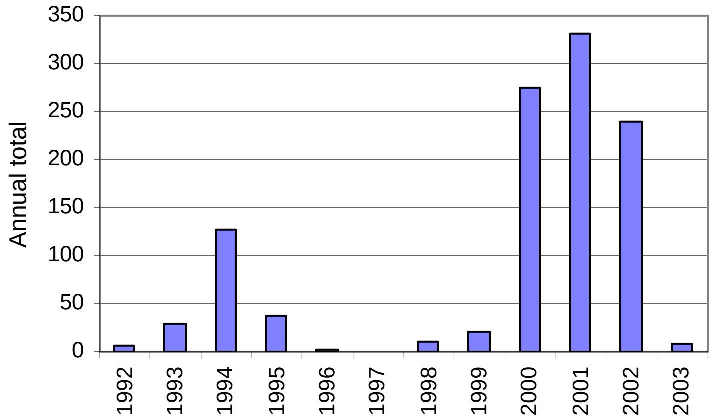

Figure 22. Total numbers of small square-spot moths (*Diarsia rubi*) captured per year, 1992-2003.

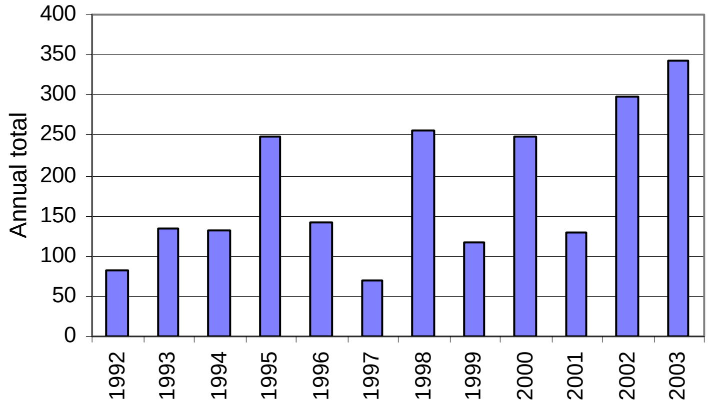

Figure 23. Total numbers of square-spot rustic moths (*Xestia xanthographa*) captured per year, 1992-2003.

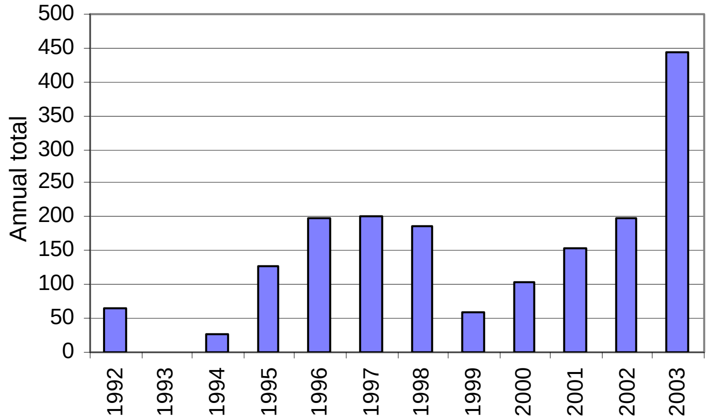

Figure 24. Total numbers of lunar underwing moths (*Omphaloscelis lunosa*) captured per year, 1992-2003.

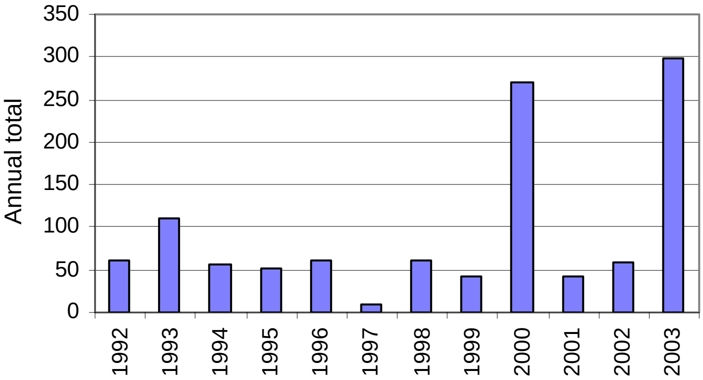

Figure 25. Total numbers of setaceous Hebrew character moths (*Amathes c-nigrum*) captured per year, 1992-2003.

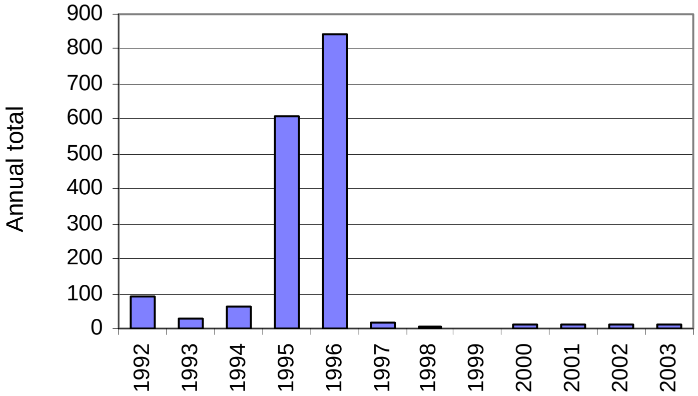

Figure 26. Total numbers of heart and dart moths (*Agrotis exclamationis*) captured per year at Drayton, 1992-2003.

Butterflies

The total number of butterflies recorded in 2001 was slightly above average, with 652 individuals recorded (Figure 27, Table 5). Nearly half of these registrations were of meadow browns, with almost as many of this species recorded as in the previous eight years combined (Table 6). It is likely that this largely results from the absence of sheep grazing the grassland. During the first five years of this project a mean of 30 ringlet butterflies was recorded, whereas there has been a total of only 19 registrations of this species in the last four years – with none at all in 2001. The peak of butterfly activity occurred in mid-July, approximately two weeks earlier than in previous years.

In 2002, the estimated total for the year was 476 (Figure 27). This was 17% below the mean for the preceding nine-year period (576) and just over half (54%) of the total recorded in the peak year of 1997. Once again, and for the fifth consecutive year, no painted lady (*Cynthia cardui*) butterflies were recorded (Table 6). Numbers of this migrant species peaked at 115 in 1996, but only one painted lady butterfly was recorded at Drayton between 1997 and 2002.

In 2003, numbers returned to a level similar to those recorded in 2000 and 2001, with a total of 626 butterflies (Figure 27, Table 5). This was slightly (9%) above the new 11-year mean of 572.

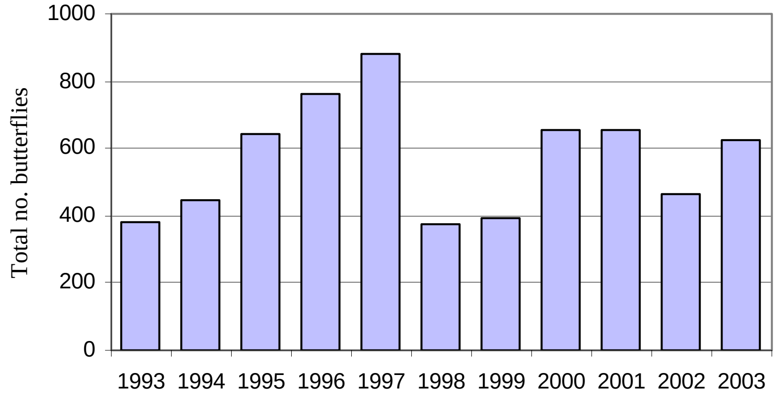

Figure 27. Mean numbers of butterflies recorded per year (index values), 1993-2003.

Table 5. Butterfly species at Drayton - numbers of species and individuals recorded annually, 1993-2003.

					Year						
Year	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Number of species	15	15	14	17	16	14	15	16	17	13[1]	15
Number of individuals	382	448	642	759	883	375	390	656	652	476[2]	626
Number of whites (Pieridae)	116	173	328	230	457	200	150	296	152	-	159
Number of non-whites	266	275	314	529	426	175	240	360	500	-	467

[1] Index values for 2002 were calculated from a smaller than normal number of assessments. For this reason, it is likely that the species total given (13) is likely to be an underestimate of the 'true number' in that year i.e. the number of species likely to have been recorded if it had been possible to complete all planned assessments.

[2] Estimate based on 81.8% of mean annual total for all other years (see Methods section).

Table 6. Butterfly species at Drayton - total numbers of registrations per year, 1993-2003.

Butterfly species	Year										
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002*	2003
Pieridae											
Brimstone	9	6	10	10	12	7	5	9	7	5	2
Green-veined white	21	24	118	173	318	162	127	232	118	-	55
Large white	31	44	24	9	37	18	13	50	27	-	48
Marbled white	0	0	0	0	0	0	1	0	1	-	0
Orange tip	5	3	7	15	13	12	11	27	17	23	6
Small white	64	105	186	48	102	20	9	14	6	-	56
Nymphalidae											
Comma	0	2	1	7	7	6	7	14	5	-	3
Painted lady	0	2	0	115	1	0	0	0	0	-	37
Peacock	36	11	23	54	55	32	33	58	54	-	11
Red admiral	3	0	9	28	4	8	6	17	6	-	1
Small tortoiseshell	60	85	67	59	233	33	26	106	74	57	92
Lycaenidae											
Common blue	0	0	0	2	0	0	0	1	2	-	0
Holly blue	0	0	0	0	2	5	0	0	0	-	0
Small copper	0	0	0	0	0	0	0	1	2	-	0
Satyridae											
Hedge brown	60	43	65	123	28	11	41	18	12	-	63
Meadow brown	40	43	53	69	20	36	60	56	301	88	213
Ringlet	21	34	52	14	29	8	8	3	0	-	25
Small heath	6	0	0	0	0	0	0	0	0	-	0
Speckled wood	6	10	14	2	1	0	33	44	16	17	12
Hesperiidae											
Large skipper	3	29	13	30	21	17	10	6	3	-	0
Small skipper	17	7	0	1	0	0	0	0	1	-	2
ANNUAL TOTALS	**382**	**448**	**642**	**759**	**883**	**375**	**390**	**656**	**652**	**476***	**626**

* Index values for 2002 were calculated from a smaller than normal number of assessments. For this reason, indices could only be reliably calculated (by CEH/Butterfly Conservation) for five individual species.

Frogs

Figure 28 shows the earliest dates on which frogspawn was recorded in the pond at Drayton. The first records occurred very early in 2002, 2003 and 2004 – all in the last week of February. The 2004 date, 20th February, was the earliest in 11 years of recording. Prior to 2002, the only February record of frogspawn at Drayton had been recorded in 1998 (25th February). Although Figure 28 appears to show an overall downward trend, regression analysis showed this to be non significant (*P* = 0.08).

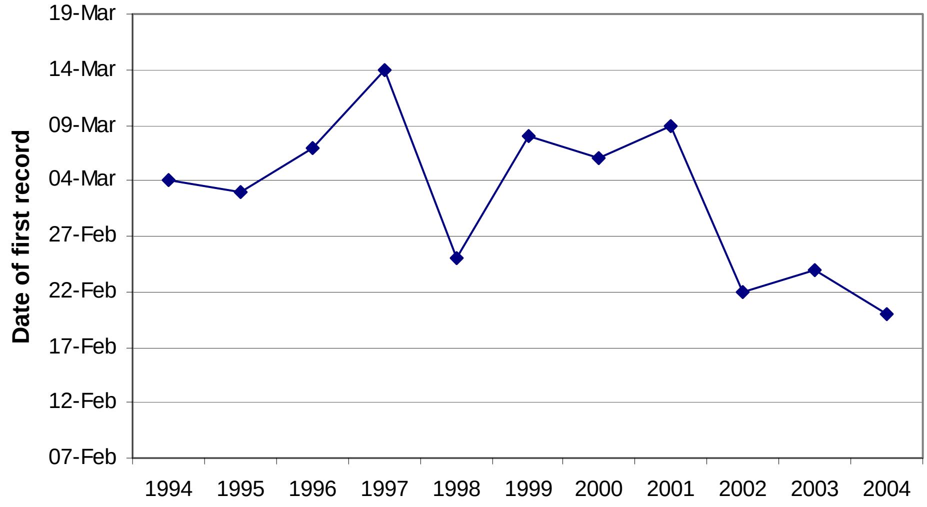

Figure 28. Dates of earliest recorded appearance of frogspawn in pond at Drayton, 1994 to 2004.

Birds

Over the period covered by this report, no less that nine Red List bird species (species of high conservation concern) were recorded in the common birds censuses at Drayton. These were grey partridge (*Perdix perdix*), skylark (*Alauda arvensis*), song thrush (*Turdus philomelos*), starling (*Sturnus vulgaris*), house sparrow (*Passer domesticus*), tree sparrow (*Passer montanus*), linnet (*Carduelis cannabina*), bullfinch (*Pyrrhula pyrrhula*) and yellowhammer (*Emberiza citrinella*). There were also another nine Amber List species (species of medium conservation concern): kestrel (*Falco tinnunculus*), lapwing (*Vanellus vanellus*), stock dove (*Columba oenas*), cuckoo (*Cuculus canorus*), green woodpecker (*Picus viridis*), swallow (*Hirundo rustica*), meadow pipit (*Anthus pratensis*), dunnock (*Prunella modularis*) and willow warbler (*Phylloscopus trochilus*).

2003 saw the first records of common buzzard (*Buteo buteo*) and chiffchaff (*Phylloscopus colybita*) as breeding species at Drayton. As well as buzzards, other raptor and owl species recorded at the site during the last three years include kestrel, sparrowhawk (*Accipiter nisus*) and little owl (*Athene noctua*). Although barn owls (*Tyto alba*) have previously been seen at Drayton, none have been recorded in the ECN surveys and a nest box erected for this species has so far not been used.

The total number of bird species recorded in the 2003 and 2004 CBC surveys (46 in each year) was slightly above the mean number recorded per year over the period from 1993 to 2004 (Table 7). The 2002 total of 38 was, however, the lowest annual total recorded to date. The highest total before 2003 was 45 (in 1994 and 1999). The previous lowest total was 39 (in 1995).

Table 7. Total numbers of bird species recorded at Drayton and numbers of breeding species, 2002-2004, and long-term means (1993-2004).

	2002	**2003**	**2004**	**Means 1993-2004**
Total no. bird species	38	46	46	42.7
Confirmed breeding species	27	25	32	28.5

The three most common breeding species at Drayton since 1993 have been chaffinch, skylark and yellowhammer. During the last three years, these three species still held more breeding territories than any other species – but the estimated annual numbers of pairs of each species were well below the longer-term mean (Table 8).

Table 8. Estimated numbers of breeding pairs (territories) for selected bird species, 2002-2004 and long-term means (1993-2004).

Species	2002	2003	2004	Means 1993-2004
Blackbird	10	5	7	9.3
Blue tit	7	4	3	5.8
Chaffinch	10	8	14	14.5
Dunnock	5	3	5	5.9
Jackdaw	1	*	*	3.4
Linnet	4	2	1	4.7
Magpie	4	3	2	2.8
Pheasant	2	*	3	4.0
Robin	5	5	4	3.7
Skylark	13	8	8	13.5
Starling	2	*	*	3.5
Tree sparrow	*	0	0	0.5
Whitethroat	2	3	6	5.0
Willow warbler	*	3	6	1.1
Wren	6	3	7	7.0
Yellowhammer	11	8	10	18.9

* present, but no clusters or other clear evidence of breeding

These three species, and some other relatively common species at Drayton (e.g. dunnock and whitethroat), appear to have shown a progressive decline in breeding populations since 1993 (Figure 29).

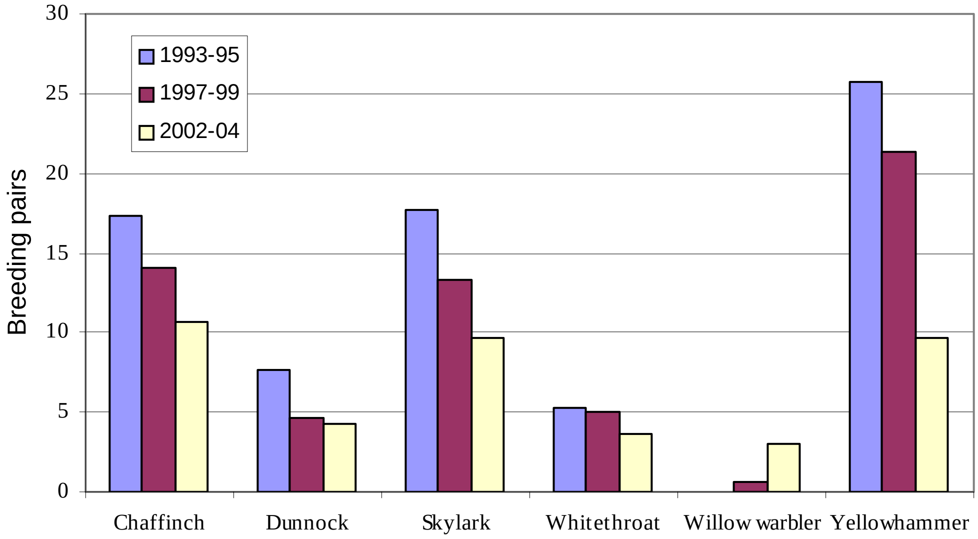

Figure 29. Mean numbers of breeding pairs recorded per year, in the three-year periods, 1993-95, 97-99 and 2002-04. Data for six bird species: chaffinch, dunnock, skylark, whitethroat, willow warbler and yellowhammer.

Initial analysis of BBS data has shown that the mean number of bird species recorded at each assessment - in the surveys of 2002, 2003 and 2004 – was 23.0 (min. 20, max. 27). Figure 30 shows the mean number of individual records per visit for the eight most frequently recorded bird species over this period.

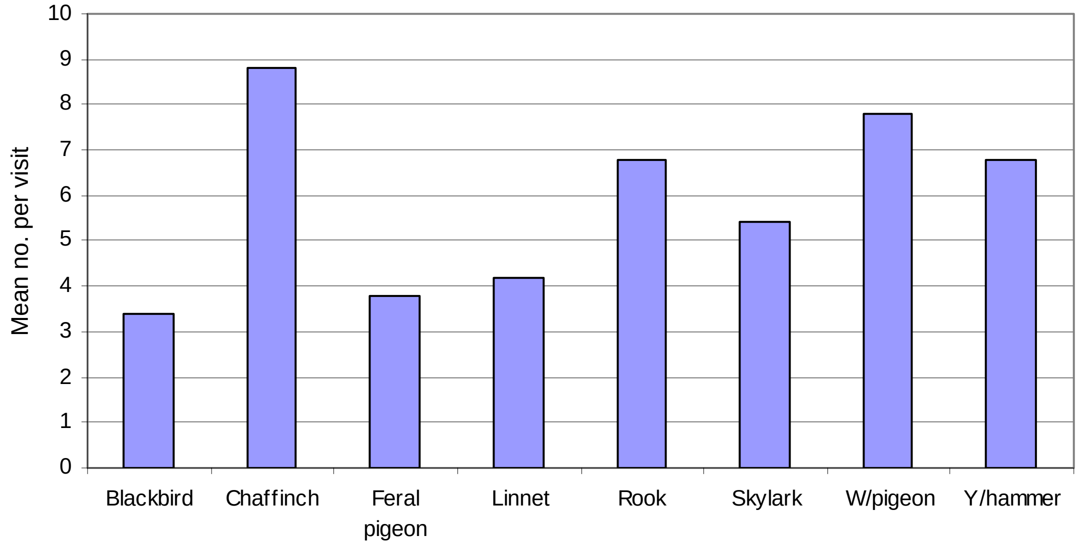

Figure 30. Mean number of individual birds recorded per BBS visit, for the eight most frequently recorded species, 2002-2004.

Rabbits and Deer

Figure 31 shows the total numbers of rabbit droppings recorded per year (spring and autumn counts combined) along the 20 transects. To some extent, counts of rabbit droppings have probably been affected by changes in management in recent years. For example, conversion of some grass field to short rotation coppice and reductions in livestock numbers in other fields have resulted in many fewer of the bare patches caused by sheep grazing, which frequently contained relatively large concentrations of droppings.

The planting of large areas of willow short rotation coppice at Drayton has resulted in an obvious increase in the roe deer population. Several deer are now frequently seen, in locations throughout the farm. No deer droppings had been recorded along the 20 transects until autumn 2003, when a single patch of 58 droppings was recorded. Since then, 72 were recorded in spring 2004 (two locations) and 8 in autumn 2004.

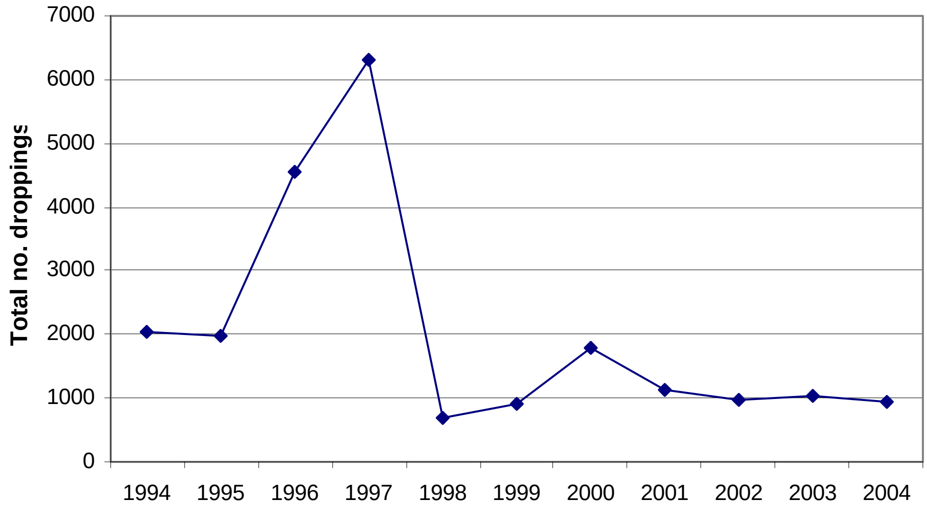

Figure 31. Total numbers of rabbit droppings recorded in spring and autumn counts along fixed transect positions, 1994 to 2004.

Bats

Pipistrelles (*Pipistrellus pipistrellus*) were by far the most frequently recorded bat species at Drayton over the period 1993-2003, and the only species noted since 1999. Previously, however, three other bat species have also been recorded: brown long-eared (*Plecotus auritus*), noctule (*Nyctalus noctula*) and a myotid species.

The total number of bats recorded in 2003 (42) was higher than in any other year. The previous highest number was 37, recorded in 1994. The mean of 10.5 bats recorded per survey in 2003, was almost double the long-term mean for all previous years (5.5/visit). The mean number of bats recorded per visit in 40 surveys over a 12-year period from 1993 to 2004 was 6.2.

ACKNOWLEDGEMENTS

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