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ENVIRONMENT AGENCY

An Investigation of Ecological Change in the Rivers Kennet and Lambourn

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Institute of Freshwater Ecology

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Statement of Use

This report presents the results of a repeat survey of invertebrates and plants on the Rivers Kennet and Lambourn. It is intended for use by the Agency's staff and others interested in the ecology and management of chalk rivers and the effects of low flows on them.

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KEY WORDS

Chalk streams; low flows; ecological change; macrophytes; macroinvertebrates

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EXECUTIVE SUMMARY

The Kennet and Lambourn catchments are important regionally for water supply, fisheries and conservation. The Axford public enquiry highlighted the shortage of data on the hydro-ecology of chalk streams and information on the management of chalk streams is also needed to fulfil the UK Biodiversity Action Plan.

This project was commissioned to provide information on long-term ecological change and the impact of the 1996-97 drought in chalk streams, by re-surveying four sites that were studied in detail in the 1970s. The sites were re-located, using markers installed in the 1970s. Macrophytes were mapped and macroinvertebrates were sampled quantitatively in the summer (June/July) and winter (December) of 1997 using the 1970s protocols.

The first site was a 50 m shaded stretch of the River Lambourn at Bagnor, where macrophytes had been mapped monthly and macroinvertebrates sampled periodically between March 1971 and December 1979. The river was managed as a trout fishery then, with regular weed cutting and bank-side maintenance. This has ceased, and the site is now more heavily shaded by overhanging trees on one bank and by tall herbs on the other.

Submerged macrophytes covered a much smaller area in 1997 than in the 1970s but the area of silt was greater. There was much more emergent vegetation than in the 1970s, which provided additional habitats for macroinvertebrates. The changes were ascribed to the drought and the lack of management. Although there were typically fewer macroinvertebrate families in each of the five habitats and two seasons in 1997 than in the 1970s, the total number of families on all five habitats in 1997 was comparable with individual years in the 1970s. Baetidae (mayflies) were less abundant in 1997 than either 1975 (high discharge) or 1976 (very low discharge). Baetidae are usually abundant when discharge is high and submerged macrophytes are plentiful, so the very low densities in summer 1997 were consistent with the prolonged drought and sparse submerged vegetation.

The second site was 100 m of the River Kennet at Littlecote, upstream of Hungerford. It was mapped from April 1974 to June 1976, and its macroinvertebrates sampled in June 1974 and June and December 1975. In 1997, this important trout fishery was managed in the same way that it had been in the 1970s, so it was viewed as a 'control' site with respect to its management and as a reference for sites upstream. In the 1970s, *Ranunculus* and gravel were the dominant habitats. Both were important for macroinvertebrates, despite the area of *Ranunculus* varying from year to year depending on the discharge and weed-cutting. *Ranunculus* failed to grow only at the onset of the 1976 drought. The discharge in 1997 was higher than in 1976 and enabled the biomass and area of submerged *Ranunculus* to be greater, thus ensuring a fast current over the adjacent gravel. However, the discharge was low enough for tall marginal emergents in summer and low growing species in winter to provide additional habitats for macroinvertebrates. The total number of macroinvertebrates on *Ranunculus* and gravel in 1997 was greater in than in 1975, probably because families moved in from adjacent marginal vegetation. The densities of Baetidae in summer 1997 and 1975 were not significantly different, supporting the argument that they need fast-flowing water and abundant submerged macrophytes to maintain high densities.

Two additional 50 m sites were examined on the River Kennet upstream of Stitchcombe Mill, (downstream of Marlborough). These are referred to as the lower and the upper Savernake sites. Both had been mapped from April 1974 to April 1976 and their macroinvertebrates sampled quantitatively in June 1974 and in June and December 1975. In the 1970s, the hatches at Stitchcombe Mill were adjusted to retain deep slow-flowing water over both sites. This strategy has been abandoned because of concern about the loss of *Ranunculus* as habitat for macroinvertebrates. The river now runs freely, as it does at Littlecote. Further changes to promote the growth of *Ranunculus* included narrowing the channel by current deflectors and by planting marginal vegetation.

In the mid-1970s the lower site was dominated by *Schoenoplectus*, with a limited cover of *Ranunculus*. In 1997, *Schoenoplectus* still dominated but had decreased from about 60% cover to less than 20%. *Ranunculus* was restricted to small areas and the site was heavily silted in this second year of drought.

In the mid-1970s, the upper site supported an abundant growth of *Ranunculus* with some *Schoenoplectus*. Weed-cutting was essential to control the *Ranunculus* and to enable trout fishing to take place. In 1974-75, the area of *Ranunculus* in summer was about 35-45%, but in 1997 it occupied less than 10% of the site as thin beds of weed in both seasons. The poor growth of *Ranunculus* in 1997 was striking because of its good growth downstream at Littlecote, and because the water flows at Savernake had been modified to provide better conditions for its growth. The area of *Schoenoplectus* also reduced (from about 20% to less than 3%) and there was heavy silt deposition, as at the lower site.

Evidence from a number of chalk streams indicates that in years of very low discharge, including 1976, the growth of *Ranunculus* is restricted by epiphytic algae and detritus, which accumulate on it. *Ranunculus* was capable of substantial growth at Littlecote in summer 1997, so it is likely that the growth of *Ranunculus* at Savernake was restricted by the growth of epiphytic algae. Nutrients from Marlborough STW, and possibly other diffuse agricultural sources, may have encouraged the growth of epiphytic algae at Savernake. As at Littlecote, marginal emergent vegetation developed through the autumn at Savernake and by December 1997 the slow flow and silted river-bed favoured the growth of *Callitriche*.

Despite these major changes, the number of macroinvertebrate families recorded at Savernake in 1997 marginally exceeded the number recorded in 1975. However, the abundance of some families differed between summer 1997 and the mid-1970s, particularly at the lower site. The greater density of Glossiphoniidae (leeches), Asellidae (crustaceans) and Chironomidae (midges) in summer 1997, when there were much lower densities at other sites, was of concern. The macroinvertebrates experienced more extreme conditions at Savernake than at Littlecote, and some of the changes at Savernake were consistent with nutrient enrichment and mild organic pollution. At Savernake, Baetidae (mayflies) were much less abundant in summer 1997 than in the 1970s, whereas at Littlecote they occurred in modest densities on both *Ranunculus* and gravel in 1975 and 1997. These features of the macroinvertebrate fauna at Savernake appeared to be associated with poor growth of *Ranunculus* and other macrophytes, coupled with accumulation of silt at the sites. In turn, these changes are consistent with the prolonged drought, but could have been compounded by nutrient enrichment.

1. INTRODUCTION

1.1 Background

According to the Environment Agency, the 1997 drought was the worst for 200 years in terms of its impact on water resources. Chalk streams in particular were badly affected, and many of their headwaters suffered low flow or no flow. The alleviation of low flows in groundwater-fed catchments is a prime concern of the Agency, as well as other organisations (Acreman & Adams, 1998). In chalk streams, low flows are exacerbated by abstraction from boreholes, resulting in a lowering of the water table. The ecological effects of these conditions need to be understood in order to identify what actions are damaging in the long-term. This can only be done by long-term assessments based on data covering the full range of different flow regimes. Comparison with data collected over a long period is also the only way to obtain a balanced appraisal of the ecological consequences of a particular drought. Shortfalls in our understanding of the hydro-ecology of chalk streams became apparent during the Axford public enquiry in 1996. This related to the Thames Water Utilities Ltd appeal against restrictions to the amount of water they could abstract from boreholes near the River Kennet.

The Agency has a particular need to improve its understanding of chalk streams in order to fulfil its duties under the UK Biodiversity Action Plan. Chalk rivers are one of a small number of habitats for which costed Action Plans have been drawn-up (UK Biodiversity Steering Group, 1995). Information about the effects of different management strategies is vital to this plan.

Fortunately, very detailed information on the macrophytes and macroinvertebrate assemblages of one location on the River Lambourn and somewhat less detailed information for two locations on the River Kennet were collected during the 1970s, in connection with a groundwater pumping scheme (Institution of Civil Engineers, 1978). The present study in the late 1990s provides a unique opportunity to compare current ecological conditions with those existing more than twenty years ago, including what was regarded as the most severe drought in 1976. Continuing these new surveys will provide a long-term data-set.

As well as being vital for water resources management, directly comparable long-term data will be useful for assessing the effects of climate change, which is one of the nine key themes that the Environment Agency is addressing (Environment Agency, 1997).

During the 1960s, the Thames Conservancy devised a plan to utilise the natural underground stores of water in the chalk aquifers of the River Lambourn and associated catchments of the Thames basin, to meet the future demand for water in the London area during droughts. The concept was to sink boreholes into the chalk, pump water to the surface and transport it by pipeline into various tributaries in order to maintain an adequate flow for abstraction in the lower reaches of the River Thames.

A number of chalk streams in the Thames catchment are famous for their trout fishing and are an important component in the ecology and natural beauty of the area. In planning and developing the groundwater-pumping scheme, it was important to take account of possible hydrological and ecological effects.

After some preliminary studies, it was accepted that a detailed ecological investigation was required to obtain essential information on the structure and functioning of the ecosystem, the impact of drought conditions, and artificial manipulation of the hydrological regime through groundwater pumping.

In October 1970, the Thames Conservancy and the Water Resources Board jointly funded a three-year baseline study on the River Lambourn and its tributary, the Winterbourne Stream, undertaken by a research team based at the University of Reading. Most of the studies on macrophytes, macroinvertebrates and fish were conducted on the River Lambourn at Bagnor, and two study sites (shaded and unshaded) were to become important as long-term reference sites.

On completion of the initial study, the sponsors agreed to fund the project for a further four years (October 1973-September 1977), during which time trial pumping was planned. This period also included the major drought of 1976, which enabled the team to acquire valuable data on the ecological consequences of low flows. Further studies at a number of other chalk stream sites were also undertaken within the contract. They included two-year research programmes (1974-76) at two locations on the River Kennet upstream of Hungerford (the Littlecote site) and downstream of Marlborough (the Savernake sites).

In 1977, the Thames Water Authority, the Central Water Planning Unit and the Nature Conservancy Council financed a further contract (October 1977 to September 1980). For this phase of the research, the project operated from the River Laboratory of the Freshwater Biological Association (now the Institute of Freshwater Ecology, IFE). Once again, the research programme maintained the continuity of the observations on the River Lambourn in addition to examining a number of other catchments of interest to the sponsoring organisations.

The major findings from each of the three contracts were reported to the sponsoring organisations in a series of reports (University of Reading 1973, University of Reading 1977, Berrie *et al.* 1980), and numerous scientific papers were also published in journals. Wright (1992) is a review paper which includes reference to a number of the earlier papers. Recently, the macroinvertebrate data for the River Lambourn at Bagnor has been entered into Microsoft Access, a relational database management system for Windows. This is now being used by IFE staff for new analyses and publications, and has also been made available for use within the present contract.

Thus, on the River Lambourn at Bagnor, and to a more limited extent at sites on the River Kennet, detailed information on the macrophytes and quantitative data on the macroinvertebrates are available as an historical baseline from which to assess the ecological impact of the current drought conditions, and to improve our understanding of the impact of low flows on the ecology of chalk streams in general.

Some early discussions on the need for a new monitoring programme on the River Lambourn took place in late 1995, culminating in the submission of a Scoping Study to the National Rivers Authority (Peters *et al.* 1995). However, the low flows of 1996, coupled with the suggestion by the newly-formed Environment Agency that the sites on the River Kennet should be re-examined, led to a new request from the Agency in early 1997 for some broader-based proposals involving the River Lambourn and the River Kennet. The worsening drought conditions through the spring of 1997 provided further impetus for a re-examination of all the major study sites starting in June 1997, in order to provide data comparable with that collected in the 1970s. In early June, the content of the research programme was agreed, and the IFE was requested to proceed with the study.

This present study complements surveys of macrophytes in the upper reaches of chalk streams (including the headwaters of the Rivers Kennet and Lambourn) which are being undertaken annually for the Environment Agency by Nigel Holmes. These investigations are to determine the effects of abstractions and drought conditions (Holmes, 1998).

Also concurrent with this survey is a macrophyte survey of four sites, on either side of Marlborough sewage works, for evaluating the effects of phosphate stripping. The first survey was done in 1997 (Holmes, 1997) and subsequent surveys have been undertaken by the Environment Agency. One site is at Stitchcombe Mill, just downstream of the Savernake sites used in this survey.

1.2 Objectives

The overall objective of the project, as given in the contract specification is:

> *'to improve the Environment Agency's knowledge of chalk stream ecology in order to increase our ability to manage chalk streams in a sustainable manner'*

The contract specification also listed twelve specific objectives:

1. To locate the sites surveyed between 1971 and 1979 on the River Lambourn at Bagnor (50 m shaded site) and between 1974 and 1976 on the River Kennet at Savernake (two 50 m sites, 'lower' and 'upper') and at Littlecote (100 m site), and to re-mark the sites with wooden stakes to ensure that the same locations are surveyed in 1997 and in subsequent surveys.

2. To map the macrophyte communities at each site so that changes in the communities between 1997 and the 1970s can be assessed.

3. To survey the macroinvertebrate communities at each site so that changes in the communities between 1997 and the 1970s can be assessed.

4. To repeat the macrophyte and macroinvertebrate surveys in June and December to ensure that seasonal changes are taken into account and that the data are comparable with the 1970s data.

5. To ensure that the riparian owners (through their riparian managers) are informed prior to each site visit, so that the survey does not interfere with their activities.

6. To collate the macroinvertebrate data collected from 1971 to 1979 so that it can be compared with similar data collected in this survey.

7. To develop a database for producing plant maps and to populate it with data from this survey.

8. To photograph the sites on each survey occasion in order to assist with the comparison and interpretation of changes in the biological data collected in the 1970s, in 1997 and in the future.

9. To compare the macrophyte and macroinvertebrate data, site photographs, and any other incidental information collected in this survey with similar data and information collected in the 1970s.

10. To train Agency biologist(s) in the survey methods used for this work.

11. To produce a report, summarising the findings, conclusions, and recommendations of the survey.

12. To collate the raw data from this survey so that it can be used by the Agency for future reference.

2. FLOW REGIME

2.1 R. Lambourn at Shaw

Information on the discharge regime of the River Lambourn has been supplied by the Thames Region of the Environment Agency. The nearest gauging station to the Bagnor study site was at Shaw, approximately 2 km downstream. It is important to recognise that whereas the river occupies a single channel at Shaw, it is divided into two channels at Bagnor. In the 1970s, two study sites were chosen on the northern channel at Bagnor because it was of wadeable depth and was more typical of the river as a whole, whereas much of the southern channel was deep and slow-flowing. Hence, when examining the discharge regime at Shaw it should be borne in mind that the actual discharge through the shaded site at Bagnor is substantially lower, although the seasonal regime in any given year will mimic the picture obtained at Shaw.

The Bagnor shaded site was studied from January 1971 to December 1979 and therefore monthly mean flows are presented for the gauging station at Shaw for the same period (Fig. 2.1). The main features over this nine-year period are the minor drought of 1973 and the major drought of 1976. Note that from late August to mid-November 1976, operational pumping of the groundwater scheme augmented river flows, but this was followed by high winter rainfall, bringing an end to an historic drought.

Although the current contract was limited to sampling in 1997, the discharge regime on the River Lambourn at Shaw from January 1990 to December 1997 is presented in Figure 2.2, because this period included several years of low discharge. In 1991 and 1992 there were successive years of low discharge prior to a three year period (1993-95) when discharge was high. Then followed a year (1996) when peak discharge was substantially lower than the previous three years and in 1997 another major drought event occurred. Thus, in the 1990s, two separate episodes of low discharge occurred over a protracted period, something not seen in the 1970s despite the historic drought of 1976.

2.2 R. Kennet at Knighton

The Environment Agency also supplied monthly mean flows for the River Kennet at Knighton, which is located approximately 8 km downstream of the Savernake study section and 2 km upstream of Littlecote.

Figure 2.3 presents the monthly mean discharge from January 1971 to December 1979 even though the ecological studies were limited to 1974-76. As at Shaw on the River Lambourn, the main features of the hydrograph at Knighton are the minor drought of 1973 followed by the historic drought of 1976.

Figure 2.4 presents the discharge regime at Knighton over the period January 1991 to December 1997. Again, the protracted drought of 1991-92 and the progressively more severe drought of 1996-97 are the dominant features of the hydrograph. However, they are separated by three years of above average flows in 1993-95.

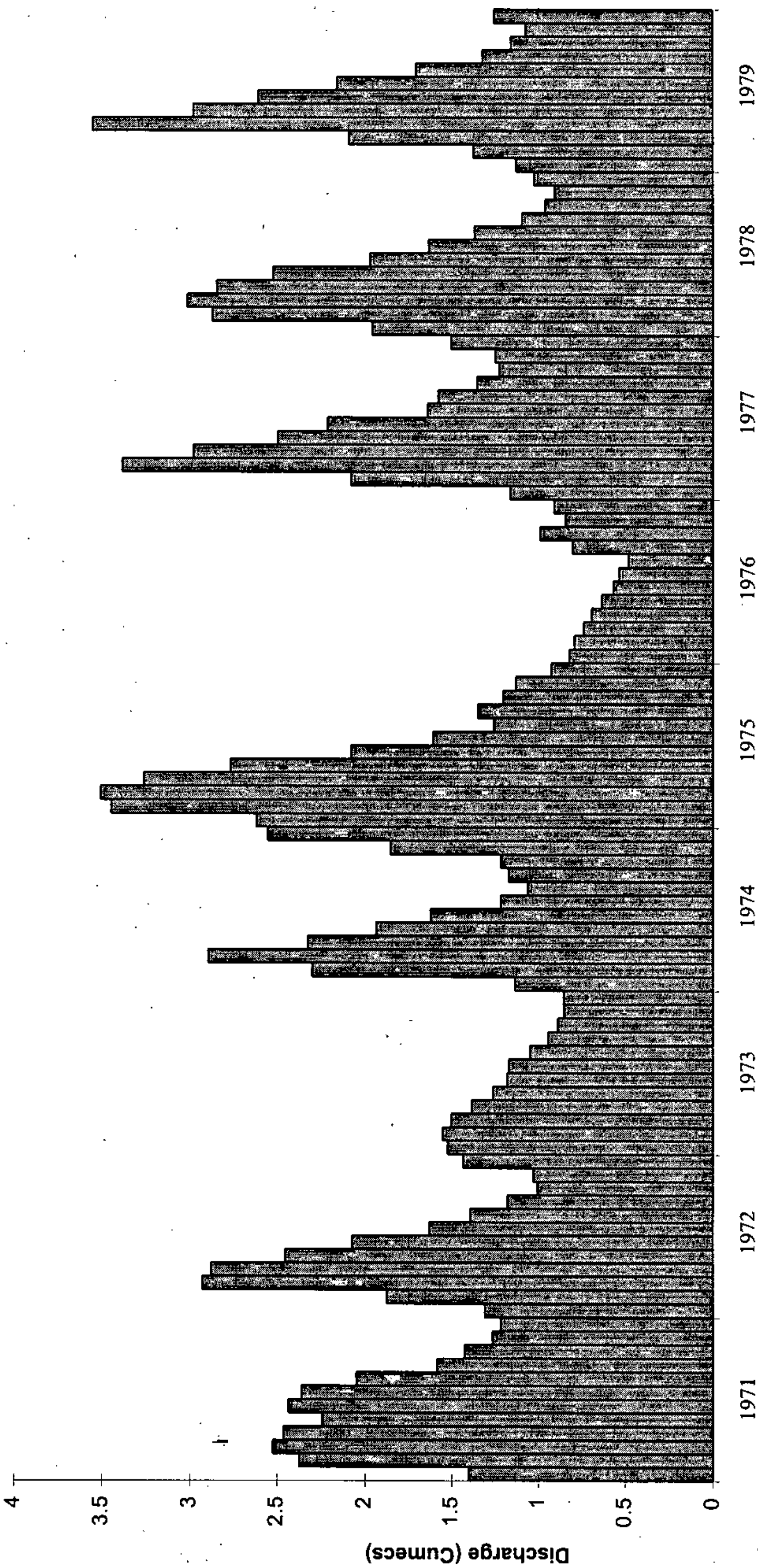

Figure 2.1. Monthly mean discharge on the R.Lambourn at Shaw, January 1971 - December 1979

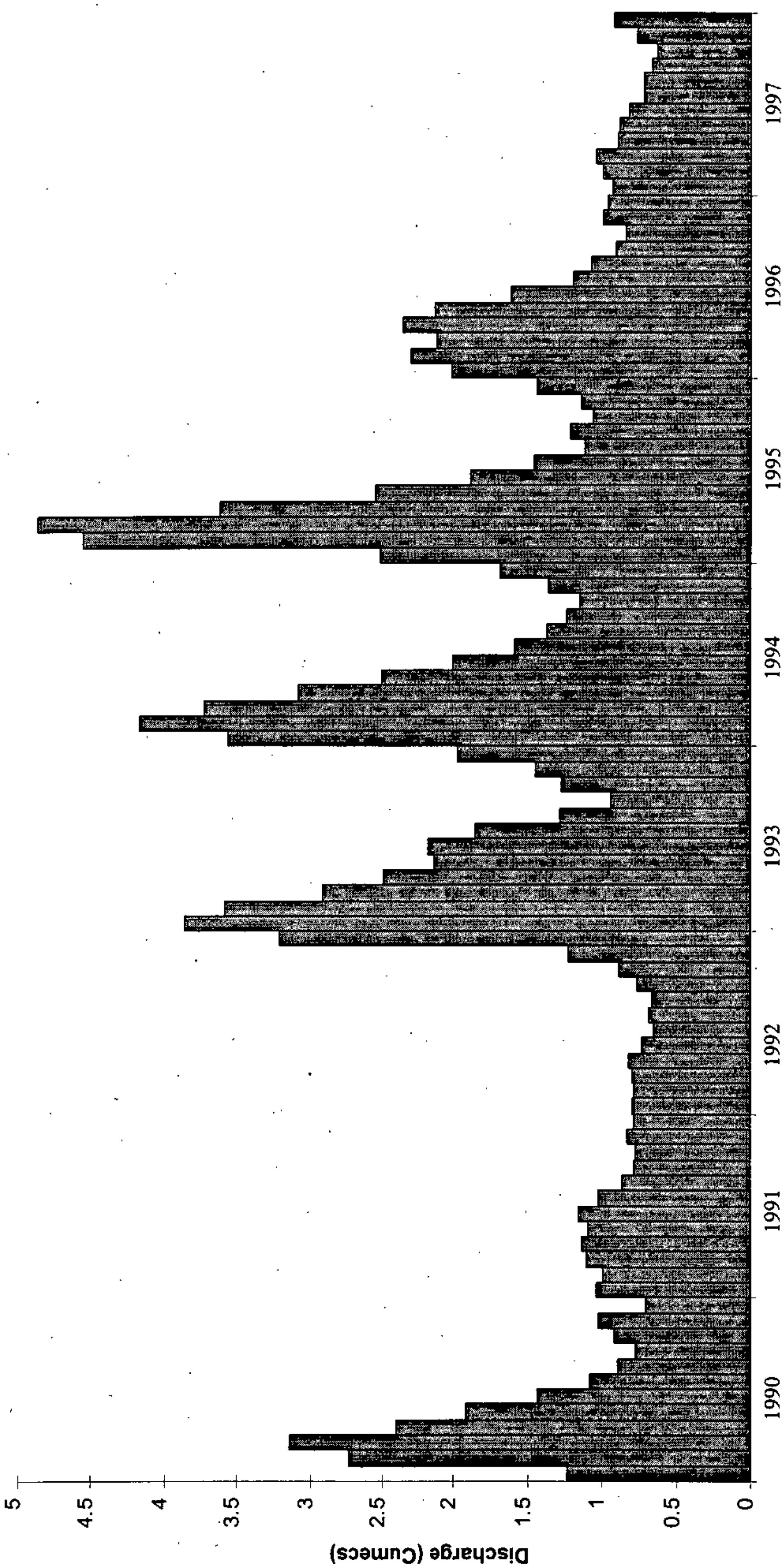

Figure 2.2. Monthly mean discharge on the R.Lambourn at Shaw, January 1990 - December 1997

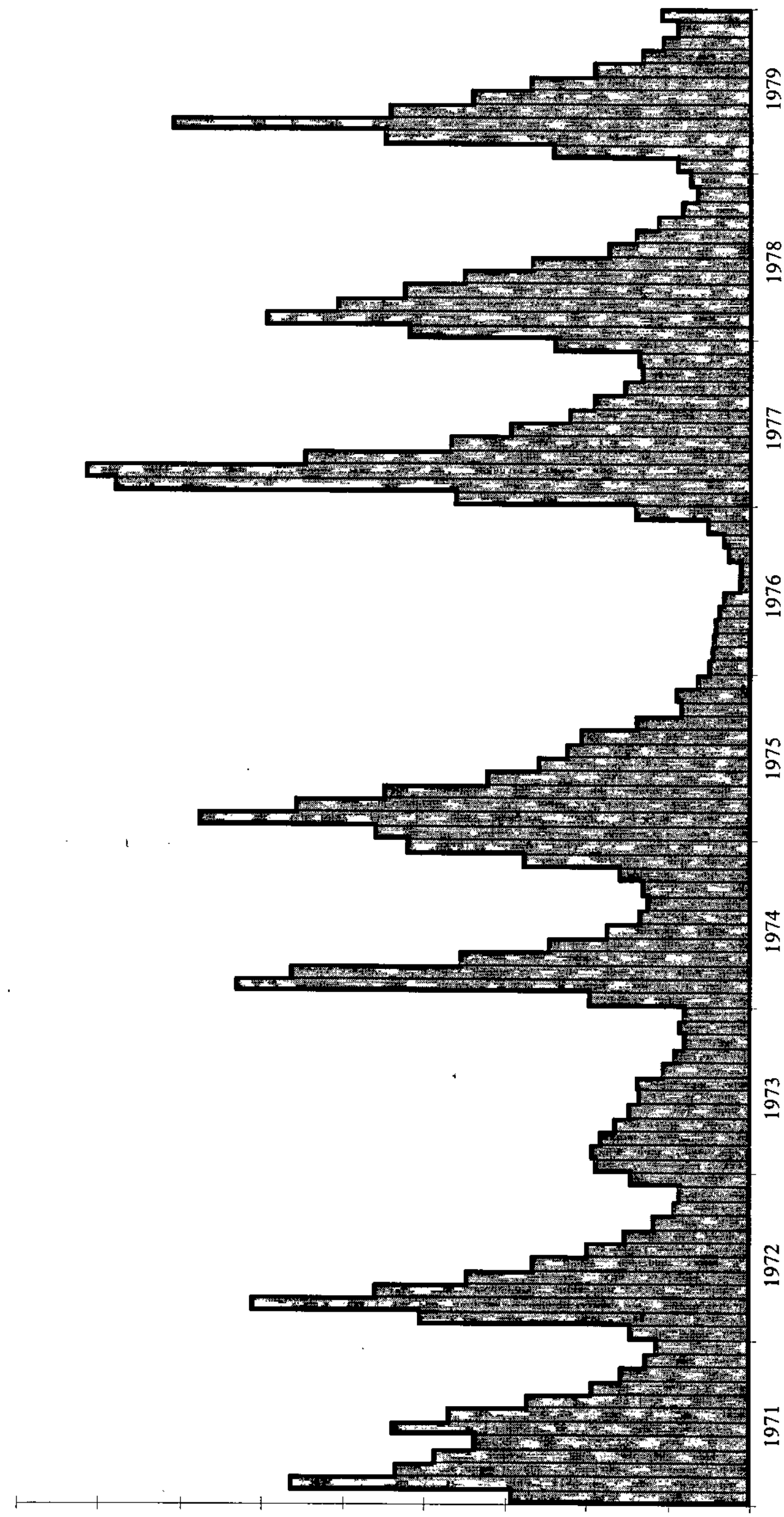

Figure 2.3. Monthly mean discharge on the R.Kennet at Knighton, January 1971 - December 1979

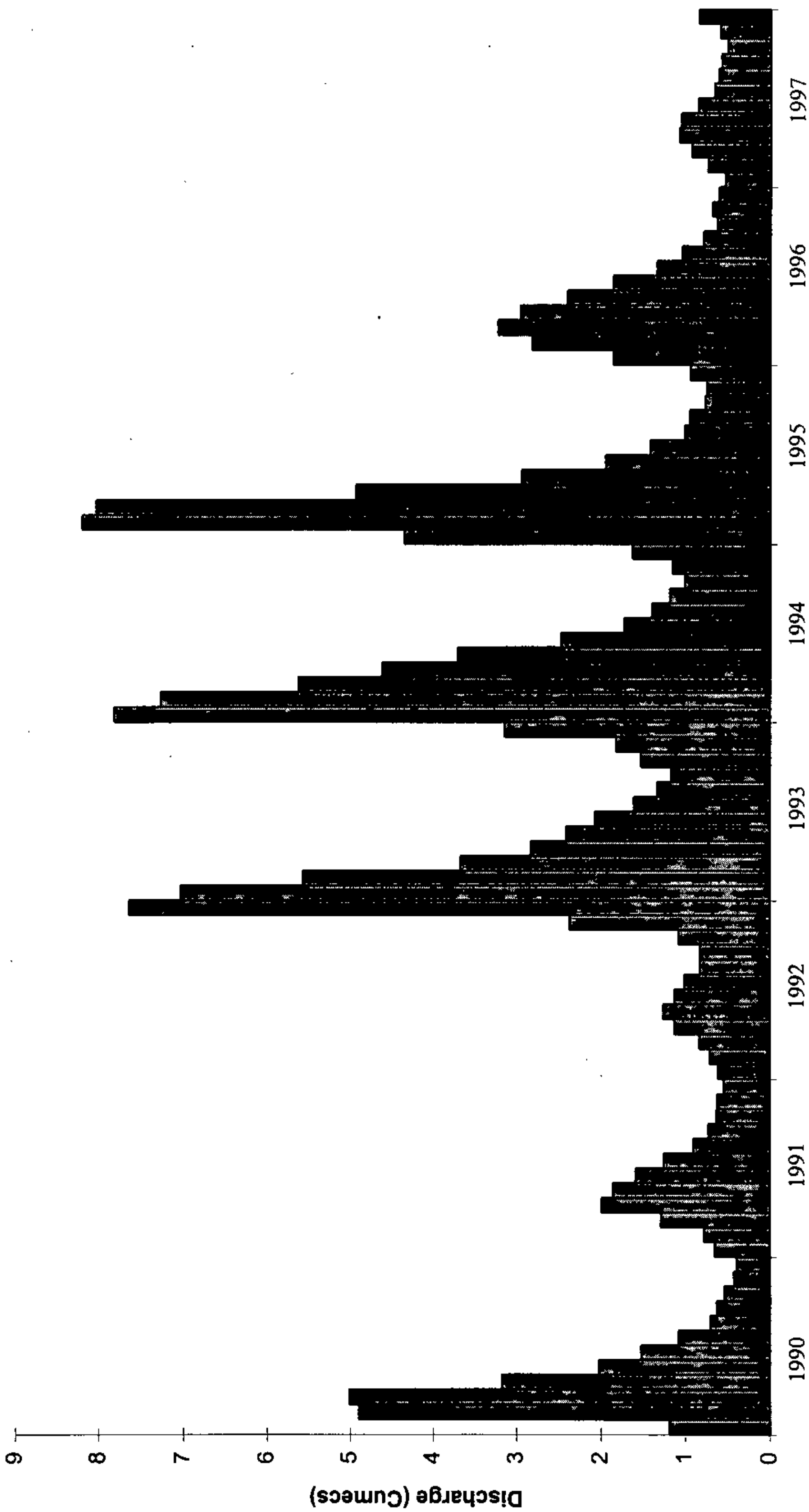

Figure 2.4. Monthly mean discharge on the R.Kennet at Knighton, January 1990 - December 1997

3. THE STUDY SITES

3.1 R. Lambourn at Bagnor (shaded site)

3.1.1 The 1971-79 research programme

The full research programme undertaken on the River Lambourn during the 1970s included many sites and a number of different research topics. This section of the report is limited to a brief description of the research undertaken on macrophytes and macroinvertebrates on the shaded site at Bagnor (SU 453692). The reader is referred to the main contract reports (University of Reading 1973, University of Reading 1977, Berrie *et al.* 1980) for a more comprehensive account of the research programme.

It is important to bear in mind that during the 1970s, the River Lambourn at Bagnor was a valuable trout fishery and that the Piscatorial Society's head keeper and his colleagues undertook periodic weed-cutting and bank maintenance in order to keep the river in a condition suitable for fishing.

The macrophyte mapping programme started in March 1971 and was repeated each month throughout the 1970s. Initially a very detailed mapping procedure was adopted, to be followed by a simplified 'points' method and finally the 'rectangles' method. A comparison of all three methods has been published (Wright *et al.* 1981a) and the rectangles method, which was finally adopted for use in the 1970s was repeated in 1997. This technique is regarded as the most efficient and also the most objective of the three procedures.

The substratum or macrophyte dominating each 50 x 100 cm rectangle of river-bed is recorded, thereby creating a simplified map of the study site. It is then possible to calculate the total area of the site on a given mapping date and calculate the percentage cover of each of the major habitat types. By repeating the procedure each month over a number of years, seasonal changes in the growth and recession of macrophytes can be observed, as can the response to conditions of high or low discharge. A detailed account of the growth and recession of aquatic macrophytes on the shaded site at Bagnor between 1971 and 1980 has been published (Ham *et al.* 1982a). It demonstrates that the five main habitats (biotopes) on the site are Lesser Water-parsnip *(Berula)*, Water Crowfoot *(Ranunculus)*, Starwort *(Callitriche)*, gravel and silt. More detailed studies to document seasonal changes in the biomass of the macrophytes between March 1971 and October 1973 were also undertaken (Wright *et al.* 1982).

Having defined the five major habitat types on the river-bed, it was necessary to develop a procedure for obtaining quantitative samples of the macroinvertebrates on each habitat. This was achieved through the development of the 'Lambourn sampler', which combined the advantages of both box and Surber samplers (Hiley *et al.* 1981). The sample area was 20 x 25 cm (0.05 m^2) and was used to sample the benthos to a depth of approximately 6 cm. Aquatic macrophytes were sampled together with the underlying substratum.

In the first year of the project, a very substantial sampling programme was undertaken in which five replicate sampling units were taken on each of the five habitat types in each month from March 1971 to February 1972. In four of these months (March, June, September and December) each of the five replicates was processed individually, but in the remaining months, it was necessary to pool and sub-sample the replicates from a given habitat in order to complete the laboratory processing. Identification was essentially to family level and the detailed results of the first year of study are presented in Wright *et al.* (1983).

On the basis of the detailed results from the first year, the months of June and December were chosen for continuation of the quantitative sampling programme for macroinvertebrates with the objective of documenting between-year changes in the fauna, with particular reference to the flow regime. Thus, from June 1972 to December 1979 this sampling regime continued, taking in both the minor drought of 1973 and the historic drought of 1976. An account of some of the findings of the River Lambourn study in the 1970s may be found in Wright (1992) and also in a more recent paper which deals with macroinvertebrates on the shaded site at Bagnor (Wright and Symes, in press).

3.1.2 The 1997 survey

Once confirmation was received that the project should proceed in 1997, a site meeting was arranged on the River Lambourn at Bagnor for 13 June 1997. Dr J. Murray-Bligh (Environment Agency) and Dr. J Wright plus Mr P. Henville (IFE) met Mr C. Robins of the Donnington Grove Country Club, and Ms E. Alison of the Berkshire, Buckingham and Oxfordshire Naturalists Trust (BBONT). The Donnington Grove Country Club hold the fishing rights at Bagnor and BBONT manage Rack Marsh, the area of land between the two channels of the River Lambourn at Bagnor. The purpose of the study was explained to Mr Robins and Ms Alison, and agreement was reached that the original 50 m site would be re-marked with a series of stakes, after which a mapping and sampling operation would be undertaken in June and December 1997.

Dr J. Wright also agreed to contact Mr C. Robins before each visit so that he knew IFE personnel were on site and could tell fishermen to avoid the area. However, Mr Robins indicated that very little management of the river takes place, compared to the 1970s, and that fishing is not as important as in the past.

During this visit it was noted that the roadside (north) bank of the river was heavily overgrown with riparian vegetation and although there was a thin mown strip 1-2 m away from the river, the public are not encouraged to walk along it. It was also apparent that the north bank itself was not as clearly defined as in the 1970s and, in particular, approximately half way along the site, emergent macrophytes had encroached onto the river-bed. Management in the 1970s by the Piscatorial keepers would have prevented this from developing as it limits the width of river available for fishing.

The far bank was also less well defined than in the 1970s, although some of the original marker stakes were relocated. In places there appeared to be a wide band of deep mud where previously there had been a vertical soil bank into which native crayfish burrowed. Mr Robins said that as far as he was aware, the native crayfish (*Austropotamobius pallipes*) had gone, and had been replaced by the signal crayfish (*Pacifasticus leniusculus*).

Within the channel, it was apparent that discharge was low, and whereas a variety of emergent macrophytes were encroaching from the margins, the typical submerged macrophytes, and in particular *Berula* and *Ranunculus* were present in relatively small quantities. Mr Robins noted that following the drought a few years ago there had been a substantial accumulation of silt. Efforts had been made to dislodge the silt and move it downstream, but otherwise no management had taken place in recent years.

Following this site meeting, the field programme went ahead as follows:

18 June – stakes positioned along each bank at 5 m intervals to facilitate mapping.

19 June – shaded site mapped using the rectangles method. (Dominant habitat type in each 50 x 100 cm rectangle recorded and substratum underlying each macrophyte also determined. Map later used to calculate percentage cover of each major habitat type and for selection of locations for macroinvertebrate sampling units).

24 June – five sampling units taken using a Lambourn sampler on each of the five habitats sampled in the 1970s (*Berula*, *Callitriche*, *Ranunculus*, Gravel and silt) and on emergent macrophytes, in recognition of the greater importance of this habitat at the site.

1 December – shaded site mapped once again, and macroinvertebrate sampling started.

2 December – macroinvertebrate sampling programme successfully completed. A total of 30 sampling units collected, as in June 1997.

3.1.3 Pictorial record of the Bagnor site

Figures 3.1a to 3.1f provide a guide to the main features of the shaded site at Bagnor on selected dates in the 1970s and in 1997.

Fig. 3.1a is a view of the site in September 1973, looking upstream. It shows carpets of *Berula*, the dominant macrophyte, growing on gravel towards the end of a minor drought (see Fig. 2.1). Two nets have been located downstream of *Berula* and gravel to catch drifting macroinvertebrates.

Fig. 3.1b is the same view in June 1975 during a period of high discharge. The carpet of *Berula* remains, but has been overgrown by *Ranunculus*, which is flowering at the surface of the water. Later in the year *Berula* resumed its dominant position. Note, on the right hand side of the photograph, that a narrow strip of bank-side vegetation has been left as cover for emerging insects, but beyond this, the bank has been cut, to help access by fishermen.

Fig. 3.1c is a further view looking upstream, taken on 21 September 1976 towards the end of the major drought of 1976. *Berula* still dominates the site, although Canadian Pondweed (*Elodoea)* had established itself amongst the *Berula* during the summer. At the time this photograph was taken, the discharge had been supplemented by operational pumping (see Fig 2.1).

Fig. 3.1d was also taken on 21 September 1976, but shows the shaded site from the upstream limit, looking downstream.

Fig.3.1e is a view looking upstream taken in June 1997. Note the limited cover of submerged macrophytes. The light-coloured weed is *Callitriche*. Notice also the extent to which trees now overhang the river on the left-hand side of the photograph and the marked growth of emergent marginal vegetation on the right hand side. If the river was intensively managed for trout fishing, as in the 1970s, it is likely that a river keeper would have limited the overhang of trees and prevented the loss of river width on the right by removing the marginal vegetation.

Fig.3.1f shows the sites in December 1997. The tall marginal vegetation has now died back, although some low growing species remain at the water's edge on the right hand side of the photograph. Gravel is still the dominant substratum on the river-bed and although the area of *Berula* has increased marginally from June 1997, the total area remains at low.

Figure 3.1a River Lambourn at Bagnor (shaded site). September 1973. View upstream

Figure 3.1b River Lambourn at Bagnor (shaded site). June 1975. View upstream

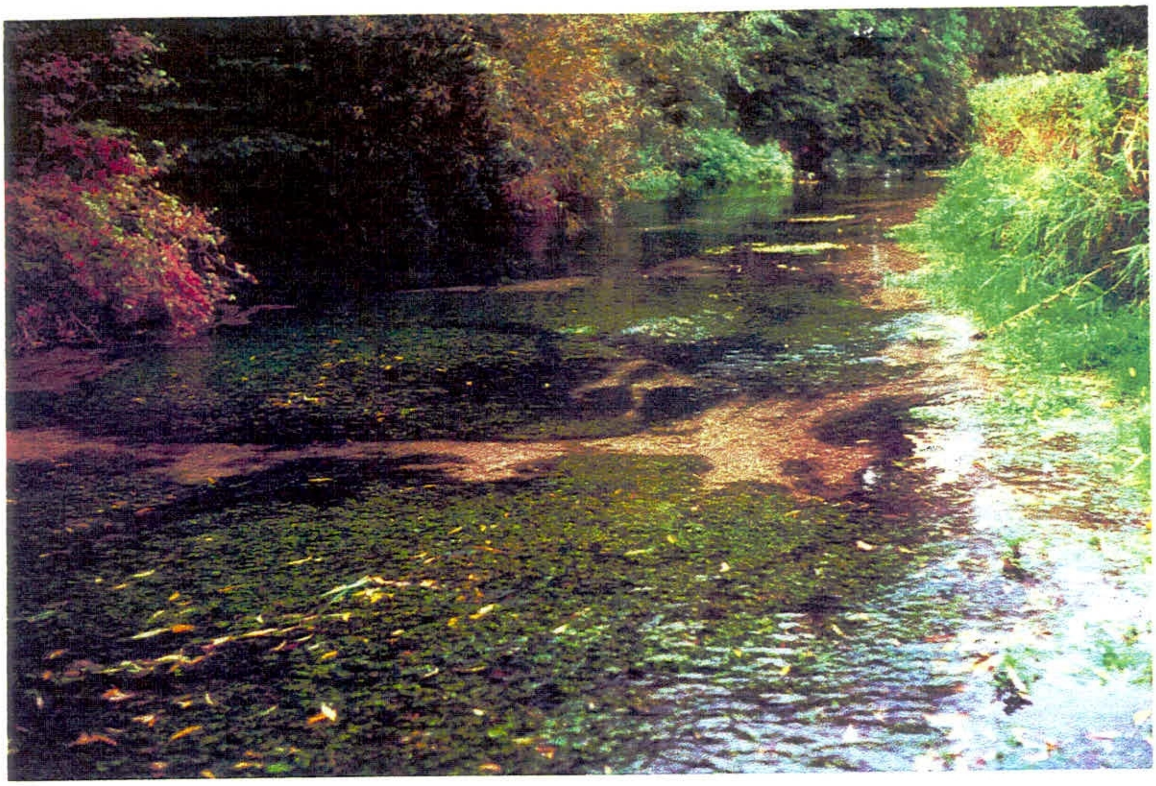

Figure 3.1c River Lambourn at Bagnor (shaded site). September 1976. View upstream

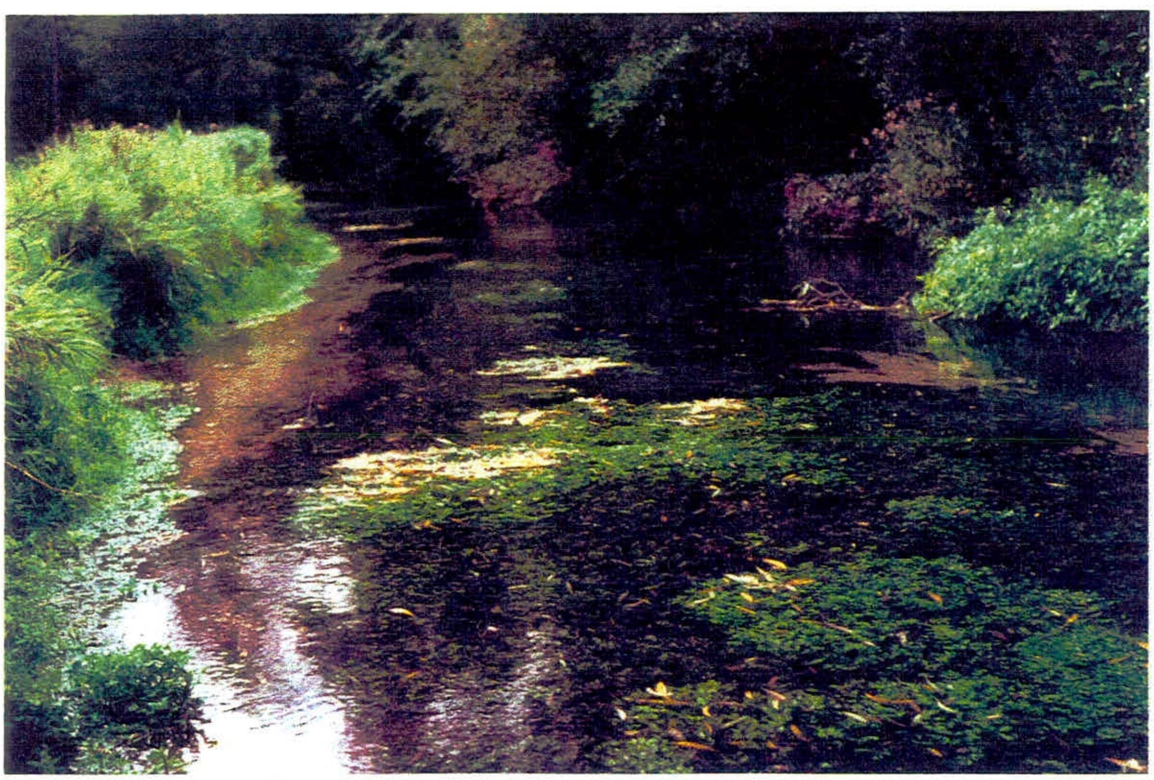

Figure 3.1d River Lambourn at Bagnor (shaded site). September 1976. View downstream

Figure 3.1e River Lambourn at Bagnor (shaded site). June 1997. View upstream

Figure 3.1f River Lambourn at Bagnor (shaded site). December 1997. View upstream

3.2 R. Kennet at Littlecote

3.2.1 The 1974-76 research programme

An account of the full range of research activities at this site (SU 312704) was presented in the contract report (University of Reading 1977) but here, the focus is on the macrophyte mapping and macroinvertebrate sampling programme. Studies on the River Kennet in the mid-1970s were part of the second major contract (October 1973 - September 1977) and were intended to broaden the geographical scope of the initial programme on the River Lambourn.

The initial plan was to undertake a two year surveillance programme (April 1974 – April 1976) on the River Kennet at Littlecote (and also at Savernake) in order to obtain data comparable in nature with that for the River Lambourn, but for a larger chalk stream. In practice, the greater depth of water and high turbidity at both Littlecote and Savernake were sufficient to cause reductions in the field programmes in the winter of 1974-75 involving a three month gap in the mapping programme and no macroinvertebrate sampling in December 1974.

The 100 m site chosen at Littlecote was free flowing, turbulent and deep in places at the upstream narrower limit. Overall, the dominant substratum was gravel, ranging from unstable pebbles at the top of the site to fine flints embedded in sand at the downstream limit. Water Crowfoot (*Ranunculus)* was the dominant macrophyte on this essentially unshaded site, and it displayed rapid early growth in the season, necessitating regular cutting in order to maintain good conditions for trout fishing.

Mapping commenced in April 1974, and, as a result of spectacular weed growth, bar-cutting of the weed was undertaken at the end of April, again in early June and once more in September. The impact of the weed-cutting programme on the growth and recession of *Ranunculus* at this site in both 1974 and 1975 has been described in a publication (Ham *et al.* 1982b). High turbidity and a substantial increase in discharge from the end of November 1974 prevented mapping and macroinvertebrate sampling during the winter, but mapping recommenced in March 1975, and continued on a regular basis until April 1976. During this period, the monthly mean discharge steadily decreased, thereby allowing the macroinvertebrate sampling programme to proceed uninterrupted in both June and December 1975. A single weed-cut took place in early June 1975.

By spring of 1976, it was apparent that a major drought was in progress and although regular mapping ended in April, photographs of the site were taken during the summer to record the major changes. The normal increase in area of *Ranunculus* failed to occur because the weed was smothered by epiphytic algae and associated detritus. In view of the atypical conditions an additional mapping operation was carried out in late June 1976 to document the limited cover of *Ranunculus* and the progressive build-up of silt on the river-bed.

The macroinvertebrate sampling programme was confined to the two major habitat types on this site, namely *Ranunculus* and gravel. However, in June 1974 the availability of both uncut and cut *Ranunculus* prompted the use of the Lambourn sampler to acquire five sampling units of each of uncut *Ranunculus*, cut *Ranunculus* and gravel. No samples were taken in December 1974 because of high discharge, but five sampling units were taken on *Ranunculus* and gravel in both June and December 1975.

3.2.2 The 1997 survey

The Littlecote site was also visited on 13 June 1997 when personnel from the Environment Agency and IFE had an opportunity to meet the Head Keeper, Mr P. Woolnough. This section of the river remains an important trout fishery and it was apparent that a number of the management techniques used in the 1970s are still used to retain optimal conditions for trout fishing. However, Mr Woolnough expressed concern over the very low water levels and it was apparent that conditions were approaching those observed in the drought of 1976.

We were fortunate in being able to relocate some of the stakes from the 1974-76 study and were given helpful advice on the positioning of new stakes to ensure that the mapping of this 100 m long site could be undertaken efficiently. As at Bagnor, we had full co-operation over the work to be undertaken, and agreed to give advance warning of proposed site visits to ensure minimum inconvenience to fishing interests and duck shooting (winter only).

Following the site meeting, the field programme went ahead as follows:

> 19 June – new stakes positioned at 5 m intervals just above water level on the baseline bank and on the far bank, as required.
>
> 3 July – 100 m site was mapped. In addition, 5 sampling units on each of *Ranunculus* and gravel collected on the same day.
>
> 3 December – 100 m site mapped.
>
> 4 December – Five sampling units taken on each of *Ranunculus* and gravel.

3.2.3 Pictorial record of the Littlecote site

Figures 3.2a to 3.2h document the main features of the 100m site on the River Kennet at Littlecote on selected dates in the mid-1970s and in 1997.

Fig. 3.2a is a general view of the site from the upstream limit looking downstream, taken in April 1974. The peak discharge passed through in February and *Ranunculus*, the dominant macrophyte, is now growing on the gravel substratum.

Fig.3.2b was taken from the downstream limit of the site looking upstream in June 1974. In the two-month period since Fig.3.2a was taken, the biomass of *Ranunculus* increased considerably, resulting in masses of white flowers on the surface. Note that the tall emergent vegetation on the nearside bank has been left for emerging insects.

Fig. 3.2c shows the site from the upstream limit, in March 1976. The historical drought of 1976 has already resulted in loss of water width, there having been no significant increase in discharge during the winter of 1975/76 (see Fig. 2.3).

Fig 3.2d was taken in June 1976 and provides a stark contrast to Fig 3.2b, taken in the same month two years earlier. Although *Ranunculus* was present throughout the spring and early summer of 1976, it failed to thrive and by June, silt was starting to accumulate in slack areas of the river-bed.

Fig.3.2e shows a further view of the site from the upstream limit in August 1976, when monthly mean discharge was lower than in any other month in 1976 (see Fig. 2.3). Note that the exposed river-bed first seen in March 1976 (Fig 3.2c) has been colonised by Greater Willowherb (*Epilobium hirsutum*) whilst the far bank is fringed by a green line of Watercress (*Nasturtium officinale* agg.)

Fig. 3.2f shows the Littlecote site in June 1997, looking upstream. Although *Ranunculus*, the dominant macrophyte, has failed to reach the surface and produce masses of white flowers (c.f. June 1974, Fig. 3.2b) discharge is greater than in June 1976 (see Fig 3.2d) and subsurface *Ranunculus* can be seen growing on a gravel substratum. Mean monthly discharge in June increased from a low in 1976, through 1997 to 1975 (see Figs 2.3 and 2.4) and the response of *Ranunculus* to the discharge regime in a given year is apparent in the photographs which document these three years. Note that the bank-side management techniques used in the mid-1970s, which provide easy access for fishermen whilst retaining marginal emergents as cover, are still employed in 1997.

Fig. 3.2g was also taken in June 1997 but presents a view from near the upstream limit of the site looking downstream. Sub-surface beds of *Ranunculus* are visible on the gravel bed. Also prominent, particularly in the shallow water of the nearside gravel area (previously exposed under the drought conditions of March 1976 - see Fig 3.2c) are beds of the emergent macrophyte Blue Water Speedwell (*Veronica anagallis-aquatica).*

Fig. 3.2h offers the same view of the site in December 1997. Discharge remains low and whereas some *Ranunculus* can still be seen below the surface of the water, there are more substantial changes to the marginal emergent species. *Veronica anagallis-aquatica* has now died back, but in its place, *Nasturtium officinale* agg. is growing well in shallow areas on both sides of the river not exposed to the full force of the current. The development of this feature under conditions of low discharge was also apparent at the site in August 1976 (Fig. 3.2e)

Figure 3.2a River Kennet at Littlecote. April 1974. View downstream

Figure 3.2b River Kennet at Littlecote. June 1974. View upstream

Figure 3.2c River Kennet at Littlecote. March 1976. View downstream

Figure 3.2d River Kennet at Littlecote. June 1976. View upstream

Figure 3.2e River Kennet at Littlecote. August 1976. View downstream

Figure 3.2f River Kennet at Littlecote. June 1997. View upstream

Figure 3.2g River Kennet at Littlecote. June 1997. View downstream

Figure 3.2h River Kennet at Littlecote. December 1997. View downstream

3.3 R. Kennet at Savernake (lower and upper sites)

3.3.1 The 1974-76 research programme

As indicated in section 3.2.1, study sites were chosen on the River Kennet during the second major contract in order to obtain data comparable with that being collected on the River Lambourn. A section of the River Kennet downstream of Marlborough but upstream of Stitchcombe Mill, which was under the control of Savernake Flyfishers, was also chosen for study. This part of the river, on which two separate 50 m sites were selected, was very different in character from the River Kennet at Littlecote. The Savernake sites, despite being further upstream than Littlecote, were generally deeper and slower flowing, due to manipulation of the hatches at Stitchcombe Mill. The end result was a canal-like section of river with relatively steady flow and even depth, which was heavily stocked with trout.

At Savernake, the substratum included large chunks of flint and gravel with some fine sediment. On the lower site Bulrush (*Schoenoplectus lacustris)* was the dominant macrophyte, with Water Crowfoot (*Ranunculus)* subdominant, whereas on the upper site, *Ranunculus* was dominant each summer, with *Schoenoplectus* maintaining around 20% cover throughout the year.

The monthly mapping programme commenced on both sites in April 1974 and continued until the planned finishing date of April 1976. However, high discharge during the winter of 1974-75 interrupted the mapping routine, and apart from one successful mapping operation in January 1975, there was a gap between October 1974 and March 1975.

On the lower site (SU 224693), macroinvertebrate sampling was confined to *Schoenoplectus* and gravel. Although samples were taken in June 1974, no sampling was possible in December of that year. In contrast, samples were taken on both habitat types in each of June and December 1975.

On the upper site (SU 222693), the sampling regime was a little more complex. In June 1974, sampling was confined to *Ranunculus* and gravel, and no samples were taken in December of that year. However, in June 1975, *Ranunculus* was very sparse and sampling of *Schoenoplectus* and gravel took place, with two additional sampling units from Lesser Water-parsnip (*Berula erecta)*. Only in late summer did *Ranunculus* start to grow on the site, and by December 1975 it proved possible to sample both *Ranunculus* and *Schoenoplectus*, in addition to gravel.

3.3.2 The 1997 survey

The Savernake sites were first examined on 13 June 1997 when Environment Agency and IFE personnel met with the Head Keeper, Mr J. Hounslow. He offered enthusiastic support for the study and explained that, as a result of his concern over the present state of his section of river, he had implemented a number of management techniques in an attempt to improve the situation. As a consequence, this section of the river was very different in character compared to the 1970s.

His basic strategy was to allow the river to run freely once more, in the belief that this should encourage the growth of *Ranunculus*. This approach contrasts with the previous strategy in which water was held up through manipulation of the hatches at Stitchcombe Mill, resulting in a deep slow-flowing channel where *Ranunculus* was unlikely to flourish but where conditions favoured *Schoenoplectus lacustris*.

Mr Hounslow had also implemented a number of other techniques, all designed to maximise the potential benefit to be gained by allowing the river to run freely. These included the removal of vertical wooden boards on the far bank which, in the 1970s, had minimised the diversity of bank-side habitat and made the river more canal-like. Coupled to this, he had planted native marginal vegetation in some places, in order to narrow the channel width and offer a diverse refuge for macroinvertebrates, both below and above the waterline. In other areas, bank-side willows had been cut and allowed to fall into the river margin, similarly narrowing the river whilst offering some refuge for both fish and macroinvertebrates. Finally, pairs of current deflectors had been placed at strategic locations in order to increase current speed and offer conditions in which *Ranunculus* could re-establish itself as an important habitat type on this section of the Kennet.

For this overall strategy to succeed, the river needs a reliable supply of high quality groundwater and clearly, at the time of the initial visit, a major drought was in progress.

In view of the major changes observed at the site, it was more difficult to establish the precise locations of the two 50 m sites surveyed during the 1970s despite the availability of a series of colour transparencies which were examined on site.. However, the lower site was eventually relocated to our satisfaction and we made our best judgement of the location of the upper site. Unfortunately, it proved impossible to relocate the 1970s stakes during this visit to provide final confirmation of site locations. Mr Hounslow agreed to the re-staking of each site and offered full cooperation over access during mapping and sampling in both seasons.

Following the initial site meeting, the field programme proceeded as follows:

20 June – each site was staked on both banks at 5 m intervals.

8 July – Lower site mapped and sampled for macroinvertebrates. Five sampling units taken on each of *Schoenoplectus* and gravel.

10 July – Upper site mapped and sampled for macroinvertebrates. Five sampling units taken on each of *Ranunculus* and gravel. During the final stages of mapping the upper site, a single 1970s stake was discovered on the far bank with a metal cap indicating that it was 35 m rather than 50 m along the site. Hence, the 1997 upper site started 15 m downstream of the 1974-76 site and overlapped it by 35 rather than the full 50 m. This finding was passed on to the Environment Agency and accepted as a minor problem to be noted when results were analysed.

During sampling on both sites (July only), it was noted that there were substantial growths of algae on the surface of the gravel in some areas. Thus, between the upper and lower sites (10 sampling units on gravel in total) it was arranged that 5 would be taken on 'clean' gravel and the other five on gravel coated with algae.

8 December – Lower site mapped and sampled for macroinvertebrates, as in July.

10 December – Upper site mapped and sampled for macroinvertebrates, as in July.

3.3.3 Pictorial record of the Savernake sites

Figures 3.3a to 3.3f document changes on the lower 50 m site and Figs 3.3g to 3.3n provide a record for the upper 50 m site at Savernake for selected dates in the mid-1970s and in 1997.

Savernake Lower

Fig.3.3a provides a general view of the site in September 1974 from the upstream limit, looking downstream. The dominant macrophyte on this site, *Schoenoplectus lacustris*, has recently been cut. Note the vertical wooden boarding on the left-hand margin, which gives the river a canal-like appearance.

Fig.3.3b was taken in December 1975, when discharge was low for the time of year, and some loss of river width was visible on the right hand side of the photograph.

Fig. 3.3c records the scene in June 1976. Although mean monthly discharge had decreased progressively since the previous December (see Fig. 2.3), water depth had increased, presumably through manipulation of the hatches further downstream at Stitchcombe Mill. As a result, water movement was minimal and a surface algal mat had accumulated around the aerial leaves of *Schoenoplectus lacustris*.

Figure 3.3d gives another view of the site in June 1976, this time taken from the downstream limit of the site, looking upstream. As before, surface and aerial leaves of *Schoenoplectus* are supporting surface mats of algae.

Fig. 3.3e was taken from the downstream limit of the site in June 1997, looking upstream. The dominant macrophyte was still *Schoenoplectus lacustris*, although it did not cover such a high proportion of the river-bed as in the mid-1970s.

Fig.3.3f demonstrates that by early December 1997, river width had decreased, relative to the position in summer 1997, and although the tall marginal vegetation had died back, some low growing emergent macrophytes were taking hold at the water margins.

Savernake Upper

Fig.3.3g is a view of the upper 50 m site at Savernake in September 1974, taken from the upstream limit looking downstream. Note the two cut tree stumps on the left-hand side and also the vertical wooden boards further downstream. In the mid-1970s this site supported a relatively stable area of *Schoenoplectus lacustris* but also seasonal growth of *Ranunculus*.

Fig.3.3h was taken in June 1976 when this site had much in common with the lower site at Savernake in that aerial stems of *Schoenoplectus* were accumulating floating mats of algae.

Fig.3.3i shows the same location in July 1997. As previously mentioned, it proved impossible to locate the 1970s marker pegs when this section of the river was re-examined and it now appears that the 1997 upper Savernake site is located marginally downstream from the 1970s site, albeit with substantial overlap between the old and new 50 m sections. The upstream limit of the 1997 site is upstream of the current deflectors and also of the large willow on the left hand bank, which is believed to be at the same location as the cut stumps seen in the 1970s photographs.

Fig.3.3j is a close-up of the river-bed just downstream of the current deflectors, whose purpose is to increase the current speed and encourage the growth of *Ranunculus*. In July 1997 it was apparent that the gravel was relatively clean in this area and that *Ranunculus* was healthy. However, it was growing in shallow water, thereby making it vulnerable to consumption by wildfowl. Note that the vertical boards present on the far bank in the 1970s have been removed and marginal emergents have been planted to narrow the channel and provide a more natural riparian zone which is capable of offering refuge for macroinvertebrates below and above the water surface.

Fig.3.3k is the same riverbank as the previous photograph but downstream, where bank-side willows have been cut and left to fall into the river, thereby reducing river width in a further effort to increase current speeds through the site.

Fig.3.3l offers a close-up in midstream near the location where the willows have been cut. Here, *Schoenoplectus* is dominant and it is noticeable that an algal mat has accumulated on nearby areas of gravel. This contrasts with the *Ranunculus* growing on clean gravel a few metres upstream where the current deflectors have provided better conditions for the growth of this macrophyte.

Fig.3.3m is a general view of the site from the downstream limit, looking upstream in December 1997.

Fig.3.3m provides a final record of the site in December 1997 from the upper limit, looking downstream. On the far bank, the sequence of current deflector, marginal emergents and cut willow bushes are clearly visible. On the near bank and into adjacent shallow water, there has been vigorous growth of *Nasturtium officinale* agg.

Figure 3.3a River Kennet at Savernake (lower). September 1974. View downstream

Figure 3.3b River Kennet at Savernake (lower). December 1975. View downstream

Figure 3.3c River Kennet at Savernake (lower). June 1976. View downstream

Figure 3.3d River Kennet at Savernake (lower). June 1976. View upstream

Figure 3.3e River Kennet at Savernake (lower). June 1997. View upstream

Figure 3.3f River Kennet at Savernake (lower). December 1997. View upstream

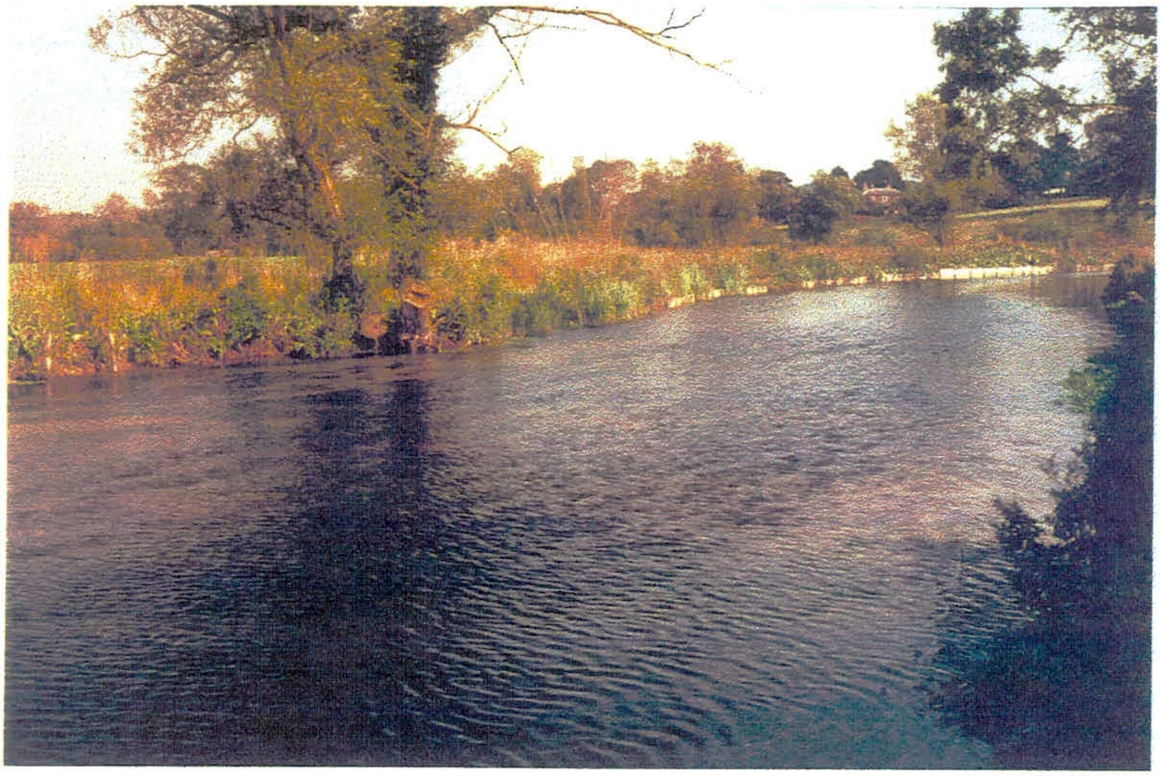

Figure 3.3g River Kennet at Savernake (upper). September 1974. View downstream

Figure 3.3h River Kennet at Savernake (upper). June 1976. View downstream

Figure 3.3i River Kennet at Savernake (upper). July 1997. View downstream

Figure 3.3j River Kennet at Savernake (upper). July 1997. Submerged and emergent macrophytes

Figure 3.3k River Kennet at Savernake (upper). July 1997. View of cut willows

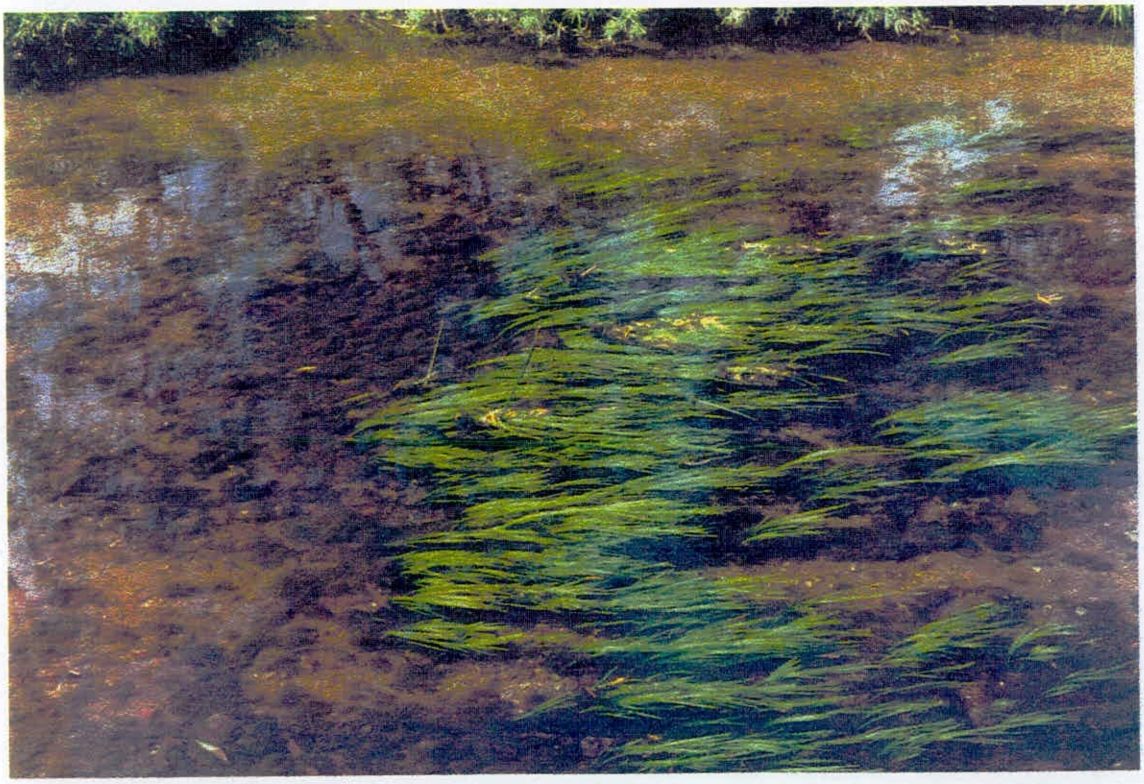

Figure 3.3l River Kennet at Savernake (upper). July 1997. *Schoenoplectus* plus algae on gravel

Figure 3.3m River Kennet at Savernake (upper). December 1997. View upstream

Figure 3.3n River Kennet at Savernake (upper). December 1997. View downstream

4. METHODS

4.1 Macrophyte mapping

4.1.1 Field procedures

A detailed account of the field procedures involved in the 'rectangles' method of mapping is presented in Wright *et al.* (1981a), but a synopsis of the approach is also given here.

Prior to mapping for the first time, it is essential to establish a straight baseline on one bank and hammer in a series of permanent stakes at 5 m intervals. This is best achieved with a transit compass, ranging poles and a measuring tape. Additional stakes are also required at 5 m intervals on the other bank at known distances from the baseline.

When mapping, a temporary grid of mapping strings is set out in order to create a 1 x 1 metre grid over the water surface. First, a 5 m tape, with numbered tags at 1 m intervals is placed between the 0 and 5 m stakes on the baseline, with a similar tape on the opposite bank. Next, a series of longer tapes (often six) which are similarly marked with numbered tags at one metre intervals are positioned across the river at one metre intervals upstream, thus linking successive metre locations on the baseline with the corresponding location on the opposite bank.

The mapping operation was occasionally undertaken by two people (eg Bagnor, June 1997), but was normally carried out by a team of three individuals. One person (the caller) stands in the river in order to describe the river-bed whilst a second (the recorder) stands on the baseline bank and marks the prepared mapping sheet with information provided by the caller. A third person normally helps with the repositioning of the cross-river tapes when it was necessary to move them upstream.

Prior to mapping, it is essential to define the features to be distinguished. For example, decisions are required on whether macrophytes can be identified to species at all times or whether species with similar morphology are to be recorded together. The range of substrata to be recorded must also be defined. From visual inspection, all particles greater than 2 mm were designated as gravel whilst those of 2 mm or less were termed silt. In practice, this last category included both sand and silt. The term silt was also retained in cases where decaying organic matter such as tree leaves was present at a given location. Note that all categories were as determined visually, irrespective of the composition of the substratum under the visible surface.

At the start of mapping, the caller entered the river downstream of the cross-river tape connecting 0 m on the baseline with 0 m on the opposite bank. The position of the nearside bank was determined to the nearest 0.5 m and relayed to the recorder on the bank who then marked the position of the bank on a blank map consisting of 50 x 100 cm rectangles representing the full 50 m length of river to be mapped. The caller then viewed the 1 m strip of river between cross-river tapes at 0 and 1 m upstream. The tapes with their numbered tags formed a 1 m grid across the river, and each square of the river-bed below was divided longitudinally, by eye, into two 1 x 0.5 m rectangles. A metal-tipped pole used by the caller was particularly useful in delimiting the metre square, by holding it vertically at the corners of the square prior to assessing each rectangle. The dominant substratum or macrophyte was determined for each rectangle, but where a macrophyte and a non-macrophyte each occupied 50%, the macrophyte was given dominance. The substratum underlying the macrophyte was also determined.

For this project the Environment Agency confirmed that only the dominant macrophyte was to be recorded, as this is the only information used in calculating the percentage cover of the habitats on each site. (In the 1970s, additional habitats within the rectangle were also recorded, although in practice this information was not used in later analyses. Collection of this additional information would have increased the time for field mapping.)

Information on each rectangle was passed to the recorder until the location of the opposite bank was given. The caller then moved one metre upstream and continued the mapping process towards the baseline for the strip of river between tapes positioned 1 to 2 m upstream. This process continued until the entire grid provided by the first positioning of the cross-river tapes had been completed. The tapes were then repositioned upstream for further mapping and this process was continued until the entire site had been mapped.

This description of mapping was as used on the River Lambourn at Bagnor, where the river was relatively narrow in relation to the River Kennet. However, the submerged and marginal emergent vegetation at Bagnor included a wide range of species, which increased mapping times. Similarly, the presence of overhanging branches and thick bushes and trees on the far bank made the positioning of mapping strings more difficult. Once tapes had been repositioned prior to mapping, checks were made that all the 1 m tags on the mapping strings were aligned in order to avoid mapping inaccuracies.

Since the Kennet sites were wider than the River Lambourn, the need to check that tapes were in alignment was even more critical on the River Kennet. At Littlecote, where the site was a full 100 m in length, the baseline itself changed direction at 50 m in order to accommodate a change in alignment of the river. At this site, the baseline established on the mown bank in 1974 was relocated in 1997. However, for ease of mapping on this very wide site, additional stakes were located at the bottom of the bank, just above the water's edge and at known distances from the true baseline. On the River Kennet at Savernake, new stakes were required. They were positioned on the mown baseline bank and left proud, as requested by Mr Hounslow where they were in full view and could be avoided during mowing operations.

On all three Kennet sites (100 m site at Littlecote, two 50 m sites at Savernake) the greater river width coupled with the fact that the habitats on the river-bed were less complex allowed the mapping grid to be increased to 100 x 100 cm squares, as used in the 1970s. Only at the bank did the mapping regime revert to 50 x 100 cm rectangles where necessary, in order to document with greater accuracy the habitats at the waters edge.

4.1.2 Laboratory procedures

Within the laboratory, EXCEL spreadsheets were prepared to represent each of the four mapped sites. The baseline was numbered 0-50 m (0-100 m for Littlecote), whilst rectangles at right-angles to the baseline were numbered 0-0.5, 0.5-1, 1-1.5 m and so on, allowing sufficient space to include the full distance from the baseline to the river, the width of the river itself and the far bank for the full length of the site. Each spreadsheet was then populated with mapping information on the dominant habitat type for each 100 x 50 cm rectangle. In the case of the Kennet sites, where 100 x 100 cm squares had been designated within the river, pairs of rectangles were substituted on the map, although single 100 x 50 cm rectangles were recorded at the river margins where these had been mapped at the site.

An automated procedure was then employed for counting the rectangles of each habitat type, from which the total area (m^{-2}) and the percentage cover of each habitat was derived. The maps and percentage cover data were derived for each of the four sites in summer and winter of 1997. The percentage cover data are presented in Chapter 5 of this report.

Please note: The 1997 computer maps, together with blank copies for each site, are being supplied to the Environment Agency as EXCEL files and hence are not included within this report.

In order to place the 1997 percentage cover data in the context of the studies during the 1970s, cover data for the shaded site on the River Lambourn (March 1971-December 1979) and all available data for the three River Kennet sites in 1974-76 were transferred to EXCEL spreadsheets for use in the production of the figures presented in Chapter 5 of this report.

4.2 Sampling for macroinvertebrates

4.2.1 Field procedures

The Lambourn sampler (Hiley *et al.* 1981) was used to obtain samples of macroinvertebrates on each of the four study sites, as in the 1970s. The dimensions of the sampler were 20 x 25 cm, resulting in a sampling unit of 0.05 m^2. For each habitat, five sampling units were taken in each season.

In general, the choice of habitats to be sampled on each site was made with a view to maximising the comparisons which could be made with samples taken in the 1970s. There was one exception to this general rule on the River Lambourn at Bagnor. The recent lack of management related to fisheries interests had resulted in the development of both low growing and tall marginal emergent species, at a time when submerged macrophytes were poorly represented. Although no comparisons would be possible with the 1970s, the area of this variable but potentially important habitat in both June and December warranted further investigation.

Quantitative sampling for macroinvertebrates on the major habitats took place after the mapping operation and was dependent on the availability of the map. In order to select potential locations for the five sampling units on each habitat, a series of four digit random numbers were used. The first two numbers represented distance along the baseline (0-50 or 0-100 m in the case of Littlecote) and the second two digits represented distance at right angles from the baseline. Thus, most of the four digit numbers represented locations within the mapped site and in this way sampling locations were chosen for each habitat type.

It was normal to obtain not just five sampling locations for each habitat type (representing the five sampling units required) but to have two reserve locations in case any of the original five proved to be inappropriate when sampling was underway. Ideally, mapping and sampling took place on separate days, with selection of the locations for sampling carried out in the laboratory. However, in cases where it was essential to undertake sampling on the same day after mapping, it was feasible to draw on a store of four digit random numbers and undertake the selection of sampling locations in the field.

The field procedure for taking macroinvertebrate samples was as follows. All sampling was carried out from the downstream limit of the site working upstream. Mapping tapes were positioned as required to locate the first sample on the river-bed and the Lambourn sampler was then lowered over the chosen location and forced into the substratum to a depth of 6 cm using both hand and foot pressure. The removal of all plant material and substratum to a depth of approximately 6 cm was carried out by hand, with further help from a small trowel for cutting through weed and removing substratum into the collecting net at the downstream limit of the sampler. The large collecting net was then removed from the frame of the sampler and by careful dipping the net and its contents into the current, the contents were concentrated into the bottom of the net.

Once on the bank, the sample was transferred into a labelled polythene bag. No water or Forman was added at this time as all samples were subjected to an initial clean-up in the laboratory the following day, prior to preservation. Samples were kept cool throughout the period before preservation. The need to move the mapping tapes periodically to collect samples from the river-bed and to transfer the net contents to labelled polythene bags meant that the ideal team for sampling was three or more team members.

4.2.2 Laboratory procedures

Each macroinvertebrate sampling unit taken with the Lambourn sampler included macrophyte, mineral material, detritus and macroinvertebrates, except for those taken on gravel and silt, which lacked the macrophyte component. Again the laboratory procedures closely mirrored those used in the 1970s (Wright *et al.* 1983).

The macrophytes were removed by flotation and carefully searched for invertebrates. Most of the invertebrates from the mineral fraction of the substratum were separated by elutriation. To achieve this, the sampling unit was placed in a bucket of water, thoroughly stirred by hand and allowed to settle until most of the mineral fraction was no longer in suspension. The water was immediately poured off through a 45 mesh sieve to collect animals and detritus. This process was repeated with clean water until no more animals were washed out. The remaining mineral material frequently contained some stone-cased caddis larvae and molluscs. Large particles were individually examined for attached caddis and molluscs, smaller particles were picked over to remove additional specimens but fine mineral material was retained and added to all previously removed macroinvertebrates before being fixed and preserved using 5% formalin in a labelled polythene bag.

The sorting and identification procedure for each sampling unit was as follows. The sample was placed in the upper of a pair of 45 and 12 mesh sieves and the formalin removed by thorough washing. The coarse and fine mesh fractions were then processed separately.

First, the coarse fraction was put into a series of trays and, on the basis of the amount of material and abundance of the macroinvertebrate fauna, a decision was reached on the proportion of the coarse fraction to be sorted and identified. This varied from the entire coarse fraction to a half or sometimes a quarter of the fraction. All specimens in the designated fraction were removed and identified to family level. The results were entered on a standard data sheet and a multiplication factor applied to estimate the total number of each family in the fraction.

The fine fraction was subjected to a similar procedure, except that the proportion sorted and identified normally varied from one half to one eighth of the total. Again, the number of individuals in each family were determined and entered on the same data sheet before an appropriate multiplication factor was applied. The totals from the coarse and fine fractions were then added to obtain the estimated number of macroinvertebrates in each family within the sampling unit. All sheets were independently checked for accuracy.

On completion of all samples from the 1997 sampling programme, the data from the five sampling units on each habitat, site and month were entered into a Microsoft Access database and verified. A query was then developed in Access for calculating the mean density of each family from a set of five sampling units on a given habitat type.

The macroinvertebrate data for the shaded site on the River Lambourn in the 1970s had already been transferred to an Access Database in a separate IFE project. However, all the 1974 and 1975 data for the River Kennet at Littlecote and Savernake was also entered in order to be able to undertake selected comparisons with the results from the 1997 sampling programme.

One major group of macroinvertebrates, the Oligochaeta, was treated differently in the 1970s and 1997 research programmes. In the 1970s, no attempt was made to count the total number of oligochaetes per sampling unit. During the first twelve months of the study at Bagnor (March 1971 – February 1972), the view was taken that because some oligochaetes undergo fission and others are damaged during the processing of samples, the oligochaetes would be picked out and then weighed as a group. The one exception to this was the Lumbricidae which, being large, were counted individually and kept separate from all other Oligochaeta. In later years at both the River Lambourn and the River Kennet sites, the Lumbricidae were still counted individually, but no numerical information was available on other oligochaetes.

In 1997, the decision was taken to count the Lumbricidae as before, but also to count all other Oligochaeta and input both categories to the database, in order to have more comprehensive information for future reference. However comparison of densities observed in 1997 and the 1970s were limited to the Lumbricidae and when comparisons were made of macroinvertebrate 'family' richness between years, the Oligochaeta and Lumbricidae counted as one 'family' and all 1970s samples were assumed to include Oligochaeta.

Mann-Whitney U-tests were used on the density counts from the five sampling units from a given habitat to compare years (i.e. 1997 with one other year during the 1970s). Note that the Mann-Whitney U-test is a non-parametric ranking procedure and that it tests for differences between the median rather than the mean values. However, as Elliott (1977) points out, if the medians are significantly different, then so are the means, but this assumption is not part of the test. The tests were undertaken in Minitab. In cases where a family was absent from each of the five sampling units in a given year but present in some units of the other year, it was calculated that when the family was present in four units the level of significance was <0.05% and when present in all five sampling units, the level of significance was <0.01%.

5. RESULTS OF MACROPHYTE MAPPING

5.1 R. Lambourn at Bagnor (shaded site)

The results obtained by mapping the site in June and December 1997, together with the maximum, minimum and mean percentage cover of the major habitat types for the site over the period January 1971 to December 1979 are presented in Table 5.1. The table also includes information on the total wetted area of the study site, expressed in square metres (m^2).

It is apparent that in 1997, the shaded site was very different from the typical condition observed during the 1970s. The total wetted area of the site decreased between June and December 1997 and was always below the mean wetted area recorded through the 1970s, although above the minimum area recorded during that period.

Table 5.1 R. Lambourn at Bagnor (shaded site). Total area of the 50 m site and the % cover of the major habitat types in June and December 1997. Historical data for the period January 1971 - December 1979 is also presented as maximum, minimum and mean values.

Date(s)	Total Area	Percentage Cover					
	m^{-2}	Berula	Call	Gravel	Ran	Silt	Other
June 1997	387	5.8	24.9	29.3	6.2	17.6	16.2
December 1997	372	9.3	1.6	44.2	2.6	31.2	11.1
71-79: Max	454	65.9	48.1	79.0	44.2	48.8	16.5
71-79: Min	336	0.5	0.0	5.7	0.1	2.8	0.0
71-79: Mean	409	38.3	10.3	26.3	13.7	9.7	1.5

Berula, the dominant macrophyte at the shaded site for most of the 1970s occupied less than 10% of the site on the two mapping dates. *Callitriche* was dominant in June (24.9%) but had largely disappeared by December, whereas *Ranunculus* was scarce in both seasons. During the 1970s other macrophytes were rarely important, but recent lack of management has allowed a number of marginal emergent macrophytes to develop. These include *Nasturtium officinale* agg., *Mentha aquatica*, *Phalaris arundinacea* and *Veronica anagallis-aquatica*. The drought conditions also allowed the progressive build-up of silt between June and December. Despite this siltation, the most important habitat in terms of area remained gravel, which increased from 29.3% in June to 44.2% in December, largely due to the loss of *Callitriche*.

A more detailed view of the shaded site during the 1970s, for comparison with the results from 1997, is presented in Fig. 5.1. The main value of being able to place the June and December 1997 mapping results against a nine-year run of data is that long-term stability, seasonal changes and atypical features can all be observed in the 1970s dataset and may help with the interpretation of the 1997 results.

Figure 5.1 demonstrates very clearly that *Berula* was normally the dominant macrophyte and that even during the drought of 1976, its percentage cover was never as low as in 1997.

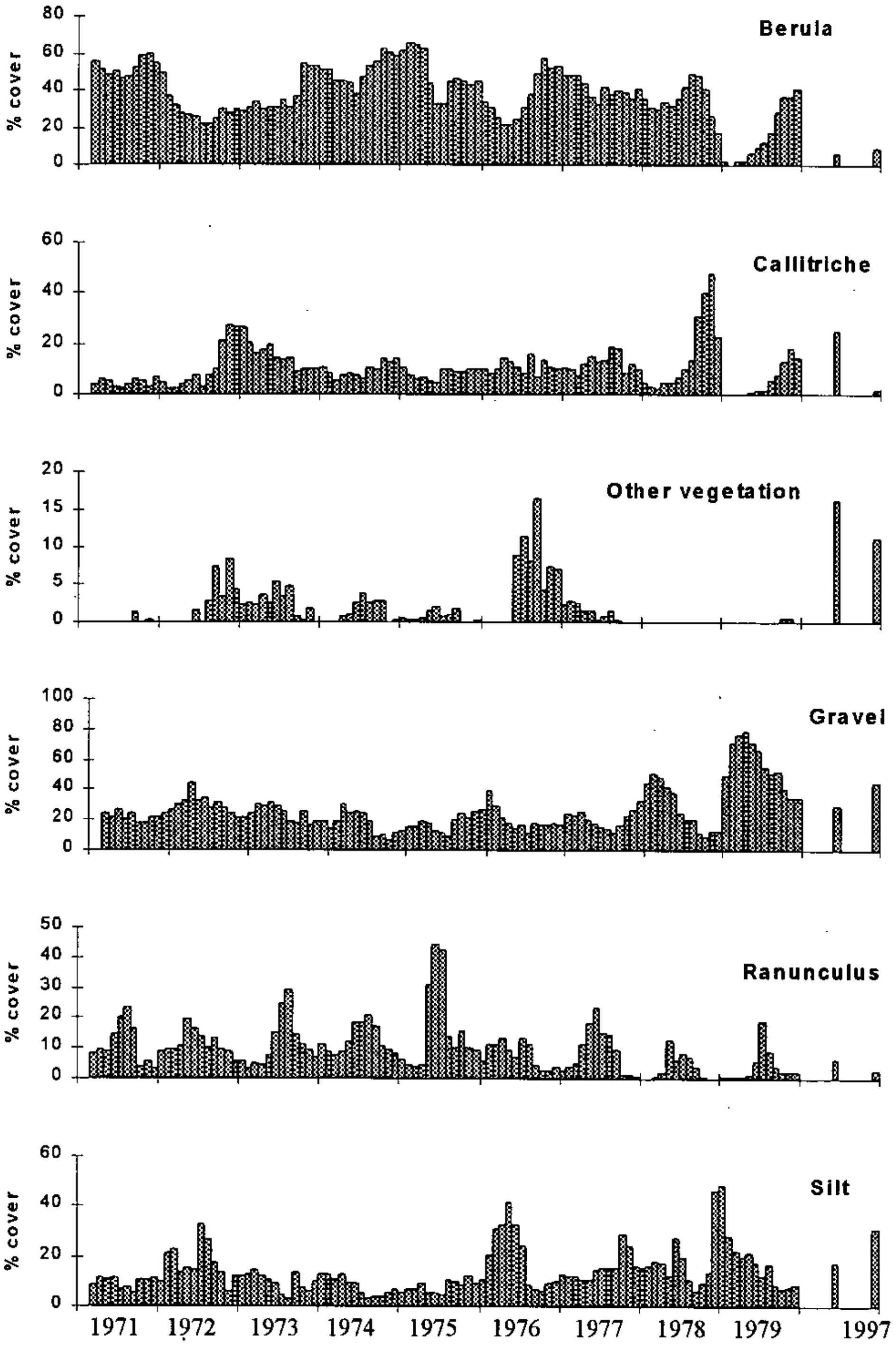

Figure 5.1 R.Lambourn at Bagnor (shaded site). Percentage cover for each major habitat type between March 1971 and December 1997, together with the results of mapping in June and December 1997. (% cover scale varies with habitat).

However, there was a short period at the end of 1978 and early in 1979 when the area of *Berula* decreased dramatically before showing a progressive increase to former levels. The reason for the loss of *Berula* was never understood at the time, although the build-up of silt within the carpets of *Berula* was noted (Berrie *et al.* 1980). Even now, we can only speculate on the possible causes of this event.

Although the total area of *Berula* tended to be relatively stable during the 1970s, this macrophyte was always colonising new areas of gravel and being ripped out of other areas, following the progressive build-up of sand and silt within the plants which made the root system less secure. It is possible, but unproven, that the drought of 1976 which allowed much silt to be deposited on the river-bed, had a long lasting impact on the river and that over the next two years, large quantities of silt moved down the river to be re-deposited downstream. If siltation of beds of *Berula* during this period eventually lead to much of the carpet of *Berula* becoming unstable in one season, then a catastrophic loss could occur, resulting in a major increase in the area of gravel, as in 1979.

It is possible that the major drought in the early 1990s meant that a large quantity of silt was slow to move down the system and had a detrimental effect on the area of *Berula*. Mr Robins commented on the need to remove accumulated silt from the site some time prior to the present study. On the other hand, the amount of shading due to overhanging trees and tall emergent vegetation may also be a limiting factor to the growth of *Berula* in summer.

Callitriche increased in area in late 1978 when *Berula* decreased and silt increased in area at the same time. *Callitriche* was also prolific in June 1997, when *Berula* was scarce. *Ranunculus* displayed the normal seasonal pattern of growth and recession during the 1970s, and it too was scarce in 1997, probably due to a combination of the low discharge and heavy shading.

The abundance of emergent vegetation in 1997 was due to a combination of lack of bank-side management and also drought conditions, which favoured the growth and survival of a variety of low growing and tall emergents in June and low growing species in December 1997. The only occasion during the 1970s when additional macrophytes became abundant at the site was during the major drought in summer 1976. During this period, it was *Elodoea*, a submerged macrophyte that grew within beds of *Berula*, rather than additional bank-side emergents, which contributed to the major part of this increase in recorded 'other vegetation'.

Finally, although the area of silt was considerable in 1997, as might be anticipated from the low flow conditions, the midstream gravel was clean. This would be a suitable habitat for the future growth of both *Berula* and *Ranunculus*, assuming that sufficient light penetrates the site in future years and a satisfactory flow is maintained

5.2 R. Kennet at Littlecote

In the 1970s, the Littlecote site was maintained as a free-flowing section of river and managed to provide optimal conditions for trout fishing. This strategy has been maintained and in 1997 the site looked much as it did in the mid-1970s, with the proviso that the site was experiencing a major drought.

Table 5.2 provides information on the area of the river and percentage cover of the major habitat types in 1997, for comparison with the maximum, minimum and mean values obtained between April 1974 and June 1976 when mapping ceased. The total area of the site in June and December 1997 was well within the limits observed during the mid-1970s, and actually increased between July and December. *Ranunculus* was the dominant macrophyte, as in the 1970s and although the percentage cover was lower than the mean value for 1974-76, it appeared to be healthy. It was also notable that there was no substantial build-up of silt on the site and that the area of clean gravel exceeded 30%. The major difference between 1997 and the earlier mapping period concerned the area of other macrophytes. In July 1997 the area was 16.8%, rising to 29.7% in December, whereas in the mid-1970s, the area of other macrophytes never exceeded 3.4%.

Table 5.2 R. Kennet at Littlecote. Total area of the 100m site and the % cover of the major habitat types in July and December 1997. Historical data for the period April 1974 - June 1976 is also presented as maximum, minimum and mean values.

Date(s)	Total Area m^{-2}	Percentage Cover Gravel	Ran	Silt	Others
July 1997	1244.5	35.9	44.2	3.1	16.8
December 1997	1310	30.5	38.9	0.9	29.7
74-76: Max	1395	71.7	84.0	11.6	3.4
74-76: Min	926	12.2	16.2	0.3	0.0
74-76: Mean	1225	38.8	57.2	2.4	1.6

Figure 5.2 presents the detailed mapping results from 1974-76 together with the results for 1997. Despite extensive bar-cutting of *Ranunculus* in both 1974 and 1975, the area of *Ranunculus* in July 1997 was lower than in July 1974 or 1975. However, by July 1997, it was growing vigorously towards the water surface, although not yet in flower. In late June 1976, the last month in which the site had been mapped during the historic drought, *Ranunculus* occupied a much smaller area of the river-bed and had actually decreased from the area present in March of that year. The normal increase in area had failed to occur because the weed was smothered by an abundant growth of epiphytic algae and associated detritus (University of Reading, 1977). Note also that in late June 1976, the area of silt had increased considerably, a feature not observed in July 1997.

The major differences in the percentage of emergent vegetation between 1997 and the mid-1970s are striking, but amenable to simple explanation. In July 1997, the emergent vegetation was dominated by *Veronica anagallis-aquatica*, much of which occurred in the upper half of the site on a shallow gravel bank which had been entirely exposed during the major drought of 1976 (see Fig 3.2c which shows this feature in March 1976). By December 1997, this macrophyte had died back, to be replaced by *Nasturtium officinale* agg. not only on the gravel bank, but also along the margins of the site (See Fig.3.2h). Note that in a photograph taken in August 1976 (Fig.3.2e) *Nasturtium officinale* agg. had also started to develop in a similar manner during the height of the drought.

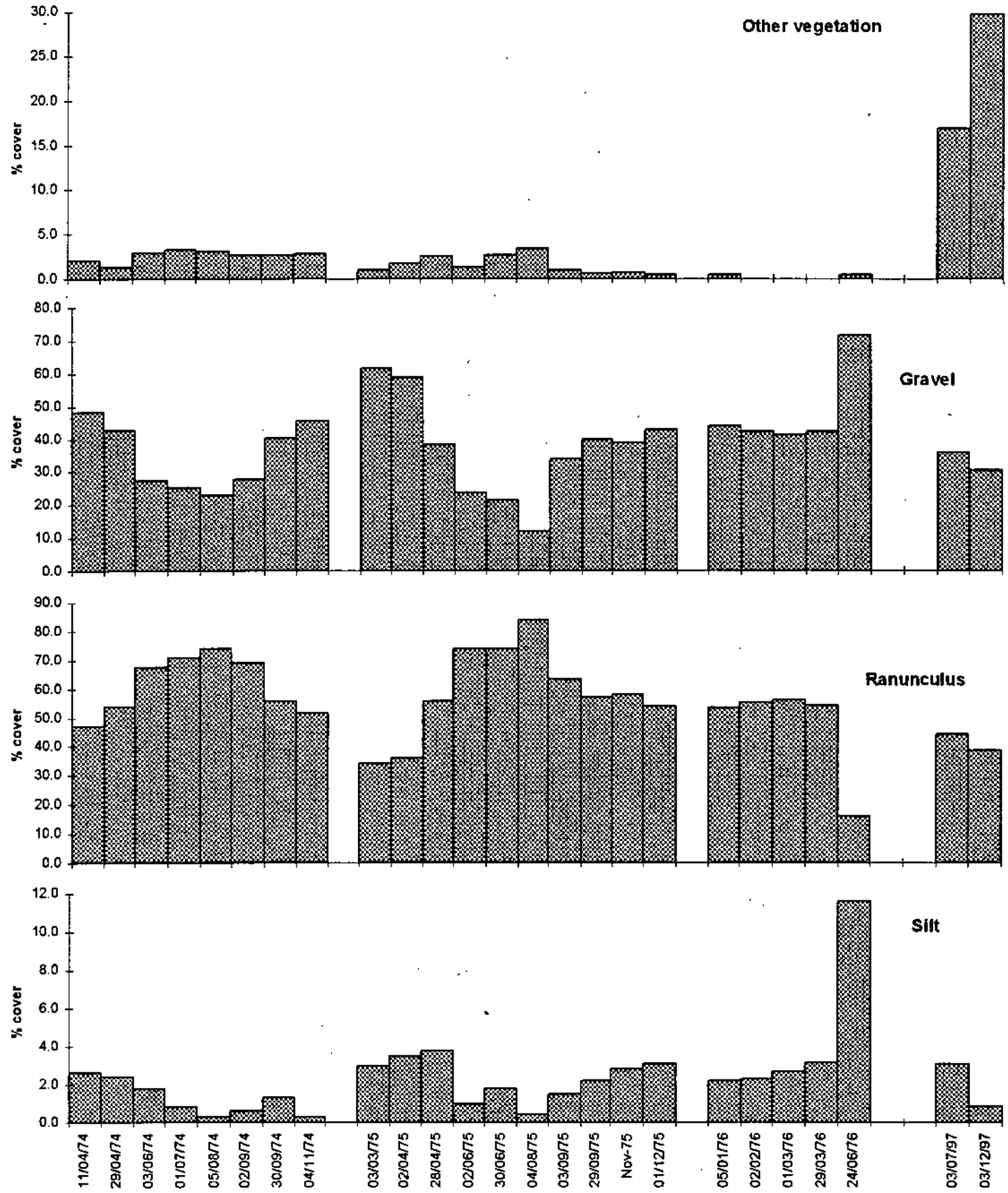

Fig 5.2 R.Kennet at Littlecote. Percentage cover data for each major habitat type between April 1974 and June 1976, together with the results of mapping in July and December 1997. (% cover scale varies with habitat).

5.3 R. Kennet at Savernake (lower and upper sites)

5.3.1 Results for Savernake (Lower)

As previously indicated, the management regime at Savernake in 1997 was very different from that in the 1970s and therefore some changes at the study sites were to be expected. Table 5.3 presents information on the area of the site and percentage cover of the major habitat types in 1997, together with summarised data for the period from April 1974 to April 1976.

The total area of the lower site decreased between July and December 1997, by which time it occupied a smaller area than at any time during the two-year study period in the 1970s. This was a consequence of the current water level management policy in which the river is being allowed to run freely but also a result of the low discharge in 1997.

Although *Schoenoplectus* remained the dominant macrophyte in 1997, it was recorded in less than a third of the area it occupied in the mid-1970s. This may be because of the recent water level policy, as *Schoenoplectus* is more commonly associated with the deep slow-flowing water regime adopted in the mid-1970s.

Table 5.3 R. Kennet at Savernake (Lower). Total area of the 50 m site and the % cover of the major habitat types in July and December 1997. Historical data for the period April 1974 - April 1976 is also presented as maximum, minimum and mean values.

Date(s)	Total Area m^{-2}	Percentage Cover				
		Gravel	Ran	Schoen	Silt	Other
July 1997	569.5	61.2	0.9	17.4	18.2	2.5
December 1997	536.0	53.6	0.2	11.8	14.1	20.3
74-76: Max	686.0	38.6	19.3	66.5	23.5	3.2
74-76: Min	553.0	14.5	0.0	55.0	1.0	0.0
74-76: Mean	661.3	25.9	4.3	60.0	8.6	1.2

So far, the new regime has not produced a positive response from *Ranunculus*, and this, together with the limited percentage cover of *Schoenoplectus* caused the area of gravel to be greater in 1997 than the maximum value recorded in the mid-1970s. Unfortunately the area of silt was also greater than the mean value for the mid-1970s. Whereas 'other' macrophytes were unimportant in July 1997, by December they had increased to 20.3%, with *Callitriche* at 17.9% being the most important of the 'other' species.

Figure 5.3 shows the detailed mapping results from 1974-76 and also for July and December 1997. The stability of the area of *Schoenoplectus* between April 1974 and April 1976 is very striking and is largely due to the fact that the strap-like leaves of this species grow from a woody rhizome system which spreads very slowly. The limited area recorded in 1997 must result in loss of suitable habitat for macroinvertebrates.

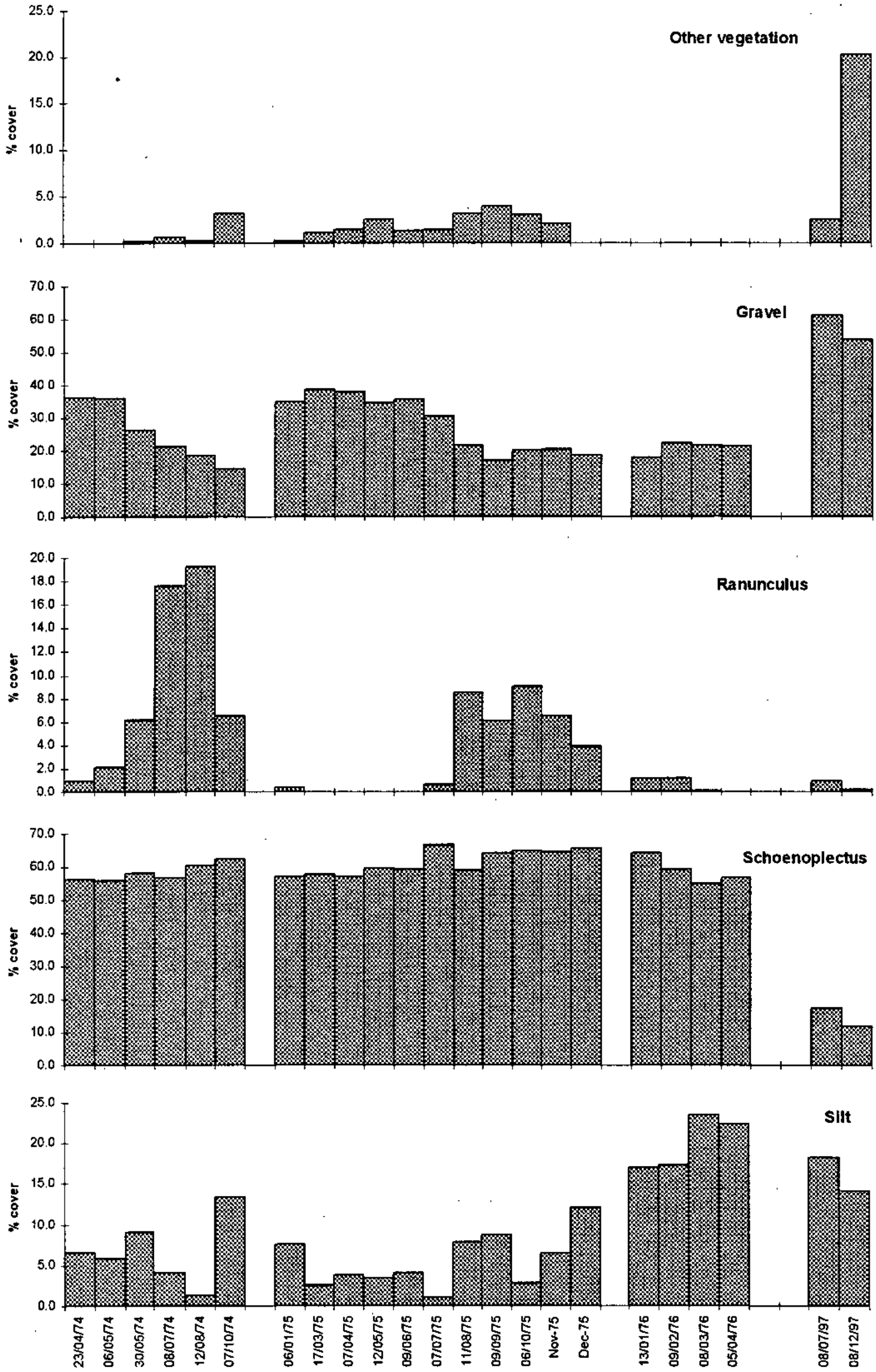

Fig 5.3 R.Kennet at Savernake (Lower site). Percentage cover for each major habitat type between April 1974 and April 1976, together with the results of mapping in July and December 1997. (% cover scale varies with habitat).

In 1974-76, *Ranunculus* was restricted to the edges of the river at this site, where the water was shallower. The area of this macrophyte varied between 1974 and 1975 but was always low in relation to its percentage cover at Littlecote, further downstream. In July 1997, the area of *Ranunculus* at Savernake was very low, despite the implementation of a flow regime which should favour the growth of this species.

The area of silt increased during the first months of 1976, probably due to the strategy of ponding the river by manipulation of the hatches at Stitchcombe Mill. Silt also accumulated in 1997, despite the fact that the river was being allowed to run freely. By December 1997, the low current speed and silted substratum provided suitable conditions for the growth of *Callitriche*, which became the dominant macrophyte at this site.

5.3.2 Results for Savernake (Upper)

Table 5.4 presents information on the total area and percentage cover of the major habitats on the upper site at Savernake in July and December 1997, together with summary data for 1974-76.

In 1997, the upper site occupied a smaller total area than in the mid-1970s for a number of different reasons. These included the new water level policy, the use of current deflectors, the planting of marginal emergents and the cutting of marginal willows to narrow the effective river width. (The river-bed beneath the cut willows was not included in the calculation of total mapped area because it was not possible to obtain macroinvertebrate samples from it, despite the fact that it was under water.) As previously indicated, it was impossible to relocate the exact 1970s site prior to the 1997 re-staking operation and only on completion of the summer mapping operation was it recognised that there was only a partial (ca. 70%) overlap between the 1970s and 1997 mapping site. However, this may not have affected the total area mapped.

Table 5.4 R. Kennet at Savernake (Upper). Total area of the 50 m site and the % cover of the major habitat types in July and December 1997. Historical data for the period April 1974 - April 1976 is also presented as maximum, minimum and mean values.

Date(s)	Total Area m^{-2}	Percentage Cover Gravel	Ran	Schoen	Silt	Other
July 1997	551.0	64.5	6.5	2.7	22.0	4.4
December 1997	541.5	52.5	8.1	2.2	19.2	17.9
74-76: Max	806.0	70.9	45.2	28.5	28.3	9.1
74-76: Min	597.0	23.4	0.0	12.5	1.4	0.0
74-76: Mean	766.0	49.5	19.1	21.8	7.0	2.5

Although *Ranunculus* was the dominant macrophyte at this site, it covered less than 10% on each mapping occasion, less than half of the mean area that it occupied during the mid-1970s. Much of the *Ranunculus* occurred in the upstream section of the site and where the current deflectors increased the current velocity. *Schoenoplectus* was still present at the site, but once again, its area had diminished very considerably from that recorded in the mid-1970s, and was never more than 3%. In consequence, gravel was the dominant habitat at this site, followed by silt, and the areas of gravel and silt recorded in July and December 1997 were well above the mean areas recorded in the mid-1970s. Finally, other macrophytes played a significant role at this site, because of the sparse cover of *Ranunculus* and *Schoenoplectus*. In particular, in December 1997 the area of other macrophytes was 17.9%, of which *Callitriche* (12.5%) was the major species.

A more detailed record of the April 1974 to April 1976 mapping results, together with the results for July and December 1997, is given in Figure 5.4. It is apparent that in the mid-1970s, *Ranunculus* became the dominant macrophyte in the summer of 1974 and 1975. It should also be noted that when mapping ceased in April 1976, there had been no recorded cover of this macrophyte since December 1975. In fact, the cover of *Ranunculus* in July and December 1997 was only marginally different from the equivalent months in 1975. It is unknown whether the area of *Ranunculus* was greater in late summer 1997.

However, the percentage cover data by itself fails to indicate the importance of *Ranunculus* on the upper site during the 1970s. For example, in April and May 1974, growth of *Ranunculus* formed large weeds beds at the surface which flowered and resulted in the need for weed-cutting. This took place at the beginning of June and involved the control of both *Ranunculus* and *Schoenoplectus*. Both species recovered rapidly and another weed cut was needed by September (University of Reading, 1977).

In contrast, during the spring and summer of 1975, up to 27 swans were seen feeding on the section of river between Stitchcombe Mill and Durnsford, upstream of the study sites. The swans fed selectively on *Ranunculus* and grazing pressure was so great that the area of *Ranunculus* did not start to increase until July. Only in August 1975 did *Ranunculus* assume dominance over *Schoenoplectus* at the upper site. This contrasts with the previous year when *Ranunculus* remained the dominant macrophyte throughout the summer.

Schoenoplectus maintained a relatively stable area of weed throughout the two year mapping sequence in the 1970s, albeit at a lower percentage cover than at the lower site at Savernake. This was to be expected because the upper site was shallower and more suitable for *Ranunculus*. In July and December 1997 the area of *Schoenoplectus* was less than 3% and it was apparent that this macrophyte had undergone a substantial reduction in percentage cover at some point in the intervening period.

During the onset of the historic drought of 1976, the percentage cover of silt increased substantially, and in both July and December 1997, silt was also a major habitat at this site, despite the strategy of allowing the river to run freely. This was partly due to the fact that slack water occurred close to the banks downstream of the flow deflectors, particularly near the bank opposite to the baseline.

As previously indicated, much of the increase in other macrophytes in December 1997 was due to growth of *Callitriche*, as also seen at the lower site at Savernake. However, some low growing marginal emergents were also recorded, in particular *Nasturtium officinale* agg. which occupied 3.8% cover.

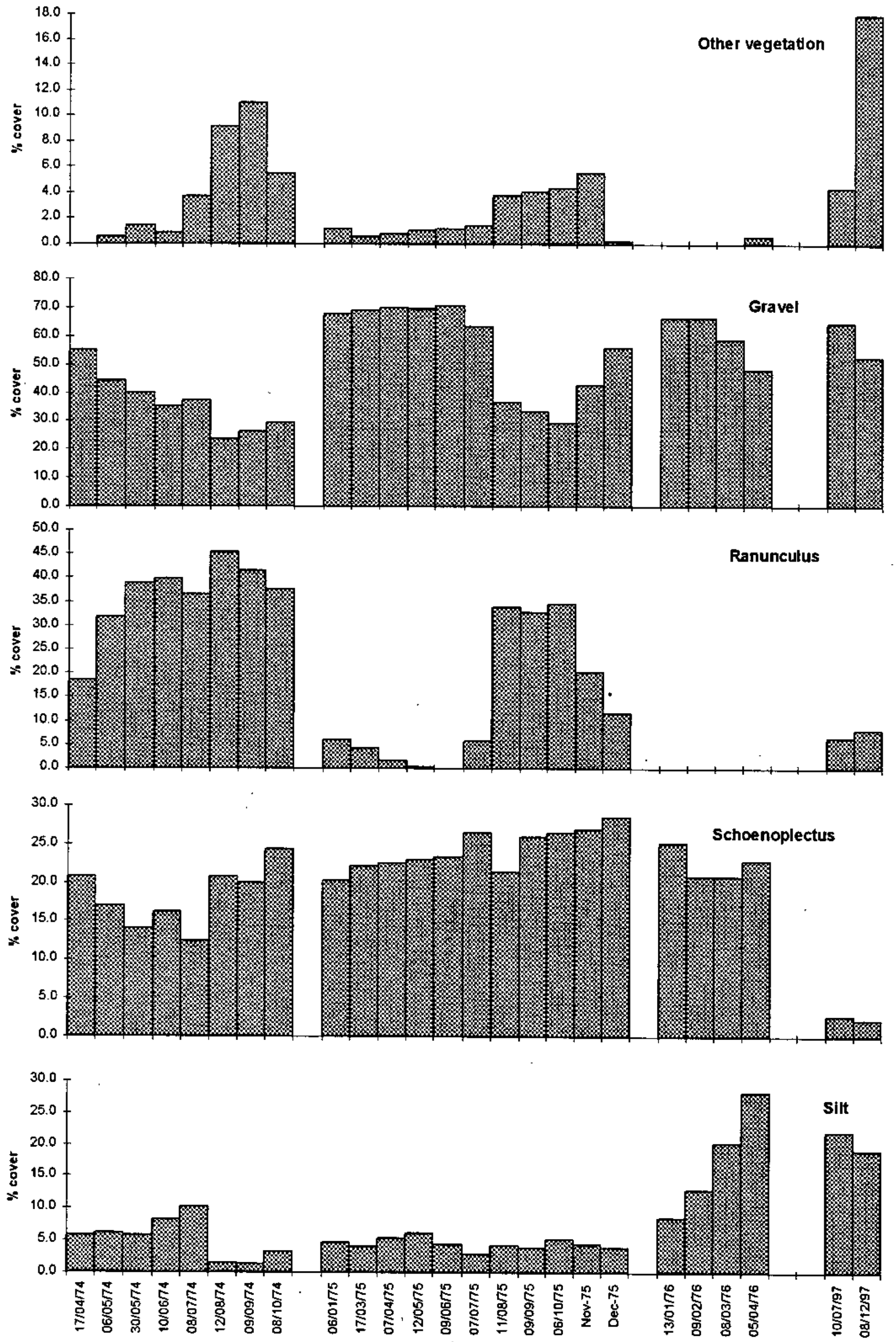

Fig 5.4 R.Kennet at Savernake (Upper site). Percentage cover for each major habitat type between April 1974 and April 1976, together with the results of mapping in July and December 1997. (% cover scale varies with habitat).

6. RESULTS OF MACROINVERTEBRATE SAMPLING

Please note: Information on the abundance of each macroinvertebrate family in each of the five sampling units for each habitat, season and study site is held in the Access Database being made available to the Environment Agency. In consequence, the raw data will not be presented within this report.

6.1 R. Lambourn at Bagnor (shaded site)

6.1.1 Family richness

The number of families of macroinvertebrates recorded on each habitat type (i.e. total number of families from 5 sampling units) in June 1997 is shown in Table 6.1. This table also provides information on the maximum, minimum and mean number of families recorded on the same habitats during the detailed studies undertaken in the 1970s. Note that the comparison is restricted to 1971 plus 1974-79 when the laboratory processing technique was the same as that used in 1979. (In 1972 and 1973, it was necessary to pool and then sub-sample the five sampling units from a given habitat). No macroinvertebrate samples were taken from emergent macrophytes during the 1970s because they rarely occupied a significant area of the river-bed. However, their importance in 1997 warranted additional sampling to determine their characteristic fauna.

Table 6.1 R. Lambourn at Bagnor (shaded site) in June 1997. Number of families of macroinvertebrates recorded on each habitat (total from 5 sampling units). Maximum, minimum and mean values derived from 7 years (1971+1974 to 1979) are also given.

Date(s)	Ber	Call	Grav	Ran	Silt	Emerg.
June 1997	30	32	25	31	24	33
1970s: Max	41	39	36	41	33	No data
1970s: Min	22	30	27	29	23	No data
1970s: Mean	33.1	33.0	31.9	33.9	28.2	No data

Without exception, the number of families recorded on each habitat was lower in June 1997 than the mean value from seven years of sampling in the 1970s. Interestingly, the habitat type with the most families in June 1997 was emergent macrophyte. In practice this comprised sampling units from four different species of macrophytes, and therefore a wide range of different families might be anticipated. In June, gravel and silt supported fewer families than the macrophytes.

In December 1997, taxon richness at family level was either higher than or as high as in June 1997 in the five habitats also sampled in the 1970s (Table 6.2). The tendency for family richness to be higher in December than June is normal, and may also be seen in the mean values from the 1970s (Tables 6.1 and 6.2). However, with the single exception of *Berula*, family richness in December 1997 remained lower than the mean richness recorded for each habitat in the 1970s. Against the general trend, the samples taken on emergent vegetation in December 1997 held marginally fewer families than the samples taken in June of that year. In December, many of the tall emergent macrophytes present in June had died back, to be replaced by low growing taxa including *Nasturtium officinale* agg. and *Mentha aquatica* and this may have been a factor in determining family richness on this occasion.

There was a general tendency for the mean number of families per habitat to be lower in June and December 1997 than the mean value for the 1970s. There were also a few cases where the number of families recorded in a given habitat in 1997 fell below the seven-year minimum for the 1970s. These included gravel in June 1997 and also *Ranunculus* and silt in December 1997. However, an appraisal of the full family listings for the site is required to determine whether there have been any changes in family composition between the 1970s and the 1997 sampling programme.

Table 6.2 **R. Lambourn at Bagnor (shaded site) in December 1997. Number of families of macroinvertebrates recorded on each habitat (total from 5 sampling units). Maximum, minimum and mean values derived from 7 years (1971+1974 to 1979) are also given.**

Date(s)	Ber	Call	Grav	Ran	Silt	Emerg.
December 1997	42	32	33	33	27	32
1970s: Max	44	43	40	42	40	No data
1970s: Min	35	32	33	39	29	No data
1970s: Mean	41.0	37.4	36.4	40.5	35.0	No data

Table 6.3 gives overall family richness at the site in relation to the season and year. Forty-six families were recorded in June 1997, of which 42 were found in the five habitats sampled in the 1970s. In the seven years 1971 plus 1974-79, the total number of families from five habitats varied from 42 to 47. Although there was no clear evidence of a loss of family richness in June 1997, it was at the lower limit of the seven-year range for the 1970s.

In December, a total of 52 families were captured, of which 49 were present on the five habitats sampled in the 1970s. Over the seven years 1971 plus 1974-79 the number of families recorded from the five habitats varied from 43 to 51.

Finally, a grand total of 58 families were recorded on the shaded site in 1997 (June and December combined) of which 52 were found on the five habitats also sampled in the 1970s. The number of families recorded per year in the 1970s varied from 46 to 53.

Table 6.3 **R. Lambourn at Bagnor (shaded site). Number of families of macroinvertebrates captured on five habitats (plus additional families from emergent macrophytes) by season and year in 1997. Also included are the maximum and minimum values from five habitats sampled in 1971 plus 1974 to 1979.**

Year/Month(s)	June	December	June + December
1997	42 (46)	49 (52)	52 (58)
1971+74-79: Min	42	43	46
1971+74-79: Max	47	51	53

Thus, we may conclude that there was no evidence of loss of overall family richness on the shaded site at Bagnor in 1997. This was despite the fact that many individual habitats were relatively taxon poor in both June and December 1997 in relation to the 1970s.

6.1.2 Family composition and abundance data for 1997

Table 6.4 presents a list of the 46 families of macroinvertebrates and their mean densities on each of the six habitat types sampled in June 1997. Note that the Oligochaeta and Lumbricidae, although presented separately, are counted as a single 'family' for the purposes of this and later analyses. (See section 4.2.2 for an explanation of the need for this protocol.) The faunal list for June includes 16 'families' of non-insects and 30 families of insects.

The densities of individuals in many of these families vary considerably between seasons due to life cycle phenomena, but they also vary between years (Wright and Symes in press). Hence, selected between-year comparisons were undertaken for some habitat types (Section 6.1.3) in an attempt to pinpoint those components of the macroinvertebrate assemblage which were sensitive to environmental change.

Table 6.5 presents a list of the 52 families captured in December 1997, together with their mean densities. They included 16 families of non-insects (of which two were additions to the June listing) and 36 families of insects (of which 10 were additions).

The total number of families recorded from the June and December sampling was 58 (Table 6.3). Twelve families found in December 1997 were not recorded in June, whereas only six families recorded in June were not captured in December. The full list of non-insect 'families' for 1997 comprised Tricladida (2 families), Mollusca (7), Oligochaeta (listed as one 'family'), Hirudinea (3), Hydracarina (listed as one 'family') and Crustacea (4). The insects included Ephemeroptera (6 families), Plecoptera (2), Hemiptera (2), Coleoptera (4), Megaloptera (1), Trichoptera (13) and Diptera (12). This represents a very rich assemblage of macroinvertebrates within a 50 m single site.

A database including all samples taken on five habitats in the 1970s (March, June September and December 1971, plus June and December 1972-79) indicated that a total of 59 families of macroinvertebrates were recorded from the shaded site at Bagnor. This is only one family more than the total of 58 families captured on the site in 1997, when six habitats were sampled. There were 53 families in common between the two listings. The following families were confined to one sampling period:

1970s samples only

Coleoptera:	Hydrophilidae
	Scirtidae
	Dryopidae
Trichoptera:	Brachycentridae
Diptera:	Tabanidae
	Muscidae

1997 samples only

Crustacea:	Niphargidae
Trichoptera:	Beraeidae
	Odontoceridae
Diptera:	Ephydridae (emergents only)
	Lonchopteridae (emergents only)

Table 6.4 **R. Lambourn at Bagnor (shaded site), June 1997. Mean densities of macroinvertebrate families (nos. 0.05 m^{-2}) based on 5 sampling units for each habitat.**

Family name	Berula	Callitriche	Gravel	Emergents	Ranunculus	Silt
Planariidae	2.8	1.6	1.4	0.2	0.8	0.8
Dendrocoelidae	0.4	0.0	0.0	0.0	0.0	0.0
Valvatidae	0.8	0.0	0.0	0.0	0.0	0.0
Hydrobiidae	13.2	14.4	7.6	34.0	11.2	6.0
Physidae	0.0	0.8	0.0	0.6	0.0	0.0
Planorbidae	0.0	1.4	0.0	3.6	0.0	0.0
Ancylidae	0.4	0.4	1.0	2.4	0.8	0.0
Sphaeriidae	12.8	7.4	4.6	0.4	2.4	18.0
Oligochaeta	178.4	122.0	44.4	16.2	70.0	53.8
Lumbricidae	6.8	0.0	4.8	0.0	9.4	2.6
Piscicolidae	0.4	0.0	0.0	0.6	0.0	0.4
Glossiphoniidae	5.6	3.0	3.0	1.6	7.2	2.8
Erpobdellidae	2.8	0.4	0.4	1.6	0.4	1.2
Hydracarina	25.6	14.4	3.6	9.0	11.6	4.4
Astacidae	0.0	2.0	0.0	0.0	0.0	0.0
Asellidae	2.0	10.8	1.2	22.2	1.6	1.2
Gammaridae	260.0	128.8	202.6	185.2	129.0	474.8
Baetidae	5.2	1.6	0.2	0.0	15.6	0.8
Heptageniidae	0.0	0.0	0.0	0.0	0.4	0.0
Ephemeridae	78.0	11.2	36.2	15.8	64.0	43.8
Ephemerellidae	73.6	38.8	13.2	12.6	89.4	10.6
Caenidae	14.8	4.4	1.0	4.0	6.8	3.2
Nemouridae	0.0	0.0	0.0	0.0	0.8	0.0
Leuctridae	0.8	3.6	14.4	5.6	12.0	2.8
Veliidae	0.0	0.0	0.0	1.0	0.0	0.0
Corixidae	0.0	6.8	0.0	1.6	0.0	0.0
Dytiscidae	0.0	1.0	0.0	1.4	0.0	0.0
Elmidae	8.0	6.6	5.2	8.6	4.4	3.8
Sialidae	0.0	0.0	0.0	0.4	0.0	0.0
Rhyacophilidae	0.0	0.4	0.0	0.0	0.8	0.0
Glossosomatidae	6.0	1.6	56.0	1.2	34.0	2.8
Hydroptilidae	2.8	1.8	0.0	2.8	3.2	0.0
Psychomyiidae	0.0	0.0	0.2	0.0	0.0	0.0
Polycentropodidae	0.8	0.4	0.0	0.0	0.0	0.0
Hydropsychidae	0.0	0.0	0.0	0.0	0.4	0.0
Lepidostomatidae	1.6	0.8	0.0	0.0	0.4	0.8
Limnephilidae	6.0	7.2	1.6	11.2	3.2	5.8
Goeridae	0.4	0.0	1.0	0.4	2.0	0.0
Leptoceridae	9.6	2.4	9.8	1.4	13.2	4.2
Tipulidae	1.6	0.8	2.8	0.4	0.4	1.4
Ptychopteridae	0.0	1.8	0.0	0.0	0.0	0.0
Dixidae	0.0	0.0	0.0	1.6	0.0	0.0
Ceratopogonidae	50.4	21.4	10.8	9.4	32.8	18.6
Simuliidae	0.0	0.0	0.0	0.0	8.2	0.0
Chironomidae	257.6	227.6	7.4	80.2	112.2	114.2
Empididae	0.4	0.0	1.2	1.2	1.2	5.4
Syrphidae	0.0	0.0	0.0	0.4	0.0	0.0

Table 6.5 R. Lambourn at Bagnor (shaded site), December 1997. Mean densities of families (nos. 0.05 m^{-2}) based on 5 sampling units for each habitat.

Family name	Berula	Callitriche	Gravel	Emergents	Ranunculus	Silt
Planariidae	2.4	0.0	0.8	0.8	0.8	0.0
Dendrocoelidae	0.8	0.0	0.0	0.0	0.0	0.0
Hydrobiidae	13.2	56.2	87.0	6.0	91.4	49.8
Physidae	0.8	0.2	0.4	0.0	0.2	0.0
Lymnaeidae	1.2	0.8	0.0	1.6	0.0	0.4
Planorbidae	3.6	5.6	2.0	4.4	1.6	0.2
Ancylidae	2.4	2.8	5.2	0.0	6.2	0.0
Sphaeriidae	6.0	3.2	4.8	1.6	0.0	7.2
Oligochaeta	242.8	107.8	79.6	27.6	53.0	47.6
Lumbricidae	4.0	9.2	5.0	0.4	15.6	0.0
Piscicolidae	0.0	0.0	0.0	0.2	1.2	0.0
Glossiphoniidae	5.2	2.4	1.4	1.6	4.0	1.0
Erpobdellidae	2.0	0.2	0.8	0.0	0.4	0.4
Hydracarina	26.4	27.2	11.2	5.2	19.2	10.4
Asellidae	18.4	11.0	9.4	34.0	9.0	35.8
Gammaridae	652.0	217.6	238.4	31.0	257.0	32.2
Niphargidae	2.4	0.0	0.8	0.4	0.0	0.2
Baetidae	5.2	3.4	0.0	0.8	2.6	0.8
Leptophlebiidae	64.8	11.2	4.8	0.8	4.0	5.0
Ephemeridae	64.0	40.2	32.4	6.0	38.0	10.6
Ephemerellidae	2.0	0.0	0.2	0.0	0.0	0.0
Caenidae	28.4	8.4	25.6	0.8	46.4	1.6
Nemouridae	0.8	0.0	0.0	0.0	0.0	0.0
Leuctridae	0.4	0.0	0.0	0.0	0.0	0.0
Corixidae	0.0	0.0	0.0	1.2	0.0	3.2
Haliplidae	1.2	0.0	0.0	0.0	0.0	0.0
Dytiscidae	2.8	1.2	0.0	0.8	0.0	0.4
Gyrinidae	0.0	0.0	0.0	0.0	0.8	0.0
Elmidae	170.0	55.2	51.4	3.8	137.8	4.0
Sialidae	0.0	0.0	0.0	0.8	0.0	0.8
Rhyacophilidae	0.4	0.0	0.0	0.0	0.2	0.0
Glossosomatidae	53.2	118.0	331.8	1.2	986.4	1.8
Hydroptilidae	433.6	263.8	4.2	42.6	171.8	15.2
Psychomyiidae	0.8	0.4	0.2	0.0	0.0	0.0
Polycentropodidae	19.6	4.0	0.8	0.0	3.2	0.0
Hydropsychidae	0.0	0.0	0.0	0.0	0.8	0.0
Lepidostomatidae	5.6	1.6	2.4	0.0	2.4	0.0
Limnephilidae	18.0	6.8	2.6	8.2	8.0	3.2
Goeridae	3.2	1.6	16.4	0.0	3.6	0.0
Beraeidae	0.0	0.0	0.0	0.0	0.0	0.4
Sericostomatidae	1.2	0.0	0.0	0.0	0.0	0.0
Odontoceridae	0.8	0.0	0.0	0.0	0.0	0.0
Leptoceridae	25.6	4.8	4.8	0.0	14.6	0.0
Tipulidae	1.2	2.4	1.8	5.2	1.4	4.6
Psychodidae	0.8	0.0	1.0	0.4	0.0	0.0
Ptychopteridae	0.0	0.4	0.2	0.0	0.8	6.4
Ceratopogonidae	11.6	8.6	7.8	5.8	9.0	4.8
Simuliidae	4.4	13.2	0.2	1.2	73.2	0.0
Chironomidae	85.6	26.4	13.6	47.2	39.8	86.8
Stratiomyidae	0.0	0.0	0.0	0.8	0.0	0.0
Empididae	11.6	4.8	1.2	0.4	8.0	0.0
Ephydridae	0.0	0.0	0.0	1.0	0.0	0.0
Lonchopteridae	0.0	0.0	0.0	0.4	0.0	0.0

Bearing in mind that the 1970s database was a result of around eight times as much sampling effort compared to the 1997 sampling programme, occasional records of very infrequent Coleoptera, Trichoptera and Diptera were to be expected. However, it should be pointed out that amongst the Diptera, the Muscidae was used as a 'dumping ground' for problematic Diptera in the 1970s and hence, the two families of Diptera recorded from emergent macrophytes in the 1997 sampling programme may have been present in the 1970s. Of greater interest are the other three families recorded in 1997 but absent from the 1970s database. In fact, all three were recorded in the nearby Winterbourne stream (Wright *et al.* 1984). A comprehensive record book in which identifications were logged for all sites sampled in the 1970s Lambourn Project indicates that these three families were captured at or in the immediate vicinity of Bagnor on one or two occasions, despite their absence from the 1970s quantitative sampling programme.

6.1.3 Between-year comparisons

The sampling programme at the shaded site was undertaken during the second year of a drought and therefore it is important to determine whether the fauna was affected by these conditions. Previous studies (Wright 1992, Wright and Symes *in press*) have shown that faunal response to low flow conditions tends to be most pronounced in the summer. Therefore, attention was focussed on comparing the densities of individual macroinvertebrate families in June 1997 with their densities in years of low discharge (June 1976) and high discharge (June 1975).

The Mann-Whitney U-test was used on the density counts from the five replicate sampling units from a given habitat type in each year. The tests were carried out on the dominant macrophyte (*Berula*) and the dominant non-macrophyte substratum (gravel).

Table 6.6 R. Lambourn at Bagnor (shaded site). Mean densities of families (nos 0.05 m^{-2}) on *Berula* (June 1997 and 1976) and Gravel (June 1997 and 1976). Families listed are those for which there were significant differences between years, based on the Mann-Whitney U-test. (* =P< 0.05; ** =P< 0.01) See text for further explanation.

Family	Berula		Gravel	
	1997	1976	1997	1976
Hydrobiidae	13.2 *	0.0		
Hydracarina			3.6	33.4 *
Baetidae	5.2	32.4 *	0.2	38.4 **
Ephemeridae	78.0 **	1.6	36.2 *	1.8
Ephemerellidae	73.6	192.4 *	13.2	113.6 *
Caenidae			1.0	18.8 *
Glossosomatidae	6.0 **	0.0		
Hydroptilidae	2.8	32.4 **		
Tipulidae			2.8 *	0.8
Chironomidae			7.4	738.0 *

Table 6.6 lists the 10 families for which Mann-Whitney U-tests indicated significant differences between 1997 and the historic drought year of 1976 on *Berula* and gravel. The mean densities of the families are also presented in order to put the results of the Mann-Whitney U-tests into context. No attempt will be made to provide an interpretation of each result, but rather, attention will focus on some of the more striking results. In particular, attention will be drawn to results which are repeated on different habitat types on a given site, and at some of the other sites included in this study.

The results for some families of Ephemeroptera (mayflies) are particularly interesting. Baetidae, Ephemeridae and Ephemerellidae all exhibited significant differences between years on both *Berula* and gravel. Baetidae, which include several species in the genera *Baetis* and *Centroptilum* with a general requirement for fast flowing water, occurred at very low densities in 1997, and despite the fact that their densities were also low in 1976 (Wright and Symes in press) they were significantly lower in 1997. Ephemerellidae, represented by *Ephemerella ignita* which favours the protection of macrophyte cover, was also significantly less common in 1997. In contrast, *Ephemera danica* (Ephemeridae), which burrows into the substratum, was present at high densities in 1997. The particular reason why its densities were so low in 1976 is unrelated to the low flow conditions and appears to be due to poor egg laying in June 1972, after heavy rain and strong winds during the adult phase in late May/early June (Wright *et al.* 1981b). The two-year life cycle of this species meant that densities increased in stages with each generation and only towards the end of the 1970s were high densities recorded at the site.

Table 6.7 R. Lambourn at Bagnor (shaded site). Mean densities of families (nos 0.05 m^{-2}) on *Berula* (June 1997 and 1975) and Gravel (June 1997 and 1975). Families listed are those for which there were significant differences between years, based on the Mann-Whitney U-test.
(* =P< 0.05; ** =P< 0.01)

Family	Berula		Gravel	
	1997	1975	1997	1975
Hydrobiidae	13.2 *	0.4		
Lumbricidae	6.8 *	1.2		
Hydracarina	25.6	117.8 *		
Gammaridae			202.6 *	14.2
Baetidae	5.2	154.0 *	0.2	31.8 **
Ephemeridae	78.0 *	5.6	36.2 **	1.4
Caenidae	14.8	128.6 *	1.0	21.2 *
Elmidae	8.0	23.2 *		
Glossosomatida	6.0 *	1.2		
Hydroptilidae	2.8	14.8 *		
Tipulidae			2.8 **	0.2
Simuliidae	0.0	310.6 **	0.0	16.4 **
Chironomidae			7.4	27.4 *
Empididae	0.4	8.0 **		

The high densities of Chironomidae, and in particular Orthocladiinae, on the shaded site in 1976 were a consequence of the low flows and the availability of a coating of diatoms and associated detritus as a source of food on the surface of the gravel. The low densities of Chironomidae recorded in 1997, despite the low flows, may possibly be a consequence of the greater shading of the site by overhanging trees and emergent marginal vegetation.

In Table 6.7, those families for which Mann-Whitney U-tests indicated significant differences between 1997 and 1975, when discharge was higher than average (Fig. 2.1) are listed. Two numerically important families which are closely associated with fast current speeds, the Baetidae and Simuliidae (blackfly larvae), were both present in significantly higher numbers in 1975 compared to 1997, on both *Berula* and gravel. The reason why *Ephemera danica* was scarce in the mid-1970s has already been explained.

6.2 R. Kennet at Littlecote

6.2.1 Family richness

The River Kennet at Littlecote was dominated by *Ranunculus* growing on a gravel substratum and therefore both the 1970s and the 1997 sampling programmes were confined to these two habitat types. The 1997 results may be compared with equivalent data for 1975, but in 1974 samples were only collected in June, when five replicates were obtained from *Ranunculus*, recently cut *Ranunculus* and gravel (Table 6.8).

Table 6.8 R. Kennet at Littlecote. Number of families of macroinvertebrates recorded on *Ranunculus* and gravel in July and December 1997, plus site total for the year. Historical data for 1975 (June and December) and 1974 (June only) are also given.

Year	June/July		December		Total for Year
	Ranunculus	Gravel	Ranunculus	Gravel	(Ran + Grav)
1997	32	31	43	34	47
1975	30	33	35	33	42
1974	30 (29)*	28	No data	No data	-

* Figure in brackets refers to data from 5 replicate samples taken on recently cut *Ranunculus*.

In 1997, both *Ranunculus* and gravel supported a wider range of macroinvertebrates in December than in July, as previously noted for the River Lambourn at Bagnor. In particular *Ranunculus* was very taxon rich in December with 43 families recorded. The family richness for the equivalent habitats and seasons in 1975 were fairly similar to 1997, except for *Ranunculus* in December 1975, which although rich in families (35) did not approach the figure obtained in 1997. The limited data for June 1974 was broadly similar to later years although marginally lower in terms of family richness. Overall, 47 families were recorded in 1997, as against 42 families in 1975. (The total number of families recorded on *Ranunculus* and gravel only on the shaded site of the River Lambourn at Bagnor in 1997 was 39). Hence, the Littlecote site supports an impressive range of macroinvertebrate families and the recent drought has not resulted in loss of family richness.

6.2.2 Family composition and abundance data for 1997

Table 6.9 lists the 35 families of macroinvertebrates captured at Littlecote in early July 1997 together with their mean densities on gravel and *Ranunculus*. The fauna includes 12 families of non-insects and 23 families of insects.

Table 6.9 R. Kennet at Littlecote, July 1997. Mean densities of macroinvertebrate families (nos. 0.05 m^{-2}) based on 5 sampling units for each habitat.

Family name	Gravel	Ranunculus
Planariidae	1.4	13.6
Dendrocoelidae	0.2	0.0
Planorbidae	0.2	3.8
Ancylidae	0.6	0.0
Sphaeriidae	13.4	28.4
Oligochaeta	23.2	32.4
Lumbricidae	5.2	0.8
Glossiphoniidae	7.0	26.8
Erpobdellidae	4.2	7.2
Hydracarina	0.8	6.4
Asellidae	0.0	0.2
Gammaridae	325.2	908.6
Niphargidae	0.0	0.4
Baetidae	53.8	56.2
Ephemeridae	0.4	0.4
Ephemerellidae	13.6	305.8
Caenidae	17.6	210.0
Leuctridae	17.8	3.4
Corixidae	0.8	0.0
Elmidae	18.6	28.2
Sialidae	0.0	0.4
Rhyacophilidae	0.8	0.8
Glossosomatidae	10.6	2.8
Psychomyiidae	4.6	0.2
Polycentropodidae	0.6	3.2
Hydropsychidae	0.4	0.6
Lepidostomatidae	0.2	23.4
Limnephilidae	0.2	2.2
Goeridae	1.2	1.4
Sericostomatidae	1.6	9.4
Leptoceridae	13.0	13.2
Tipulidae	2.0	1.2
Ceratopogonidae	1.4	7.2
Simuliidae	20.8	114.6
Chironomidae	23.8	61.4
Empididae	0.0	0.4

Table 6.10 gives the 45 families of macroinvertebrates and their mean densities on gravel and *Ranunculus* in December 1997. On this occasion there were 16 families of non-insects (of which 5 were additions to the July listing) and 29 families of insects (of which 7 were additions).

Table 6.10 R. Kennet at Littlecote, December 1997. Mean densities of macroinvertebrate families (nos. 0.05 m^{-2}) based on 5 sampling units for each habitat.

Family name	Gravel	Ranunculus
Planariidae	15.8	26.8
Valvatidae	0.0	0.8
Hydrobiidae	0.0	0.8
Physidae	3.4	47.6
Lymnaeidae	0.0	0.4
Planorbidae	5.6	10.8
Ancylidae	5.0	0.4
Sphaeriidae	29.2	29.2
Oligochaeta	191.2	122.4
Lumbricidae	0.0	5.2
Piscicolidae	1.6	6.4
Glossiphoniidae	10.6	22.0
Erpobdellidae	12.8	24.8
Hydracarina	4.8	10.4
Asellidae	3.6	5.6
Gammaridae	326.0	678.8
Niphargidae	5.8	0.0
Baetidae	4.0	19.6
Heptageniidae	0.8	1.2
Leptophlebiidae	0.0	3.2
Ephemeridae	0.0	0.8
Ephemerellidae	0.0	2.4
Caenidae	139.4	792.8
Corixidae	0.0	0.8
Haliplidae	0.0	4.0
Dytiscidae	0.8	0.4
Gyrinidae	1.0	0.0
Elmidae	124.4	111.6
Sialidae	0.0	0.4
Rhyacophilidae	0.0	1.6
Glossosomatidae	771.8	42.0
Hydroptilidae	1.2	8.8
Psychomyiidae	3.4	8.8
Polycentropodidae	9.8	14.8
Hydropsychidae	1.6	47.2
Lepidostomatidae	10.0	6.4
Limnephilidae	15.4	0.4
Goeridae	15.8	2.0
Sericostomatidae	6.6	7.6
Leptoceridae	29.2	18.8
Tipulidae	5.4	0.4
Dixidae	0.0	0.8
Ceratopogonidae	4.4	4.0
Simuliidae	3.2	298.4
Chironomidae	29.4	690.8
Empididae	0.2	2.8

As previously indicated (Table 6.7) a total of 47 families were captured in 1997. Twelve families found in December 1997 were not recorded in July, whereas two families captured in July were absent from samples collected in December 1997. The full listing of non-insect families for 1997 comprised Tricladida (2 families), Mollusca (7), Oligochaeta (1), Hirudinea (3), Hydracarina (1), and Crustacea (3). The insects included Ephemeroptera (6), Plecoptera (1), Hemiptera (1), Coleoptera (4), Megaloptera (1), Trichoptera (11) and Diptera (6).

In contrast to the 49 families captured in 1997, just 42 families were recorded in 1975 after similar sampling effort on the same habitats (Table 6.8). Forty of these families were recorded in both years, but the following families were captured in one year only:

1975 samples only		**1997 samples only**	
Trichoptera:	Brachycentridae	Crustacea:	Asellidae
Diptera:	Psychodidae		Niphargidae
		Ephemeroptera:	Ephemeridae
		Plecoptera:	Leuctridae
		Hemiptera:	Corixidae
		Coleoptera:	Gyrinidae
		Diptera:	Dixidae

Of the families only captured in 1975, caddis belonging to the Brachycentridae, comprising the single species *Brachycentrus subnubilus,* (referred to as the 'Grannom' by fishermen) was found in very low densities on *Ranunculus* in December 1975. This species was also recorded on the shaded site at Bagnor on the River Lambourn in the 1970s but was not captured at that site in 1997.

The longer list of families recorded in 1997 included Asellidae which, though absent in 1975 were recorded at very low densities in June 1974 in Gravel (mean of 0.2 individuals 0.05 m^{-2} sample) and *Ranunculus* (0.04 individuals 0.05 m^{-2}). The presence of Niphargidae in 1997, also recorded at Bagnor on the River Lambourn was an interesting occurrence. In contrast, the absence of *Ephemera danica* (Ephemeridae) in 1974/75 may have been a temporary occurrence, resulting from the poor conditions for swarming and egg laying in June 1972 (Wright *et al.* 1981). Finally, two other families were recorded in June 1974, though not in 1975 or 1997. They were Astacidae (Crayfish) and a dipteran family, Ptychopteridae.

6.2.3 Between-year comparisons

Table 6.11 lists the 11 families for which Mann-Whitney U-tests indicated significant differences between June 1975, when mean monthly discharge at Knighton on the River Kennet was 2.64 cumecs and July 1997, when the monthly mean was 0.67 cumecs. (In June/July 1976, the mean discharge at Knighton was even lower at 0.36cumecs in June and 0.17 cumecs in July, but unfortunately no sampling took place at this time). Apart from the low discharge in 1997, it should also be borne in mind that the later sampling time has some potential for influencing the densities of some macroinvertebrates

The mean density of *Gammarus pulex* (Gammaridae) on *Ranunculus* in July 1997 was much greater than in June 1975, a feature also noted on the River Lambourn at Bagnor when Gravel was compared in June of 1997 and 1975 (Table 6.7). In fact, the nine-year peak densities of *G. pulex* on the River Lambourn at Bagnor were recorded in December 1976, at the end of the historic drought (Wright, 1992).

Table 6.11 **R. Kennet at Littlecote. Mean densities of families (nos. 0.05 m^{-2}) on *Ranunculus* (July 1997 and June 1975) and Gravel (July 1997 and June 1975). Families listed are those for which there were significant differences between years, based on the Mann-Whitney U-test.**
(* =P< 0.05; ** =P< 0.01)

Family	Ranunculus		Gravel	
	1997	1975	1997	1975
Hydrobiidae			0.0	1.2 *
Lumbricidae	0.8	69.6 **		
Gammaridae	908.6 *	189.6		
Caenidae	210.0 *	32.0		
Leuctridae	3.4 *	0.0	17.8 **	0.0
Rhyacophilidae	0.8	9.6 *	0.8	7.4 *
Hydroptilidae			0.0	6.2 *
Limnephilidae			0.2	1.8 *
Goeridae			1.2	11.8 *
Tipulidae			2.0	11.8 *
Ceratopogonidae			1.4	17.2 *
Chironomidae	61.4	739.2 *	23.8	242.0 *

Despite the low discharge in July 1997, it was apparent that the site held moderate densities of mayfly larvae in the Baetidae (Table 6.9) which were not significantly lower than in June 1975. However, the mean densities on *Ranunculus* and gravel in June 1975 (104.8 and 99.2 individuals 0.05 m^{-2}) were higher than in July 1997 (56.2 and 53.8). In contrast, the densities of Caenidae on *Ranunculus* were significantly higher in July 1997.

Stoneflies of the family Leuctridae, which occurred on the River Lambourn at Bagnor in both the 1970s and in 1997, were recorded at Littlecote for the first time in 1997. The reason for the apparent absence of this family in 1974 and 1975 is unclear.

It is also difficult to offer a convincing explanation for the fact that there were four families of caddis which occurred at higher densities on gravel in 1975 than in 1997.

Finally, the Chironomidae, previously noted as less abundant on the River Lambourn at Bagnor in 1997 compared with both 1975 and 1976, also demonstrated significant differences at Littlecote in July 1997 compared with June 1975. However, it is possible that densities of chironomid larvae may have been higher in June 1997 prior to the time when *Ranunculus* started to grow more vigorously.

6.3 R. Kennet at Savernake (lower and upper sites)

6.3.1 Family richness

Further upstream on the River Kennet at Savernake, the dominant habitat types sampled on the lower of the two sites were *Schoenoplectus* and gravel. These same habitats were sampled in 1975 (June and December) and in 1974 (June only). The number of families of macroinvertebrates recorded in each habitat and month, together with totals for 1997 and 1975 are given in Table 6.12.

In general, *Schoenoplectus* supported marginally more families than gravel (single exception June 1974), and in all instances, the number of families on a given habitat was higher in December than in summer. Overall, a total of 39 families were recorded in 1997, as against 35 in 1975. Hence, there was no evidence of loss of family richness at this site since the mid-1970s. Note that this lower site at Savernake is somewhat less rich in families than the River Kennet at Littlecote, where 47 families were captured in 1997 and 42 families were recorded in 1975.

Table 6.12 R. Kennet at Savernake (Lower site). Number of families of macroinvertebrates captured on *Schoenoplectus* and gravel in July and December 1997, plus site total for the year. Historical data for 1975 (June and December) and 1974 (June only) is also given.

Year	June/July		December		Total for Year
	Schoenoplectus	Gravel	Schoenoplectus	Gravel	(Schoen+Grav)
1997	31	27	33	32	39
1975	27	24	32	29	35
1974	26	28	No data	No data	-

The equivalent data on family richness for the upper site at Savernake is presented in Table 6.13. At this site, the habitats available for sampling varied from year to year. In June 1974, it was possible to sample *Ranunculus* and gravel, as originally planned for this site, which is somewhat shallower and faster-flowing than the lower site at Savernake. However, in June 1975, very little *Ranunculus* was available and it was necessary to sample *Schoenoplectus* instead. By December 1975 both *Schoenoplectus* and *Ranunculus* were available and were sampled, but in 1997 the original strategy of confining the sampling programme to *Ranunculus* and gravel was implemented.

Table 6.13 R. Kennet at Savernake (Upper site). Number of families of macroinvertebrates captured on *Ranunculus* and gravel in July and December 1997, plus site total for the year. Historical data for these habitats plus *Schoenoplectus* in 1975 and 1974 (June only) is also given.

Year	June/July			December			Total for Year
	Schoen	Ran	Gravel	Schoen	Ran	Gravel	(All habitats)
1997	No data	28	29	No data	32	27	38
1975	29	No data	29	32	31	31	37
1974	No data	29	27	No data	No data	No data	

At this site, there was no clear tendency for *Schoenoplectus* and *Ranunculus* to support more families of macroinvertebrates than gravel. However, whereas in June/July the maximum number of families captured on any habitat type never exceeded 29, the number in December typically increased to 31 or 32, although gravel (December 1997) was an exception with just 27 families.

The total number of families recorded in 1997 was 38, marginally higher than the 37 found in 1975 and hence at this site, as at the lower Savernake site, there was no evidence of loss of family richness.

6.3.2 Family composition and abundance data for 1997

A list of the 33 families of macroinvertebrates recorded on the lower site at Savernake, together with their mean densities on gravel and *Schoenoplectus* is presented in Table 6.14. The fauna included 14 families of non-insects and 19 families of insects.

Table 6.14 R. Kennet at Savernake (Lower site) July 1997. Mean densities of macroinvertebrate families (nos. 0.05 m^{-2}) based on 5 sampling units for each habitat.

Family name	Gravel	Schoenoplectus
Planariidae	1.2	5.4
Hydrobiidae	1.0	0.4
Physidae	1.2	0.4
Planorbidae	0.8	0.4
Ancylidae	1.2	0.4
Sphaeriidae	1.6	1.6
Oligochaeta	134.2	147.2
Lumbricidae	2.0	0.0
Piscicolidae	0.0	5.0
Glossiphoniidae	22.8	53.6
Erpobdellidae	8.8	13.6
Hydracarina	4.8	7.0
Asellidae	17.6	46.2
Gammaridae	223.6	146.0
Niphargidae	1.2	0.0
Baetidae	0.8	37.6
Ephemerellidae	14.6	62.0
Caenidae	1.6	1.0
Haliplidae	0.4	1.4
Dytiscidae	11.2	2.6
Elmidae	2.2	3.6
Sialidae	2.4	4.2
Glossosomatidae	0.0	0.4
Hydroptilidae	0.0	0.4
Polycentropodidae	0.0	0.6
Limnephilidae	0.2	2.0
Goeridae	0.0	0.4
Sericostomatidae	2.4	3.2
Leptoceridae	4.4	3.4
Tipulidae	0.2	0.0
Ceratopogonidae	3.2	2.4
Simuliidae	2.8	169.4
Chironomidae	595.0	791.0
Empididae	0.0	0.2

The equivalent data for the same site in December 1997 is given in Table 6.15. Here, 16 families of non-insects (2 additions to the July listing) and 20 families of insects (4 additions) are listed.

Table 6.15 R. Kennet at Savernake (Lower site) December 1997. Mean densities of macroinvertebrate families (nos. 0.05 m^{-2}) based on 5 sampling units for each habitat.

Family name	Gravel	Schoenoplectus
Planariidae	28.6	97.0
Dendrocoelidae	2.4	3.4
Valvatidae	0.4	8.4
Hydrobiidae	0.0	0.4
Physidae	0.8	3.6
Planorbidae	1.2	2.8
Ancylidae	0.4	1.6
Sphaeriidae	1.8	10.4
Oligochaeta	25.2	115.2
Lumbricidae	4.4	1.2
Piscicolidae	3.0	3.2
Glossiphoniidae	12.6	26.4
Erpobdellidae	15.2	46.2
Hydracarina	16.2	48.2
Asellidae	23.4	153.4
Gammaridae	244.6	422.4
Niphargidae	1.0	0.0
Baetidae	5.2	9.8
Ephemerellidae	0.4	2.0
Caenidae	14.4	85.4
Corixidae	3.2	0.0
Haliplidae	0.2	0.0
Dytiscidae	5.0	5.0
Elmidae	9.6	34.4
Sialidae	0.2	2.0
Rhyacophilidae	0.0	0.2
Glossosomatidae	1.2	1.6
Hydroptilidae	0.0	5.6
Polycentropodidae	1.2	14.0
Hydropsychidae	1.0	9.2
Goeridae	0.2	0.4
Sericostomatidae	4.0	2.8
Leptoceridae	35.8	21.2
Ceratopogonidae	2.6	12.2
Simuliidae	0.8	51.2
Chironomidae	53.8	302.0
Muscidae	0.0	0.8

Of the total of 39 families recorded at the lower site in 1997 (Table 6.12), six were only recorded in December and three were confined to the July listing. The full list of non-insects for the lower Savernake site in 1997 included Tricladida (2 families), Mollusca (6), Oligochaeta (1), Hirudinea (3), Hydracarina (1), and Crustacea (3). The insects comprised Ephemeroptera (3), Hemiptera (1), Coleoptera (3), Megaloptera (1), Trichoptera (9) and Diptera (6).

The major differences in family composition between the River Kennet at Littlecote and this site were therefore the reduction in richness of families of Ephemeroptera (6 to 3), Trichoptera (11 to 9) and the absence of Plecoptera at Savernake.

As indicated in Table 6.12, a total of 39 families were captured in 1997, whereas just 35 families were identified from a similar set of samples in 1975. Thirty-four families were recorded in both years but the following families were only captured in one year.

Lower Savernake - 1975 samples

Trichoptera:	Lepidostomatidae

Lower Savernake - 1997 samples

Tricladida:	Dendrocoelidae
Crustacea:	Niphargidae
Hemiptera:	Corixidae
Trichoptera:	Hydropsychidae
Diptera:	Muscidae

The caddis *Lepidostoma hirtum* (Lepidostomatidae) occurred in small numbers on *Schoenoplectus* in June 1975 (and also in 1974) but was not recorded in 1997. In contrast, five families were recorded in 1997 but not in 1975 (or 1974). These included the flatworm *Dendrocoelum lacteum* (Dendrocoelidae) which specialises in the capture of *Asellus,* and crustaceans in the family Niphargidae (The latter was also found at Bagnor and Littlecote in 1997).

Appraisal of the family listings for the June samples taken in 1974 yielded three additional families not recorded in either 1975 or 1997. These were all Diptera and included Psychodidae, Ptychopteridae and Tabanidae.

A listing of the 33 families of macroinvertebrates recorded on the upper site at Savernake in July 1997 (same total as for the lower site) and their mean densities on Gravel and *Ranunculus* is given in Table 6.16. At this site, the assemblage comprised 15 families of non-insects and 18 families of insects.

The equivalent data for the upper site in December 1997 may be found in Table 6.17, where 15 families of non-insects (just one addition to the July listing) and 19 families of insects (4 additions) are listed.

At the upper site at Savernake a total of 38 families were recorded in 1997 (Table 6.13), of which 5 were only taken in December and four were only recorded in July. The full list of non-insects for the upper Savernake site in 1997 included Tricladida (2 families), Mollusca (6), Oligochaeta (1), Hirudinea (3), Hydracarina (1), and Crustacea (3). The insects comprised Ephemeroptera (3), Coleoptera (3), Megaloptera (1), Trichoptera (10) and Diptera (5). Thus, the two sites at Savernake were closely similar in terms of family composition.

Table 6.16 R. Kennet at Savernake (Upper site) July 1997. Mean densities of macroinvertebrate families (nos. 0.05 m^{-2}) based on 5 sampling units for each habitat.

Family name	Gravel	Ranunculus
Planariidae	8.8	1.6
Dendrocoelidae	1.2	0.4
Valvatidae	0.2	0.0
Physidae	0.4	0.4
Planorbidae	0.0	2.4
Ancylidae	5.6	3.6
Sphaeriidae	0.4	2.0
Oligochaeta	30.4	26.4
Lumbricidae	16.6	9.2
Piscicolidae	0.0	2.0
Glossiphoniidae	16.6	17.2
Erpobdellidae	6.0	11.6
Hydracarina	2.8	4.4
Asellidae	9.6	34.4
Gammaridae	196.4	165.6
Niphargidae	0.0	0.4
Baetidae	2.8	10.8
Ephemerellidae	17.6	67.2
Caenidae	1.6	3.6
Dytiscidae	2.8	0.4
Elmidae	3.8	8.4
Sialidae	0.0	0.8
Rhyacophilidae	0.2	1.2
Glossosomatidae	0.6	0.0
Hydroptilidae	1.0	0.0
Limnephilidae	3.0	0.0
Goeridae	0.4	0.4
Sericostomatidae	7.0	4.4
Leptoceridae	6.2	1.6
Tipulidae	0.4	0.0
Ceratopogonidae	4.0	4.0
Simuliidae	0.2	120.8
Chironomidae	160.4	254.8
Empididae	0.4	0.8

From Table 6.13, it is apparent that whereas 38 families were captured in 1997, just 37 families were identified from a similar level of sampling effort in 1975, although there were differences in the macrophytes sampled in summer (*Schoenoplectus* in 1975 and *Ranunculus* in 1997). Thirty-four families were recorded in both years but the following families were only found in one of these two years.

Upper Savernake - 1975 samples

Gastropoda:	Lymnaeidae
Trichoptera:	Molannidae
Diptera:	Ptychopteridae

Upper Savernake - 1997 samples

Tricladida:	Dendrocoelidae
Crustacea:	Niphargidae
Ephemeroptera:	Caenidae
Trichoptera:	Hydropsychidae

Table 6.17 R. Kennet at Savernake (Upper site) December 1997. Mean densities of macroinvertebrate families (nos. 0.05 m^{-2}) based on 5 sampling units for each habitat.

Family name	Gravel	Ranunculus
Planariidae	27.2	5.0
Dendrocoelidae	0.2	0.0
Valvatidae	0.0	0.4
Hydrobiidae	0.0	0.4
Physidae	0.0	0.4
Planorbidae	0.4	1.8
Ancylidae	1.6	3.6
Sphaeriidae	0.4	3.2
Oligochaeta	16.2	11.6
Lumbricidae	2.2	4.8
Piscicolidae	3.2	1.2
Glossiphoniidae	7.2	10.0
Erpobdellidae	9.8	18.2
Hydracarina	30.4	28.4
Asellidae	20.2	83.8
Gammaridae	294.8	303.6
Baetidae	4.4	23.0
Ephemerellidae	1.6	7.6
Caenidae	34.8	27.6
Haliplidae	0.8	0.0
Dytiscidae	0.4	1.2
Elmidae	20.8	87.4
Sialidae	0.8	0.2
Rhyacophilidae	0.0	0.4
Glossosomatidae	0.4	4.0
Polycentropodidae	0.4	1.2
Hydropsychidae	0.0	1.6
Lepidostomatidae	0.8	0.8
Goeridae	0.0	0.4
Sericostomatidae	2.4	7.2
Leptoceridae	18.0	63.6
Tipulidae	0.0	0.8
Ceratopogonidae	1.2	1.8
Simuliidae	2.4	41.2
Chironomidae	99.4	70.8

The three families recorded in 1975 were all very infrequent and were never recorded in the additional samples taken in June 1974. Three of the four families only reported from the 1997 samples were also confined to this set of samples at the lower Savernake site. These were Dendrocoelidae, Niphargidae and Hydropsychidae and this observation adds weight to the probability that they were genuinely absent or very uncommon at Savernake in 1974/75. No families were recorded only in the samples taken in June 1974.

6.3.3 Between-year comparisons

Table 6.18 lists the 15 families for which Mann-Whitney U-tests indicated significant differences between June 1975 and July 1997 on one or more of the habitats sampled on the lower site at Savernake. The comments made for the Littlecote site on differences in the timing of the field sampling in 1975 and 1997 also apply to these results.

This is the only site at which leeches in the family Glossiphoniidae occurred at significantly higher densities in 1997 compared to 1975. Another non-insect family, Asellidae, also occurred at significantly higher densities on *Schoenoplectus* in summer 1997 than in 1975. Although Asellidae are still not as abundant as Gammaridae, they have become much more common at this site than in 1975. Their numbers increased in density threefold between July and December 1997 (Table 6.15).

Table 6.18 R. Kennet at Savernake (Lower site). Mean densities of families (nos 0.05 m^{-2}) on *Schoenoplectus* (July 1997 and June 1975) and Gravel (July 1997 and June 1975). Families listed are those for which there were significant differences between years, based on the Mann-Whitney U-test. (* =P< 0.05; ** =P< 0.01)

Family	Schoenoplectus		Gravel	
	1997	1975	1997	1975
Sphaeriidae	1.6	19.2 *		
Glossiphoniidae	53.6 *	15.6		
Asellidae	46.2 *	2.8		
Baetidae	37.6	119.6 *	0.8	9.4 *
Ephemerellidae	62.0	216.8 *	14.6	173.2 *
Dytiscidae	2.6 *	0.0		
Glossosomatidae			0.0	46.8 *
Polycentropodidae			0.0	1.4 *
Limnephilidae			0.2	13.8 **
Goeridae			0.0	8.8 *
Sericostomatidae			2.4	14.6 *
Leptoceridae	3.4	11.6 *		
Tipulidae			0.2	5.4 *
Ceratopogonidae	2.4	8.8 *		
Chironomidae			595.0 *	47.6

The results also provide clear evidence that mayfly larvae in the families Baetidae and Ephemerellidae on each of *Schoenoplectus* and gravel were significantly less abundant during the drought summer of 1997 than in 1975. A similar finding was recorded on the River Lambourn at Bagnor for Baetidae (less abundant in 1997 than in 1975 or 1976) and for Ephemerellidae (less abundant in 1997 than in 1976).

The lower abundances of six different families of Trichoptera (five on gravel and one on *Schoenoplectus*) were striking and recall a similar situation for four families at Littlecote.

The significant differences for Chironomidae on gravel (higher densities during the drought year of 1997 compared to 1975) were not unexpected, particularly in view of the additional food and living space resulting from the accumulation of algae on some areas of gravel in July 1997. Whereas the mean density of chironomid larvae from 'clean' gravel in July 1997 was 110.5 (mean of 2 sampling units), the equivalent density for algal-covered gravel was 918 individuals 0.05 m^{-2} (mean of 3 sampling units). However, the high densities of Chironomidae on Schoenoplectus in July 1997 (Table 6.14) were not significantly higher than those recorded in June 1975 on the same macrophyte.

Table 6.19 presents the Mann-Whitney U-test results for the upper site at Savernake. Here the gravel comparisons were made between 1997 and 1975 as on the lower site, but comparisons on *Ranunculus* were only possible between 1997 and 1974. In total, only eight families showed significant differences between years.

Bivalve molluscs in the Sphaeriidae, which occurred in lower densities on *Schoenoplectus* on the lower site at Savernake in 1997 compared to 1975, were also significantly less common at the upper site in 1997 on both *Ranunculus* and gravel.

The high densities of Asellidae on *Schoenoplectus* on the lower site in July 1997 were also observed on *Ranunculus* on the upper site, providing further evidence that this crustacean is now more common than in the 1970s.

Similarly, the lower densities of both Baetidae and Ephemerellidae on gravel in 1997 compared to 1975 were not unexpected in view of similar findings on the lower site. The fact that the Mann-Whitney U-test did not generate significant differences for the Baetidae on *Ranunculus* when 1997 and 1974 were compared was the result of one low count in 1974. In practice, the mean density per sampling unit (n=5) varied from 141 individuals 0.05 m^{-2} in June 1974 to just 10.8 individuals in July 1997.

Table 6.19 R. Kennet at Savernake (Upper site). Mean densities of families (nos 0.05 m^{-2}) on *Ranunculus* (July 1997 and June 1974) and Gravel (July 1997 and June 1975). Families listed are those for which there were significant differences between years, based on the Mann-Whitney U-test.
(* =P< 0.05; ** =P< 0.01)

Family	Ranunculus		Gravel	
	1997	1974	1997	1975
Sphaeriidae	2.0	40.8 *	0.4	37.6 **
Lumbricidae	9.2 **	0.2	16.6 *	1.2
Asellidae	34.4 **	0.6		
Baetidae			2.8	15.2 *
Ephemerellidae			17.6	296.2 *
Polycentropodidae			0.0	2.8 *
Simuliidae	120.8 *	13.2		
Chironomidae	254.8 *	71.8		

The results for two major families of Diptera, the Simuliidae and Chironomidae are interesting, but not necessarily straightforward to interpret. The Simuliidae like the Chironomidae include a number of species with short generation times and hence the densities of individuals in both families are subject to great changes over short periods of time. In 1974, *Ranunculus* grew well through April and May and, having reached the water surface, was subject to a weed cut in early June. In contrast, in 1997, *Ranunculus* was present in small weed-beds growing in shallow water. The fact that both simuliid and chironomid larvae occurred in significantly greater densities on *Ranunculus* in 1997 than in 1974 may be due to the 1974 weed-cut, the restricted area of available habitat in 1997 or some other factor related to the current management regime. Overall, the signs are mixed. Whereas the ability of *Ranunculus* to support simuliid larvae is encouraging, the densities of baetid larvae remain low and this coupled with the high densities of both Chironomidae and Asellidae within the same weed beds indicates that, at present, the habitat provided by *Ranunculus* at Savernake is very different from that at Littlecote.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

7.1.1 Introduction

This study took place in the second year of a major drought. Four different sites were investigated, each one of which had been the subject of previous studies in the 1970s. However, it would be inappropriate to assume that the only impact on each site capable of modifying the macrophyte cover and/or macroinvertebrate assemblages from their status in the 1970s, was the current low discharge regime.

On the River Lambourn at Bagnor, no regular management for trout fishing is taking place at present, in contrast to the weed-cutting and bank maintenance undertaken at the site by the Piscatorial Society in the 1970s. However, on the River Kennet at Littlecote, there does appear to be a similar river management regime as in the 1970s because this section of the river has been retained as an important trout fishery. Thus, the Littlecote site offers the nearest thing to a 'control' site, with respect to management. In contrast, further upstream at Savernake, major changes have been implemented in the management of the river following concerns over both water quantity and quality. These changes include the decision to allow the river to run freely, as at Littlecote, and the use of current deflectors to encourage the regrowth of Ranunculus. In addition, vertical wooden boards, which contained the river on the far bank when the water level was higher level through the manipulation of hatches at Stitchcombe Mill, have now been removed. In their place, emergent macrophytes have been planted and bank-side willows have been felled and allowed to enter the river to in order to increase habitat diversity.

7.1.2 R. Lambourn at Bagnor

The general appearance of the site in 1997, coupled with the mapping results, indicates that this site has changed considerably since the 1970s. This is due to a combination of the lack of the river management practices previously undertaken for trout fishing in the 1970s and the effects of the long drought of 1996-97. Lack of management has allowed the encroachment of marginal emergents, and in particular the tall emergents including *Phalaris arundinacea* and *Veronica anagallis-aquatica*. The low flow conditions have resulted in shallow water through the site and in turn, this has not only encouraged the tall emergents, but has also enabled a wide range of low-growing species to establish themselves more effectively (eg *Nasturtium officinale* agg. and *Mentha aquatica*).

Lack of control of the bank-side trees and bushes on the far bank has also increased shading. This may have had a negative impact on the growth of submerged vegetation, but the poor growth of *Ranunculus* and the progressive build-up of silt on the site in 1997 must, in large measure, be due to the drought. The reason for the limited area of *Berula* at present is less certain, but it may have followed an earlier build-up of silt on the site leading to instability of the carpet of *Berula*, followed by wholesale rip-out of weed, as observed in the late 1970s. *Callitriche* appears to have the potential for rapid expansion in area when the physical environment becomes favourable and competition for space from other macrophytes is not severe.

In 1997, *Berula* and *Ranunculus* grew in sparse beds of weed on clean gravel. However, both species appeared to be healthy and looked capable of expanding in area once conditions become more favourable.

The recent study also provided an opportunity to determine whether the macroinvertebrate fauna of an unmanaged site during a drought differed from the fauna observed during a wide range of discharge conditions during the 1970s, when the river was intensively managed for trout fishing.

The number of families of macroinvertebrates captured on each of the five major habitats tended to be lower in both June and December 1997 than the mean number recorded on each habitat during the 1970s. However, the site list of 52 families occurring on the five major habitats in 1997 compared favourably with the range of 46-53 families recorded over seven years in the 1970s. Family richness on *Berula* in December 1997 was higher than the mean richness during the 1970s (the only habitat and month for which this was the case) and this certainly contributed to the overall site richness in 1997.

Additional samples were taken on emergent macrophytes in view of their importance in 1997. Faunal richness was high in relation to other macrophytes in June, but not in December, when many of the tall emergents had died back. Sampling of emergent macrophytes added a further six families, making a total of 58 families for the site in 1997. It was concluded that there had been no loss of family richness on the shaded site at Bagnor as a result of lack of management or the current drought, and that the site still supports a very rich assemblage of macroinvertebrate families.

When the 58 families recorded in 1997 were compared with a list of 59 families recorded in 1971-79 (approximately eight times the sampling effort of 1997), there were 53 families in common. There were no major surprises in the six families recorded only in the 1970s or the five families captured only in 1997.

Although only family level identifications were required in this contract, it was apparent that the native crayfish (*Austropotamobius pallipes*), which was common during the 1970s, has now been replaced by the signal crayfish (*Pacifasticus leniusculus*).

A comparison of the densities of all the macroinvertebrate families in June from selected habitats and years was undertaken in order to shed light on the impact of the discharge regime. The data available for *Berula* and gravel in June 1996 (major drought) and June 1995 (high discharge) were compared with June 1997.

Undoubtedly, the most important result involved mayflies in the family Baetidae. Densities of baetid larvae in June 1997 were significantly lower on both *Berula* and gravel (Table 6.7) than those recorded in June 1975 during a period of high discharge, as might be expected. However, they were also significantly lower than the densities recorded during the major drought of 1976 (Table 6.6).

Wright and Symes (in press) plotted weighted mean densities of selected macroinvertebrates on the shaded site against monthly mean discharge for the period March-May for each of the years 1971 to 1979. In general, years of low discharge (1973 and 1976) supported low densities of Baetidae in June and years when discharge was high supported much higher densities. However two years, 1972 and 1979, did not fit the overall pattern and had lower densities than might be anticipated. In spring 1972 discharge through the shaded site was reduced substantially for a limited period during the repair of hatches upstream. In 1979, although discharge was high, the site supported very little macrophyte (17.3% in total), following the catastrophic loss of *Berula* at the end of 1978 (Fig. 5.1).

The very low densities of baetid larvae on the shaded site in June 1997 is most probably the result of the low flow regime over a two year period coupled with the very limited availability of the submerged macrophytes favoured by the larvae, that is *Berula* and *Ranunculus* (Table 6.4). Note that even during the historic drought of 1976, the area of submerged macrophyte on the shaded site remained high (Fig.5.1). However, the additional possibility that the proportion of the total discharge down the river has recently been altered in favour of the other channel, should not be discounted.

A manuscript which examines taxon richness at this site and the densities of selected families in 1997 in relation to comparable data collected under a range of discharge regimes between 1971 and 1979 has recently been accepted for publication (Wright *et al.* in press).

7.1.3 R. Kennet at Littlecote

The site at Littlecote was subject to major change in the mid-1970s as a result of the onset of the drought in 1976. Unfortunately, the mapping operation only lasted from April 1974 to June 1976, but additional photographs were taken in 1976 to supplement and extend the mapping period. The changes in discharge and the consequences for *Ranunculus*, the dominant macrophyte at this site, are clearly seen when photographs for June 1974 and June 1976 are compared (Figs 3.2b and d). In 1974, *Ranunculus* grew in profusion and had to be cut on three occasions (April, June and September 1974), whereas in 1976, the normal increase in cover and biomass failed to take place because the weed was smothered by epiphytic algae and associated detritus.

In the summer of 1997, the discharge was lower than in 1974 but greater than in 1976 (Figs 2.3 and 2.4). Although *Ranunculus* was slow-growing through the spring and had still not reached the surface by the time of mapping in July, the area of *Ranunculus* (44.2%) whilst lower than both 1974 and 1975, was much higher than observed in 1976. It provided a suitable habitat for a wide range of macroinvertebrate families typically associated with this plant.

In fact, macroinvertebrate family richness in June 1997 was very similar to that in both 1974 and 1975 (Table 6.8). However, in December 1997, the number of macroinvertebrate families taken on *Ranunculus* (43) was unusually high and contributed to the overall family richness of 47 families in 1997, compared to just 42 families in 1975. The reason why *Ranunculus* was so taxon-rich in December is not entirely clear. However, the fact that the margins of the river were well vegetated with *Nasturtium officinale* agg. in December may have provided additional refuge for some families through the autumn, leading to further colonisation of *Ranunculus* in early winter, when the discharge remained low. Thus, we may conclude that at Littlecote, there was no loss of family richness during the 1997 drought, and in fact the total family richness exceeded that recorded during 1975, when discharge was high in the early part of the year.

In comparing the densities of macroinvertebrates on *Ranunculus* and gravel in 1997 and 1975, based on the Mann-Whitney U-test, some caution is required in the interpretation of differences because it proved impossible to undertake the River Kennet sampling before July in 1997. Hence, densities in June 1975 were compared with densities in July 1997.

Curiously, the densities of four families of Trichoptera on gravel were lower in July 1997 than in June 1975. In view of the fact that overall family richness on this site was not compromised by the low flows of 1997, it is possible that the later sampling time in 1997 contributed to this result.

However, perhaps the most interesting result related to the Baetidae, for this was the only site of the four sites examined, where the Mann-Whitney U-test failed to demonstrate significant differences between the densities of larvae in the summers of 1997 and 1975. Mean densities on *Ranunculus* and gravel in June 1975 (104.8 and 99.2 individuals 0.05 m^{-2}) were higher than in July 1997 (56.2 and 53.8), but as previously stated, these differences were not significant. The fact that Littlecote supported healthy beds of *Ranunculus* in July 1997, separated by clean gravel and only limited accumulation of silt (Fig 5.2) must have contributed to the retention of conditions suitable for members of the Baetidae.

7.1.4 R. Kennet at Savernake

The River Kennet at Savernake presents a more complex situation than either the Littlecote site or the River Lambourn at Bagnor. Longstanding concerns over the progressive loss of *Ranunculus* below Marlborough over a period of years had prompted changes in river management in an attempt to promote the vigorous growth of *Ranunculus*, as previously recorded in the 1970s. The reduction of water levels, use of current deflectors, removal of vertical boarding and reduction of channel width through the planting of marginal emergents etc has already been described.

There is evidence from a number of chalk-stream locations that in years of low discharge, the growth of *Ranunculus* is restricted by the accumulation of epiphytic algae and associated detritus on the surface of the plants (Ham *et al.* 1981, Wright and Berrie 1987). At Savernake, the potential for this problem to be compounded by the presence of nutrients from Marlborough STW, and other diffuse sources resulting from agricultural activities within the catchment, must also be considered.

At Littlecote in 1976, the drought was so extreme (Fig. 2.3) that growth of *Ranunculus* was severely restricted (Fig. 3.2e). However, in summer 1997, despite the prolonged drought, *Ranunculus* was capable of good growth and the gravel substratum remained clean between the beds of weed. The fact that a similar discharge regime was incapable of supporting good growth of *Ranunculus* at Savernake in 1997, despite the management protocols designed to encourage *Ranunculus*, raises the question of whether water quality, in addition to water quantity is a relevant factor for this section of the river.

Although the dominant macrophytes of the lower and upper mapping sites at Savernake differed in 1997, just as they had in the 1970s, the overall pattern of change observed at the two sites was consistent. At the lower site, *Schoenoplectus* was the dominant macrophyte as it had been in 1974-75, but the total area of this macrophyte was much reduced. A simple explanation for this would be that the reduced water levels and faster current produced less than optimal conditions for this macrophyte. However, it is also possible, though unproven, that surface algae had suppressed the growth of the strap-like leaves or that swans or other wildfowl had cropped it in the absence of abundant *Ranunculus*. Although small quantities of

Ranunculus were present, their area was minimal and substantially lower than in 1974-75, despite the more favourable depth.

In 1997, the area of silt on the lower site was greater than in 1974-75 and almost as much as in spring 1976, despite the shallow water and faster current velocity. However, this was the second year of a drought and it is probable that silt accumulated in 1996 was not removed by the modest increase in discharge during the winter of 1996/97.

As a consequence of all these changes, the area of macrophytes at the lower site available as habitat for supporting high densities of macroinvertebrates was much reduced.

Efforts to encourage the regrowth of *Ranunculus* on the upper site by reduction of the channel width and the use of current deflectors showed some benefit in that the optimum location for weed growth was where the current deflectors increased local current speed. Despite this, the total area of *Ranunculus* remained below 10% on both sampling occasions in 1997, and weed occurred as thin beds in shallow water. As a result, it would be possible for wildfowl to limit the density and progressive colonisation of this macrophyte.

The contrast with 1974-75 is hard to underestimate. As previously indicated in section 5.3.2, the growth of *Ranunculus* in April and May 1974 was spectacular, reaching about 40% cover and requiring a major weed-cut in early June to reduce the volume of surface-flowering weed. Further growth took place through the summer resulting in the need for a second cut in September. By contrast, in spring and early summer 1975, a maximum of 27 swans fed selectively on *Ranunculus* and it appears that their grazing pressure held back the increase in area of weed until July (University of Reading, 1977). Despite this, by late summer the site had around 35% cover of *Ranunculus*.

In 1997, the area of *Schoenoplectus* at the upper site never exceeded 3%, whereas in the mid-1970s the area was typically in excess of 20%. Thus, both the dominant and sub-dominant macrophytes were less common at this site than in the 1970s. This was also the case at the lower site.

At the upper site, silt accumulated progressively in 1976 as the major drought developed, and during 1997, silt occupied an important area of the river-bed. As at the lower site, it may have accumulated over the two-year period 1996-97.

In summary, the total area of submerged macrophytes on the upper site available for colonisation by macroinvertebrates was lower in 1997 than in the mid-1970s. However, the growth in area of *Callitriche* by December 1997, coupled with marginal *Nasturtium officinale* agg. probably generated additional habitats for macroinvertebrates through the autumn and early winter.

The two sites at Savernake are not as rich in families of macroinvertebrates as Littlecote, but this was also true in the mid-1970s. Hence, these differences may simply be a consequence of position along the length of the river.

Interestingly, at both the lower and the upper site at Savernake, the number of families of macroinvertebrates recorded in 1997 (39 and 38 respectively) marginally exceeded the number recorded in 1975 (35 and 37). Thus, despite the different discharge regimes in the two years, the different river management protocols which modified the available habitats, and possible differences in water quality, a high proportion of the families recorded in 1975 were also present in 1997. This demonstrates that, at family level, the macroinvertebrate fauna of this section of river has been robust over the wide range of conditions. However, before the total loss (or appearance) of new families at a site, the physical and botanical characteristics, together with the water chemistry of that site can influence the abundance of each family, thereby influencing the structure and functioning of the macroinvertebrate assemblage.

The Mann-Whitney U-tests revealed a larger number of significant differences between July 1997 and comparable records for June 1974/75 for the lower site at Savernake (15 families) compared with the upper site (8 families). This result might be expected if the efforts to manage the upper site in favour of *Ranunculus* were having some modest benefit.

At the lower site, leeches of the family Glossiphoniidae and crustaceans of the family Asellidae occurred in significantly higher densities in July 1997 than in June 1975 within beds of *Schoenoplectus*. These are families that achieve a more prominent role in the community under conditions of nutrient enrichment and organic pollution. They may have been able to increase their numbers more effectively as a result of the two year drought, but their increased abundances do suggest that changes in water quality are taking place which need careful monitoring. Although the densities of Asellidae were slightly lower at the upper site at Savernake, they were also significantly higher in July 1997 than in June 1974. Also notable was the fact that the flatworm *Dendrocoelum lacteum* (Dendrocoelidae), which specialises in the capture of *Asellus*, was recorded in 1997 at both the lower and upper sites, it was never recorded in the mid-1970s.

On *Schoenoplectus* and gravel at the lower site, and on gravel at the upper site, mayfly larvae in the family Baetidae were present in significantly lower densities in July 1997 than in June 1975. This follows the pattern of previous observations on the River Lambourn at Bagnor, but not at Littlecote on the River Kennet, where healthy growth of *Ranunculus* provided adequate conditions for modest densities of larvae. Although the Mann-Whitney U-test did not indicate a significant difference between the densities of baetid larvae on *Ranunculus* at the upper site at Savernake for July 1997 and June 1974, this was due to a single low count in one of the 1974 sampling units. In practice, the mean density per 0.05 m^2 was 141 individuals in June 1974 and just 10.8 individuals in July 1997. Thus, mayflies in the Baetidae were present in very low densities in this, the second year of a major drought.

In addition, larvae of the blue-winged olive, *Ephemerella ignita* (Ephemerellidae) were also present in significantly lower densities in July 1997 compared to June 1975, at both the upper and lower sites.

One reason why the lower site at Savernake had more significant differences between the densities of individual families of macroinvertebrates in summer 1975 and 1997 was that in 1997, no fewer than five families of Trichoptera occurred at lower densities. At Littlecote, a similar feature was noted and the later timing of the sampling programme in 1997 (July) may have been a contributory factor. This could also be the case at Savernake, although additional factors, such as siltation of gravel beds might also be relevant.

At Savernake, densities of Chironomidae were significantly higher on gravel (lower site) and *Ranunculus* (upper site) in summer 1997 compared to 1975. This is a reversal of the situation at Bagnor and Littlecote, where densities were significantly lower in summer 1997 than in

1975 and 1976 at Bagnor and 1975 at Littlecote. The reason for the higher densities of larvae at Savernake appears to be the high availability of food in the form of algae and associated detritus on the surface of the gravel (lower site) and also on the slow-growing *Ranunculus* at the upper site.

In conclusion, although there was no loss of macroinvertebrate family richness at Savernake in 1997, the densities of a number of macroinvertebrate families indicated that this section of the River Kennet was experiencing more adverse conditions than Littlecote. These features of the macroinvertebrate fauna appear to be associated with poor growth of *Ranunculus* and other macrophytes coupled with accumulation of silt at the study sites. In turn, these changes are consistent with the prolonged low discharge, but may also be compounded by nutrient enrichment.

7.2 Recommendations

Over the winter of 1997/98, protracted heavy rains brought an end to the drought of 1996-97, and a substantial increase in groundwater levels. The studies undertaken by the IFE team during 1997 were designed to re-establish the sites first investigated in the 1970s, to investigate the extent to which ecological changes have taken place and to ensure that expertise in the mapping and sampling of the sites was passed on to Environment Agency staff to enable them to continue this long-term study.

The overall recommendations from this first year of the study are as follows:

A) It is essential to continue with the mapping and sampling programme in order to determine whether there have been any long-term ecological effects as a result of this two-year drought.

B) If the effects of the drought are reversible, then it is also important to establish the rate at which recovery takes place.

C) Finally, some of the study sites provide useful case-histories of ecological response to both natural and man-induced changes.

Some specific recommendations related to the individual study sites are given below:

R. Lambourn at Bagnor.

1. At this site there is a particular need to monitor the (expected) recovery of the submerged macrophyte community under conditions of higher discharge and to determine the response of the macroinvertebrate assemblage.

2. In particular, it is important to determine whether the Baetidae occur at greater densities once the discharge regime and the cover of submerged macrophytes return to more characteristic levels for this site.

3. The current non-interventionist management strategy at Bagnor is already influencing the flora and may have long-term consequences for the fauna. Maintaining the present monitoring programme will yield information of wider relevance to river management and conservation.

4. There would also be merit in having the capacity to determine the proportion of the total discharge which flows through the north and the south channels of the river at Bagnor.

R. Kennet at Littlecote

5. The management strategy adopted at this site has been maintained over a long period of time, and the site appears to offer a useful 'baseline' against which to monitor the more complex changes which have occurred at Savernake, further upstream. Hence it would be valuable to continue to monitor both the macrophyte and macroinvertebrates of this site as a control.

R. Kennet at Savernake

6. The need to monitor the River Kennet at Savernake until *Ranunculus* assumes its previous status is paramount. It is also important to document major changes in the status of the macroinvertebrate fauna.

7. The expected increase in discharge during 1998, together with any benefits related to phosphate stripping at Marlborough STW (commenced late 1997) may influence both the flora and the fauna of this section of the River Kennet. If changes occur, the rate and extent of any 'recovery' needs to be documented.

8. The continued monitoring of these sites at Savernake also offers an opportunity to determine the effectiveness of the river management practices that were instigated in an attempt to favor the growth of *Ranunculus*.

Continuing these surveys provides a unique opportunity to establish long-term ecological data which will enhance our understanding of chalk streams in general. The surveys need to be repeated a number of times so that natural annual variation can be taken into account when comparing conditions now with those in the 1970s. This is also important for identifying changes resulting from different management practices and when considering the possible impact of climate change.

8. REFERENCES

Acreman, M. and B. Adams (1998) *Low flows, groundwater and wetland interactions – a scoping study.* Report to Environment Agency (W6-013), UKWIR (98/WR/09/1) and NERC (BGS WD/98/11). Environment Agency R&D Technical Report W112.

Berrie, A. D., Mackey, A.P., Ham, S.F. and Cooling, D.A. (1980) *Ecological study of chalk streams.* A report to the Thames Water Authority, the Department of the Environment and the Nature Conservancy. Report for the period October 1977 to September 1980. River Laboratory, Freshwater Biological Association.

Elliott, J.M. (1977) Some methods for the statistical analysis of samples of benthic invertebrates. *Scientific publications of the Freshwater Biological Association*, No. 25, 160pp.

Environment Agency (1997) *An Environmental Strategy for the Millenium and Beyond.* Bristol: The Environment Agency.

Institution of Civil Engineers (1978) *Thames Groundwater Scheme.* (Ed: A.M. Burt) Proceedings of a Conference held at Reading University on 12-13 April 1978. Institution of Civil Engineers, London.

Ham, S.F., Wright, J.F. and Berrie, A.D. (1981) Growth and recession of aquatic macrophytes on an unshaded site of the River Lambourn, England from 1971 to 1976. *Freshwater Biology*, **11**, 381-390.

Ham, S.F., Cooling, D.A., Hiley, P.D., McLeish, P.R., Scorgie, H.R.A. and Berrie, A.D. (1982a) Growth and recession of aquatic macrophytes on a shaded section of the River Lambourn, England, from 1971 to 1980. *Freshwater Biology*, **12**, 1-15.

Ham, S. F., Wright, J.F. and Berrie, A.D. (1982b) The effect of cutting on the growth and recession of the Freshwater macrophyte Ranunculus penicillatus (Dumort.) Bab. Var. calcaeus (R.W. Butcher) C.D.K. Cook. *Journal of Environmental Management*, **15**, 263-271.

Hiley, P.D., Wright, J.F. and Berrie, A.D. (1981) A new sampler for stream benthos, epiphytic macrofauna and aquatic macrophytes. *Freshwater Bio*logy, **11**, 79-85.

Holmes, N.T. (1997) *MTR survey of the River Kennet at Marlborough.* A report to Thames Region of the Environment Agency. Alconbury Environmental Consultants, Huntingdon.

Holmes, N.T. (1998) *Winterbourne recovery: a monitoring programme using plants following the 1989-1992 groundwater drought. Report of 1996 and 1997 surveys in Thames Region of the Environment Agency (incorporating information from 1992-1995 surveys).* A report to Thames Region of the Environment Agency. Alconbury Environmental Consultants, Huntingdon.

Peters, J.C., Wright J. F. and Berrie, A.D. (1995) *Scoping study for the proposed River Lambourn monitoring programme.* A report to Thames Region of the National Rivers Authority.

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

University of Reading (1973) *Ecological study of the River Lambourn.* A report to Thames Water Authority and the Central Water Planning Unit. Report for the period October 1970 to September 1973. University of Reading, England.

University of Reading (1977) *Ecological study of the River Lambourn.* A report to Thames Water Authority and the Central Water Planning Unit. Report for the period October 1973 to September 1977. University of Reading, England.

Wright, J.F. (1992) Spatial and temporal occurrence of invertebrates in a chalk stream, Berkshire, England. *Hydrobiologia.* **248**, 11-30.

Wright, J.F., Hiley, P.D., Ham, S.F. and Berrie, A. D. (1981a) Comparison of three mapping procedures developed for river macrophytes. *Freshwater Biology*, **11**, 369-379.

Wright, J.F., Hiley, P.D. and Berrie, A.D. (1981b) 'A nine-year study of the life cycle of *Ephemera danica* Mull. (Ephemeridae: Ephemeroptera) in the River Lambourn'. *Ecological Entomology* **6**, 321-331.

Wright, J.F., Cameron, A.C., Hiley, P.D. and Berrie, A.D. (1982) Seasonal changes in biomass of macrophytes on shaded and unshaded sections of the River Lambourn, England. *Freshwater Biology*, **12**, 271-283

Wright, J.F., Hiley, P.D., Cameron, A.C., Wigham M.E. and Berrie, A.D. (1983) A quantitative study of the macroinvertebrate fauna of five biotopes in the River Lambourn, Berkshire, England. *Archiv fur Hydrobiologie* **96**, 3, 271-292.

Wright, J.F., Hiley, P.D., Cooling, D.A., Cameron, A.C., Wigham, M.E. and Berrie, A.D. (1984) The Invertebrate fauna of a small chalk stream in Berkshire and the effect of intermittent flow. *Archiv fur Hydrobiologie*, **99**, 2, 176-199.

Wright, J.F. and Berrie, A D. (1987) Ecological effects of groundwater pumping and a natural drought on the upper reaches of a chalk stream. *Regulated. Rivers: Research and Management*, **1**, 145-160.

Wright, J F and Symes K L (in press) A nine-year study of the macroinvertebrate fauna of a chalk stream. *Hydrological Processes*.

Wright, J.F., Gunn R.J.M., Winder, J.M., Blackburn, J.H. & Wiggers, R. (in press) The response of chalk stream macroinvertebrates to a prolonged drought – the value of a long-term dataset *Verh. Int. Ver. Limnol.*