An Investigation of Ecological Change in the Rivers Kennet and Lambourn

Progress report for the period April 1999 –March 2000

J. F. Wright, R. J. M. Gunn, J. M. Winder,
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Institute of Freshwater Ecology
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Research Contractor:

Institute of Freshwater Ecology
River Laboratory
East Stoke
WAREHAM
Dorset BH20 6BB

Commissioning Organisation:

Environment Agency
Kings Meadow House
Kings Meadow Road
READING
Berkshire
RG1 8DQ

Thames Region Operational Investigation

Commissioning Organisation
Environment Agency
Kings Meadow House
Kings Meadow Road
READING
Berkshire
RG1 8DQ
Tel: 0118 953 5160 Fax: 0118 953 5819

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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.

Research contractor
This document was produced under contract by:

Institute of Freshwater Ecology
River Laboratory
East Stoke
WAREHAM
Dorset BH20 6BB
Tel: 01929 462314 Fax: 01929 463180

Environment Agency Project manager
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Dr J Murray-Bligh – Thames Region.

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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. There is a need for reliable long-term data on the ecology of these chalk streams to ensure effective management and to fulfill the UK Biodiversity Action Plan. Between 1971 and 1979, an intensive study was conducted on the macrophytes and macroinvertebrate assemblages at a shaded site on the River Lambourn at Bagnor. Between 1974 and 1976, further studies took place at three sites on the River Kennet. Two of these sites were located downstream of Marlborough (Upper and lower sites at Savernake) and the third site was at Littlecote, upstream of Hungerford.

In 1997 the Environment Agency (Thames Region) commissioned the Institute of Freshwater Ecology (IFE) to re-examine these four sites in summer (June/July) and winter (December) using the 1970s protocols. The macrophytes were mapped and a quantitative sampling programme for the macroinvertebrate fauna was undertaken at each site. The objective was to provide information on long-term ecological changes at these sites and the impact of the 1996-97 drought. The results have been fully reported in Wright *et al.* (1999a).

The winter of 1997/98 marked the end of the prolonged drought. It was recognised by the IFE and the Environment Agency that there was an urgent need to document any long-term consequences of this drought and, in addition, to collect information on the rate at which recovery took place. Because management practices had changed on some sites between the 1970s and late 1990s, it was also clear that a long-term study could shed light on this important topic. As a result, the Environment Agency drew up a Phase 2 contract for a collaborative project between the Agency and the IFE. Each year the IFE is to repeat the June macrophyte mapping and macroinvertebrate sampling at each site and present the results in a report. In addition, a scientific paper on one aspect of the results is to be written each year. The results of the June 1998 sampling programme may be found in Wright *et al.* (1999b) and the scientific paper is Wright *et al.* (in press). The current report presents the results for the June 1999 sampling programme together with some conclusions and recommendations.

The 50 m shaded site on the River Lambourn at Bagnor is now heavily shaded by trees on one bank and by tall marginal vegetation on the other through lack of management as a trout fishery. In 1997 submerged macrophytes occupied a smaller area of the riverbed than in the 1970s, whereas silt and marginal emergents were more important. These changes were thought to be due to a combination of the 1996/97 drought and lack of management.

Since then, despite high discharge in spring 1998 and the resumption of the normal flow regime in 1999, progressive colonisation of the riverbed by submerged macrophytes has been slow and the area of deposited silt remains high. Additional monitoring is required to determine whether the area of submerged macrophyte will eventually double to reach the 1970s mean, or whether a new equilibrium will be achieved as a consequence of lack of active management of the site.

Despite these changes at the site, there is evidence of long-term stability in macroinvertebrate family composition between the 1970s and the late 1990s. During the 1970s, quantitative sampling of five habitats yielded between 42 and 47 families in June each year. In June 1997, at the height of the drought, 42 families were captured, 45 families were recorded in June

1998 and 47 families were found in June 1999 from the same five habitat types.

However, the densities of some important families in chalk streams such as Baetidae (mayflies) and Simuliidae (blackflies) were adversely affected by the drought of 1996/97. Although there is evidence of some recovery, these families, together with many other families, need large areas of submerged macrophytes in order to develop high site densities and fulfil their important role in the functioning of the ecosystem.

The 100 m study site on the River Kennet at Littlecote remains an important trout fishery, as in the 1970s. The river is allowed to run freely, and even in the 1996/97 drought, *Ranunculus* (Water crowfoot) covered 44.2% of the site in July 1997, supplemented by emergent marginal vegetation. In summer 1998 and 1999, *Ranunculus* increased in area further, necessitating periodic bar-cutting as is the normal practice on this section of river.

During the late 1990s, macroinvertebrate family richness on the two major habitats (gravel and *Ranunculus*) varied from 35 families in July 1997, through 32 families in June 1998 to 36 families in June 1999. Because *Ranunculus* remained as an important habitat throughout the drought, families such as Baetidae and Simuliidae maintained modest populations in 1997, and they assumed progressively higher densities in June 1998 and June 1999. The Littlecote site may be viewed as a 'control' against which to assess the greater changes at Savernake.

The two 50 m study sites on the River Kennet at Savernake suffered progressive loss of *Ranunculus* during the 1990s and all attempts at promoting re-growth by habitat management failed. In July 1997 the dominant macrophyte on the lower site was *Schoenoplectus* (Clubrush) (17.4% cover) whereas on the upper site *Ranunculus* was dominant with just 6.5% cover. During the winter of 1997/98 two potentially important events occurred. First, the drought ended, and although winter discharge was not exceptional, a particularly wet spring led to very high discharge in May 1998, immediately prior to mapping. Second, phosphate stripping commenced at Marlborough STW in November 1997.

The June 1998 mapping demonstrated that there had been spectacular growth of *Ranunculus* on each site. On the lower site *Ranunculus* dominated with 43.6% cover, far higher than the area noted at any time during the mid-1970s or in 1997. On the upper site *Ranunculus* occupied 48.8%, again a spectacular increase since 1997. It was apparent that, under favourable conditions, *Ranunculus* was capable of rapid recovery, presumably due to the survival of root systems within the gravel substratum. In June 1999, the area of *Ranunculus* on each site was even higher.

Despite these major changes in habitats for macroinvertebrates, taxon richness at family level remained relatively stable at each site with 33 families recorded at each one of the two sites in July 1997, 32 families at each site in June 1998 and 34 families at each site in 1999. There were, however, some differences in family composition between sites and years.

However, there were major changes in the density of some families between July 1997 during the drought and June 1998 and 1999, under high flows. Several families normally associated with conditions of nutrient enrichment including Glossiphoniidae (leeches), Erpobdellidae (leeches), and Asellidae (the water hog-louse) which occurred at high densities in July 1997 were present at lower densities in June 1998 and 1999. In contrast, populations of mayflies in the family Baetidae, which had been at low population densities during the drought, showed much higher population densities in June 1998 and 1999.

1. INTRODUCTION

1.1 Background

In 1997, the Environment Agency, Thames Region, commissioned the Institute of Freshwater Ecology to undertake studies on the macrophytes and macroinvertebrate assemblages at four sites on the Rivers Kennet and Lambourn. These included two sites on the River Kennet (Savernake upper and lower) downstream of Marlborough, a further location on the same river upstream of Hungerford (Littlecote) and a fourth site on the River Lambourn (Bagnor – shaded site). Each one of these sites had been the focus of detailed studies by a team of freshwater ecologists in the 1970s, and valuable historical data were available for each location. The low flows of 1996 and the worsening drought conditions through the spring of 1997 provided the impetus for a re-examination of these sites.

Macrophyte mapping followed by quantitative sampling of the macroinvertebrates on major habitat types was undertaken in each of June/July 1997 and December 1997, using the 1970s protocols in order to ensure compatibility of the data. The results, including a photographic record comparing all sites in the 1970s and 1997, together with an appraisal of changes in the macrophytes and macroinvertebrate assemblages over this period were included in a comprehensive report to the Environment Agency (Wright *et al.* 1999a).

There was always an intention that this study would continue beyond the 1996-97 drought, and Environment Agency staff accompanied IFE staff during the field work of 1997 in order to gain familiarity with the techniques. When the drought ended in winter 1997/98, and spring of 1998 was notable for high rainfall, it was apparent that a resampling programme had great potential to provide valuable information on the rate at which both the macrophytes and the macroinvertebrates responded to the end of a prolonged drought. The winter of 1997/98 also marked the beginning of a programme of phosphate stripping at Marlborough sewage treatment works.

As the optimum time for sampling in June 1998 approached, it became clear that the Environment Agency would be unable to devote manpower to the mapping and sampling programme at the four sites. In view of the potential loss of valuable data, the IFE team stepped in to repeat the mapping and sampling programme for June, on the understanding that the Environment Agency would attempt to find financial resources to support the collection, processing and reporting on the samples for summer 1998. Financial help was secured, and information on the mapping and macroinvertebrate sampling programme on the four sites, together with a brief appraisal of the response of the biota to the end of the drought and recommendations for further work were presented to the Environment Agency in Wright *et al.* (1999b).

The Environment Agency recognised that natural variation occurs between years in the flora and fauna of chalk streams and that it is essential to document the scale of this variation in order to demonstrate the scale of response to extreme events such droughts and confirm any long-term changes to the chalk stream ecosystem. With this in mind, a Phase 2 contract was drawn up as a collaborative project between the Agency and the Institute of Freshwater Ecology. This allows for the mapping and sampling programme at all four sites to continue until June 2001, thereby providing a five-year run of data (1997 –2001). In addition to yearly reports which present the macrophyte and macroinvertebrate data for the year, a Technical Report, incorporating an overall analysis of the results and a comparison of the results with conditions in the 1970s will be produced at the end of the contract in March 2003. As its contribution to this collaborative project, the Institute of Freshwater Ecology will produce one scientific paper in each of five years (1999-2003) on one or more aspects of this series of surveys.

1.2 Objectives

The overall objective 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 Phase 2 contract specification also lists twelve specific objectives:

1. To liaise with land agents at Bagnor, Littlecote and Savernake and get agreement to map and sample in June 1998, 1999, 2000 and 2001.

2. To map the sites at Bagnor, Savernake (lower) and Savernake (upper) each year, as in 1997, to determine change in the percentage cover of macrophytes and other habitats.

3. To undertake quantitative sampling of the macroinvertebrate fauna at the 4 sites as follows:

    Bagnor – 30 sampling units
    Littlecote – 10 sampling units
    Savernake (lower) – 10 sampling units
    Savernake (upper) – 10 sampling units

    This is the same sampling effort as used in summer 1997.

4. To take photographs of the sites to document their status and for comparison with summer 1997 and the 1970s.

5. To process the 60 quantitative macroinvertebrate sampling units at family level each year, as in 1997.

6. To input the June 1998, 1999, 2000 and 2001 macroinvertebrate data from the 4 sites into Access97 and to verify it.

7. To populate the plant database with the mapping data for June 1998, 1999,2000 and 2001 in order to create maps and cover data for Bagnor, Savernake (lower) and Savernake (upper).

8. To analyse the macrophyte and macroinvertebrate data in relation to the data from the 1970s and 1997.

9. To compile the raw data collected in this survey and collate it so that it can be used by the Agency for future reference.

10. To produce annual progress reports on the work undertaken in each reporting period, together with information on the structure of the results database and a summary of any conclusions and recommendations (to include an evaluation of the desirability of continuing the surveys in the following year).

11. To produce a scientific paper each year (total of five) analysing the results of one or more aspects of this series of surveys.

12. To produce a technical report of this work, including an overall analysis of the results and comparison with conditions in the 1970s.

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 discharge through the shaded site at Bagnor is substantially lower than at Shaw, but the seasonal regime in any given year will mimic the picture obtained at Shaw.

The discharge regime on the River Lambourn at Shaw from January 1990 to December 1999 is presented in Figure 2.1. This period included a two-year drought in 1991 and 1992, followed by a period of three years (1993-95) when the characteristic discharge regime resumed with high peak flows early in the year. Then followed a further two-year period of drought (1996-1997) in which there were no high flows in the winter of 1996/97. High rainfall through the winter of 1997/98 brought an end to the drought, but peak flows remained below those experienced between 1993 and 1995. However, the wet spring resulted in a mean discharge in May 1998 (immediately prior to sampling) that approached the monthly mean values recorded in each of 1993-96 and was over twice the discharge recorded in May 1997. In 1999, the characteristic discharge regime was observed once more, as in the period 1993-95.

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 2.2 presents the discharge regime at Knighton between January 1990 and December 1999. The protracted drought of 1991-92 and the progressively more severe drought of 1996-97 are apparent, separated by those years (1993-95) in which the characteristic discharge regime prevailed. As previously noted on the River Lambourn at Shaw, winter rains in 1997/98 marked the end of the drought but peak discharge fell short of that recorded in the mid-1990s. In spring 1998, the rainfall was sufficient to result in a monthly mean discharge in May 1998 that exceeded the values recorded in the same month in all earlier years shown in Fig.2.2. In particular, the mean discharge in May 1998 was almost four times the mean discharge recorded in May 1997. However, by 1999, the characteristic seasonal discharge regime, as observed between 1993 and 1995, had resumed.

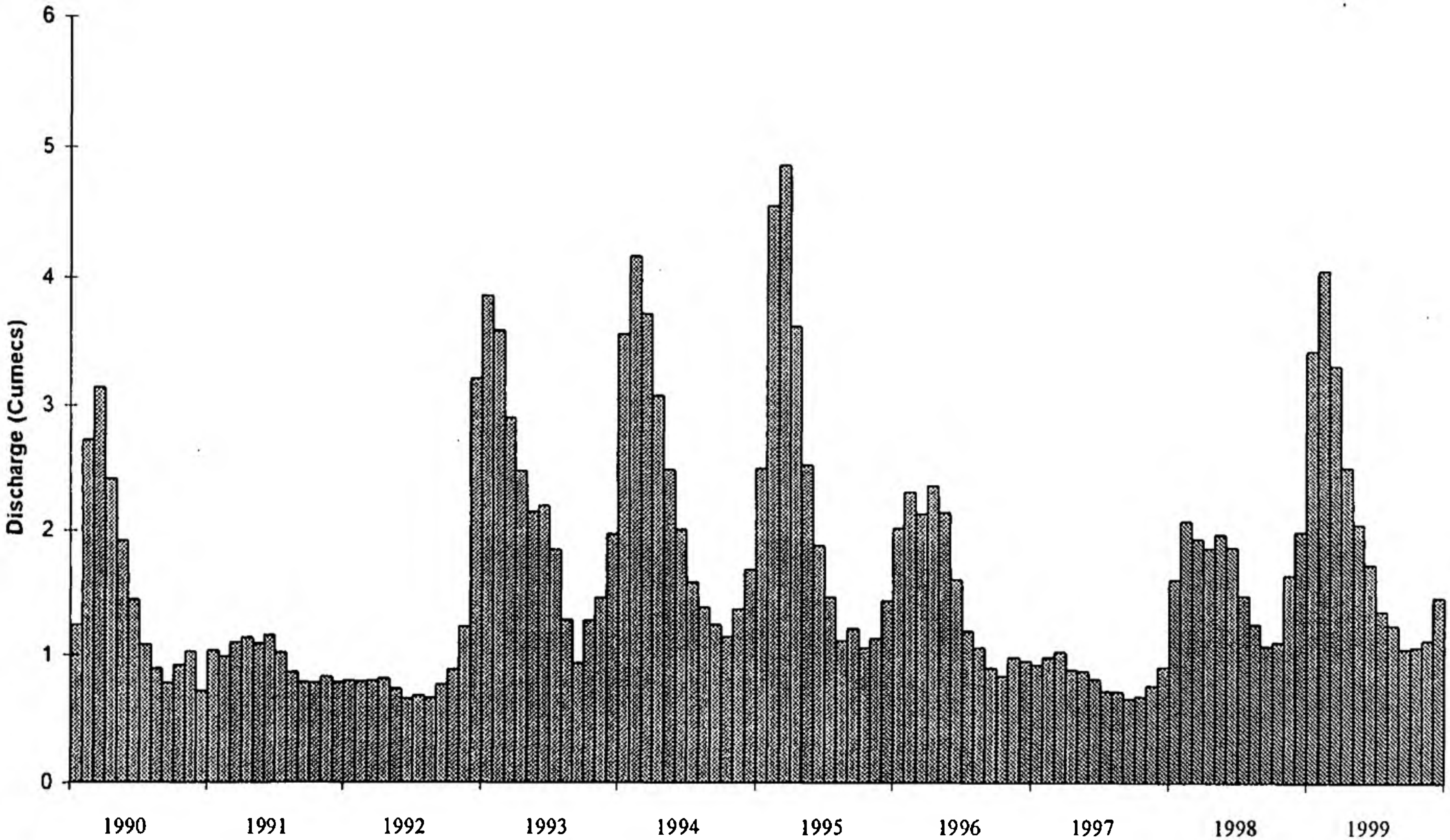

Figure 2.1. Monthly mean discharge on the R. Lambourn at Shaw, January 1990 – December 1999

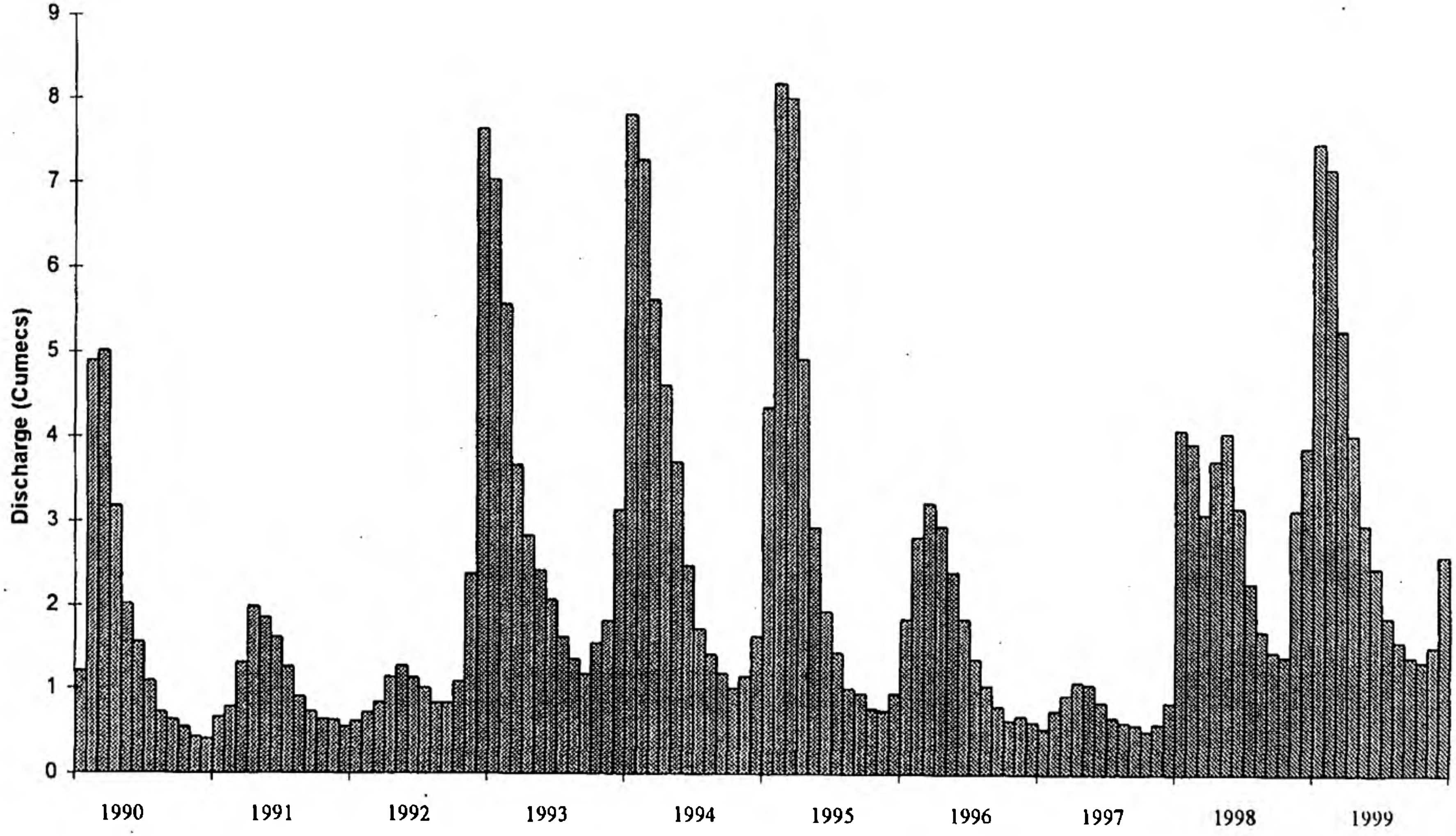

Figure 2.2. Monthly mean discharge on the R. Kennet at Knighton, January 1990 – December 1999

3. THE STUDY SITES

A comprehensive photographic record of the four study sites during the 1970s and in 1997 was given in Wright *et al.* (1999a). Additional photographs taken at each site in June 1998 were presented in Wright *et al.* (1999b). The purpose of this section is to provide further documentation of the sites in June 1999.

3.1 The R. Lambourn at Bagnor (shaded site), June 1999

Figure 3.1a is a view looking upstream taken in June 1999. The area of *Ranunculus* has increased substantially on this lower section of the study site compared to June 1998 (see Fig.3.1a in Wright *et al.* 1999b), but even so, the total area of *Ranunculus* on the shaded site only increased from 1.9% in June 1998 to 7.7% in June 1999 (further details on % cover are given in Table 5.1). The site remains unmanaged with overhanging trees and bushes on the left-hand side of the photograph and emergent marginal vegetation on the right hand side.

Fig.3.1b is a view looking downstream from a vantage point near the top of the 50 m site. *Berula* has now started to develop as substantial carpets of weed on the river-bed and its area has increased from 9.6% in June 1998 to 20.0% in June 1999. However, it still remains well below its mean percentage cover of 38.3% observed through the 1970s (see Table 5.1).

3.2 R. Kennet at Littlecote, June 1999

Fig. 3.2a is a general view of the site in June 1999 from the upstream limit looking downstream. In 1999, as in 1998, *Ranunculus* has grown well during the early part of the season and is flowering at the water surface. Bar-cutting of the weed has already taken place.

Fig.3.2b was taken from the middle of this 100 m site looking downstream. Once again, it is apparent that the *Ranunculus* has been subjected to bar-cutting and that between strips of surface weed, there are sections where much of the weed has already been taken out.

3.3 R. Kennet at Savernake (lower and upper sites), June 1999

Savernake Lower

Fig.3.3a provides a general view of the site in June 1999, looking upstream. As in the previous summer, *Ranunculus* has grown well during the early part of the season and there are occasional patches of surface weed in flower. In fact *Ranunculus* occupied 53.7% cover in June 1999, compared to 43.6% cover in June 1998 (see Table 5.3). In contrast, the 'other' macrophytes were less in evidence in June 1999 (7.2%) compared to 16.7% in June 1998 (see also Fig. 3.3b. in Wright *et al.* 1999b). 'Other' macrophytes included *Callitriche*, (which declined from 8.4% in June 1998 to 2.4% in June 1999) and emergent macrophytes, including *Mentha aquatica* and *Veronica anagallis-aquatica*, (which declined from 8.3% to 4.8%).

Fig. 3.3b shows a close-up of surface *Ranunculus* on the site in June 1999. It is apparent that the weed has been on the surface for some time, given the amount of accumulated debris (see also Fig.3.3b in Wright *et al.* 1999b where *Ranunculus* has only just reached the surface).

Savernake Upper

Fig.3.3c is a view of the upper 50 m site at Savernake in June 1999 looking downstream. Surface-flowering *Ranunculus* is present at this site, which also shows accumulated debris on surface weed. It is apparent that the water-level is slightly lower in June 1999 than in June 1998, based on the fact that two wooden water deflectors are clearly visible in the June 1999 photograph but not in June 1998 (see Fig. 3.3c in Wright *et al.* 1999b).

Fig.3.3d was taken a little further upstream in June 1999 and shows more surface-flowering *Ranunculus* covered in debris.

Figure 3.1 a) R. Lambourn at Bagnor (shaded site). June 1999. View upstream from the bottom of the site showing beds of *Ranunculus*.

Figure 3.1 b) R. Lambourn at Bagnor (shaded side). June 1999. View downstream from near the top of the site showing carpet of *Berula*.

Figure 3.2 a) R. Kennet at Littlecote. June 1999. View downstream from the top of the 100m site.

Figure 3.2 b) R. Kennet at Littlecote. June 1999. View downstream from the middle of the 100m site.

Figure 3.3 a) R. Kennet at Savernake (lower). June 1999. View upstream.

Figure 3.3 b) R. Kennet at Savernake (lower). June 1999. Surface *Ranunculus* bed with accumulated debris.

Figure 3.3 c) R. Kennet at Savernake (upper). June 1999. Downstream view of the site from upper site limit.

Figure 3.3 d) R. Kennet at Savernake (upper). June 1999. Downstream view of the site from further upstream.

4. METHODS

Note: The methods section, as given in Wright *et al.* (1999a), is repeated here with only minor amendment to help readers who are unfamiliar with the procedures used in this study.

4.1 Macrophyte mapping

4.1.1 Field procedures

A detailed account of the field procedures involved in the 'rectangles' method of mapping was given in Wright *et al.* (1981), but a synopsis of the approach is repeated 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 opposite 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. (Mapping strings are in the process of being set out in Fig. 3.3a).

The mapping operation may be undertaken by two people, 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 repositioning the cross-river tapes when they are moved 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 as a single taxon. 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 enters 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 is determined to the nearest 0.5 m and relayed to the recorder on the bank who then marks 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 views the 1 m strip of river between cross-river tapes at 0 and 1 m upstream. The tapes with their numbered tags form a 1 m grid across the river, and each square of the river-bed below can be divided longitudinally, by eye, into two 1 x 0.5 m rectangles. A metal-tipped pole used by the caller was found to be 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 is then determined for each rectangle, but where a macrophyte and a non-macrophyte each occupy 50%, the macrophyte is given dominance. The substratum underlying the macrophyte is 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 is passed to the recorder until the location of the opposite bank is given. The caller then moves one metre upstream and continues the mapping process towards the baseline for the strip of river between the tapes positioned 1 to 2 m upstream. This process continues until the entire grid provided by the first positioning of the cross-river tapes has been completed. The tapes are then repositioned upstream for further mapping and this process is continued until the entire site has been mapped.

This account describes the mapping procedure on the River Lambourn at Bagnor, where the river is narrower than the River Kennet. However, the submerged and marginal emergent vegetation at Bagnor include a wide range of species, which increase mapping times. Similarly, the presence of overhanging branches and thick bushes and trees on the far bank makes the positioning of mapping strings more difficult. Once tapes have been repositioned prior to mapping, checks are made that all the 1 m tags on the mapping strings are aligned in order to avoid mapping inaccuracies.

Since the Kennet sites are wider than the River Lambourn, the need to check that tapes are in alignment is even more critical on the River Kennet. At Littlecote, where the site is a full 100 m in length, the baseline itself changes 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. Initially, 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. More recently, most of these stakes have been removed, but the precise location of each 50 m site can still be defined at the outset of each mapping operation.

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.

Note that from June 1998 onwards, the decision was taken to draw a sketch–map of the weed beds on the Littlecote site, using 5 m metres strings across the river for guidance instead of undertaking the full mapping procedure outlined above. This avoided the need for three people to spend a whole day mapping a site on which *Ranunculus* was the dominant macrophyte.

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 percentage cover data are presented in Chapter 5 of this report.

Please note: The June 1999 computer maps are being supplied to the Environment Agency as EXCEL files and hence are not included within 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 has 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 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 of the net and its contents into the current, the contents were concentrated into the bottom of the net.

In June/July and December 1997 the following procedure was adopted. Once on the bank, the sample was transferred into a labelled polythene bag. No water or formalin 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. This procedure was particularly relevant to the December samples in which there were large numbers of small stone-cased caddis larvae in the family Glossosomatidae that needed careful removal from larger stones. The requirement 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. In June 1998 and 1999, the decision was taken to preserve each sample in the field, in order to eliminate the additional step of an initial clean up of each sample in the laboratory. Any large stones were carefully examined and leeches, molluscs and caddis etc. carefully removed and retained with the sample before the stones were discarded.

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 the processing of all the samples, 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 1990s sampling programme.

One major group of macroinvertebrates, the Oligochaeta, was treated differently in the 1970s and in the late 1990s research programme. 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 the late 1990s, 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 the 1990s 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.

5. RESULTS OF MACROPHYTE MAPPING

5.1 R. Lambourn at Bagnor (shaded site)

The results obtained by mapping the site in June 1999 have been inserted into Table 5.1 for comparison with the equivalent results for June of 1998 and both June and December 1997. This table also presents the maximum, minimum and mean percentage cover of the major habitat types for the site over the period January 1971 to December 1979 and information on the total wetted area of the study site, expressed in square metres (m^2).

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 & December 1997, June 1998 and June 1999 (latter in bold). Historical data for January 1971 - December 1979 is presented as maximum, minimum and mean values.

Date(s)	Total Area m^{-2}	Percentage Cover Berula	Call	Gravel	Ran	Silt	Other
June 1997	387	5.8	24.9	29.3	6.2	17.6	16.2
Dec 1997	372	9.3	1.6	44.2	2.6	31.2	11.1
June 1998	439	9.6	2.3	51.7	1.9	26.8	7.8
June 1999	**397**	**20.0**	**3.5**	**35.8**	**7.7**	**22.0**	**10.9**
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, when the mean percentage cover was 38.3% (Table 5.1), has now started a slow recovery from 5.8% in June 1997, through 9.3% in June 1998 to 20.0% in June 1999. Although the rate of increase in area is slow in relation to that observed in the late 1970s after an earlier substantial rip-out of carpets of *Berula*, the site does now appear to be moving back towards a state in which *Berula* is the dominant macrophyte on this partially shaded site. Given the current lack of management of the site compared to the 1970s, the greater shading by tree cover on one bank and the presence of more emergent vegetation on the other may limit the potential for *Berula* to resume the level of dominance observed in the 1970s.

Callitriche showed only a very modest increase in area compared to the previous year (from 2.3% to 3.5%) and was still well below the long term mean of 10.3% in the 1970s.

In contrast, *Ranunculus*, occupied 7.7% cover in June 1999 (1.9% in June 1998) and was most noticeable at the lower end of the site (see Fig. 3.1a) where the shading from tree cover and emergent macrophytes was less. Even so, despite the resumption of a normal flow regime, the area of *Ranunculus* remained well below the mean area of 13.7% recorded in the 1970s.

The 'other' macrophyte category, that is the emergent macrophytes, increased slightly in area from June 1998 (7.8%) to June 1999 (10.9%) with *Mentha* remaining the dominant emergent macrophyte.

Although gravel remained the dominant habitat on this site in June 1999, the fact that all the macrophytes increased in cover between June 1998 and June 1999 meant that the overall area of gravel decreased from 51.7% to 35.8% over this period.

Finally, the area of silt, which had remained high at 26.8% cover in June 1998, despite the high winter flows of winter 1997/98, was only marginally lower at 22% in June 1999. In this case, the lack of active instream management may be contributing to this situation, given that during the 1970s, when the Piscatorial Society keeper was active, the mean area of silt was just 1.5%.

5.2 R. Kennet at Littlecote

Mapping of the 100 m site at Littlecote is a full day's work for a team of three. In view of the fact that, under high discharge conditions, the river bed is largely *Ranunculus* and gravel, it was apparent that a good approximation of percentage cover could be obtained by making a sketch map on the date of sampling, thereby saving valuable time. Hence, in Table 5.2, the estimate for the total area of the site and percentage cover of the major habitat types in June 1998 and June 1999 is given within brackets.

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. Estimated values for June 1998 and 1999 are given within brackets. Historical data for April 1974 - June 1976 is presented as maximum, minimum and mean values.

Date(s)	Total Area	Percentage Cover			
	m^{-2}	Gravel	Ran	Silt	Others
July 1997	1244.5	35.9	44.2	3.1	16.8
Dec 1997	1310	30.5	38.9	0.9	29.7
June 1998	(1245.5)	(27.7)	(71.5)	(0.0)	(0.7)
June 1999	(1362)	(37.9)	(61.2)	(0.5)	(0.4)
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

The estimate for the total area of the site increased in June 1999 from the value obtained during the drought in July 1997. In June 1998, the high winter and spring flows had removed emergent marginal vegetation which had been such a feature of the site in July and December 1997. This discharge regime favoured early growth of *Ranunculus* and in June 1998 the first bar-cutting had already taken place. *Ranunculus* occupied an estimated 71.5% of the site, gravel was present on a further 27.7% and there was no accumulation of silt. In spring 1999, the *Ranunculus* had also grown very well, and a bar-cut had taken place prior to estimation of the percentage cover of each habitat in June 1999. *Ranunculus* remained the dominant habitat (61.2%), with large areas of gravel (37.9%) plus small patches of silt, predominantly in marginal areas but also within cut areas of *Ranunculus*.

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

5.3.1 Savernake (Lower site)

The results obtained by mapping this site in June 1999 are given in bold in Table 5.3 and can be seen alongside the equivalent information for June 1998 and June 1997 (also December 1997). The summarised data for the period from April 1974 to April 1976 has also been included to provide a broader context.

The total area of the site increased again in June 1999 from the value noted in June 1998. Given that the mean discharge for June 1999 was marginally lower than in June 1998, this was probably due to the larger area and volume of *Ranunculus* on the site in June 1999 (Table 5.3). Note that the bank maintenance undertaken during the winter of 1997/98, which decreased the total width of the site, resulted in an increase in current speed, thereby favouring the growth of *Ranunculus*.

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 & December 1997, June 1998 and June 1999 (latter in bold). Historical data for April 1974 - April 1976 is 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
Dec 1997	536.0	53.6	0.2	11.8	14.1	20.3
June 1998	617.5	26.8	43.6	7.3	5.6	16.7
June 1999	**653.5**	**23.6**	**53.7**	**6.3**	**9.3**	**7.2**
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

Major changes in submerged macrophytes have occurred at this site between the mid-1970s and the 1990s (Table 5.3). *Schoenoplectus* which had occupied around 60% of the site in the mid-1970s remained the dominant macrophyte in 1997, but was recorded in less than a third of the area it occupied in the mid-1970s. *Ranunculus*, which was subdominant in the mid-1970s was still present in 1997, but occupied less than 1% of the study site. However, following the end of the drought, *Ranunculus* underwent a remarkable resurgence and became the dominant macrophyte on this site. In June 1998 it occupied 43.6% of the site and in June 1999 the percentage cover was even higher at 53.7%. In contrast, in 1974-75 the highest % cover ever recorded was only 19.3%. Note also that phosphate stripping commenced at Marlborough STW in November 1997.

Schoenoplectus, which in July 1997 only occupied 17.4% of the site continued to decrease in area through June 1998 (7.3%) and also June 1999 (6.3%), probably as a result of the early summer growth of *Ranunculus*. Later in the year, if *Ranunculus* is subjected to severe cutting or dies back, the beds of *Schoenoplectus* may become more apparent.

The area of 'other' macrophytes reduced from 16.7% in June 1998 to just 7.2% in June 1999. Both submerged *Callitriche* and the emergent marginals (dominated by *Mentha*) were less in evidence in June 1999 (see Fig.3.3a).

The dominant position of *Ranunculus* has led to a further modest decrease in the area of gravel, which is now back to the long-term mid-1970s mean but the area of silt has increased slightly between June 1998 and 1999 (5.6% to 9.3%), possibly due to low current speeds generated downstream of major weedbeds.

5.3.2 Savernake (Upper site)

Table 5.4 presents information on the total area and percentage cover of the major habitats on the upper site at Savernake in June 1999, together with the equivalent information for June 1998, July and December 1997, and summary data for 1974-76.

In June 1999, the total area of the site was unchanged from June 1998 but was noticeably greater than in 1997 as a result of the end of the drought. However, it remained substantially lower than in the mid-1970s, predominantly due to the planting of marginal emergents and the cutting of marginal willows to narrow the effective river width (See Wright *et al.* 1999a). Note that 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 this area, despite the fact that it was under water.

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, June 1998 and June 1999 (latter in bold). Historical data for April 1974 - April 1976 is presented as maximum, minimum and mean values.

Date(s)	Total Area	Percentage Cover				
	m^{-2}	Gravel	Ran	Schoen	Silt	Other
July 1997	551.0	64.5	6.5	2.7	22.0	4.4
Dec 1997	541.5	52.5	8.1	2.2	19.2	17.9
June 1998	604.5	36.2	48.8	1.7	4.1	9.2
June 1999	**605**	**23.1**	**56.5**	**2.1**	**15.0**	**3.2**
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

As previously noted on the lower site at Savernake, the area of *Ranunculus* at the upper site was even higher in June 1999 than in June 1998 with 56.5% of the site covered by this macrophyte. This exceeded the highest percentage cover (45.2%) recorded in 1974-75.

Schoenoplectus was still present with just 2.1% cover, but in view of the way in which *Ranunculus* is now favoured at this site, it is unlikely that it will increase its area substantially in the near future. The area of 'other' macrophytes also decreased, as previously observed on the lower site at Savernake.

Whereas the area of gravel decreased further due to the spectacular growth of *Ranunculus*, silt started to increase once again from just 4.1% in June 1998 to 15% in June 1999. Again, this is probably as a result of slack areas created behind large weedbeds, particularly so given that some of the *Ranunculus* on this site had reached the surface some time ago.

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 and study site is held in an 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 1999 is shown in Table 6.1 in bold. This table also gives the equivalent information for June 1998 and June 1997 and the maximum, minimum and mean number of families recorded per habitat during the detailed studies undertaken in the 1970s. (**Note**: the 1970s data-set is restricted to seven years data comprising 1971 plus 1974-79 when the laboratory processing technique was the same as that used in 1997 and 1998. 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, from 1997 onwards, they did warrant additional sampling to determine their characteristic fauna.

Table 6.1 R. Lambourn at Bagnor (shaded site) in June of 1997, 1998 and 1999 (latter in bold). 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
June 1998	37	32	24	26	27	34
June 1999	**40**	**34**	**24**	**31**	**28**	**35**
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 increased or remained the same (gravel) from June 1998 to June 1999. In particular, overall family richness on *Berula* increased to 40 families as the area of *Berula* increased and hence the age structure of the carpets diversified. The family richness on *Ranunculus* also increased at a time when this macrophyte increased in area after occurring at low % cover in June 1998. As a result all macrophytes, including the marginal emergents supported over 30 families per habitat, whereas the two other habitats (gravel and silt) were less taxon-rich. Curiously, the number of families on gravel in the 1990s has never reached the minimum number (27) recorded during the 1970s.

In June 1997, a total of 46 families were recorded, of which 42 were found in the five habitats sampled in the 1970s. In June 1998 the total rose to 52 families (45 on five habitats) whilst in

June 1999 the total was 48 families (47 on five habitats). In the seven years 1971 plus 1974-79, the total number of families from five habitats varied from 42 to 47, and hence the 47 recorded in June 1999 was at the upper limit of the 1970s range.

6.1.2 Family composition and abundance data for June 1999

Table 6.2 presents a list of the 48 families of macroinvertebrates and their mean densities on each of the six habitat types sampled in June 1998. Note that the Oligochaeta and Lumbricidae, although presented separately, are counted as a single 'family' in this report. See section 4.2.2 of this report for an explanation of the need for this protocol. The faunal list for June 1999 includes 17 'families' of non-insects and 31 families of insects compared to 17 and 35 in June 1998 and 16 and 30 in June 1997.

Overall, 45 families of macroinvertebrates were recorded at this site in both June 1998 and June 1999. However, the following differences were noted between the families recorded in these two years.

June 1998 only

Crustacea:	Astacidae
Plecoptera:	Nemouridae
Hemiptera:	Corixidae
Trichoptera:	Hydroptilidae
Diptera:	Stratiomyidae
	Ephydridae
	Muscidae

June 1999 only

Mollusca:	Valvatidae
Megaloptera:	Sialidae
Diptera:	Ptychopteridae

Although several live specimens of *Pacifasticus leniusculus* (Astacidae) were found in June 1998, only the occasional carapace of a dead specimen was recovered in June 1999. Astacidae, Nemouridae, Corixidae and Hydroptilidae were all recorded in June 1997 in addition to June 1998 (but not June 1999). Note also that the three families present in June 1998 (but not June 1998) were also recorded in June 1997. Clearly, any families that occur at low density on the site, may or may not be picked up by the sampling programme in any one year, and it would be unwise to read too much into an absence for a single year.

Table 6.2 **R.Lambourn at Bagnor (shaded site), June 1999. Mean densities of macro-invertebrate families (nos per 0.05 m^{-2}) based on 5 sampling units for each habitat type**

Family name	Berula	Callitriche	Emergents	Gravel	Ranunculus	Silt
Planariidae	7.40	0.80	0.80	0.60	1.80	0.80
Dendrocoelidae	2.60	0.80	0.00	0.00	0.00	0.40
Valvatidae	1.60	0.80	0.40	0.00	0.00	0.00
Hydrobiidae	29.80	40.60	23.80	25.80	12.40	15.60
Physidae	0.60	0.00	0.00	0.00	0.20	0.00
Lymnaeidae	0.60	0.00	0.00	0.00	0.20	0.00
Planorbidae	7.80	5.80	0.80	1.60	6.80	4.80
Ancylidae	9.60	1.20	1.40	2.00	2.60	0.40
Sphaeriidae	1.40	29.60	2.40	0.40	0.00	22.80
Oligochaeta	58.60	168.40	59.40	5.40	26.20	64.80
Lumbricidae	4.60	0.80	1.20	0.80	0.60	0.00
Piscicolidae	1.00	0.40	0.40	0.00	1.60	0.80
Glossiphoniidae	1.60	0.80	1.60	0.00	0.00	1.20
Erpobdellidae	0.20	2.40	0.20	0.00	0.00	0.40
Hydracarina	1.40	0.40	1.40	0.80	9.60	0.00
Asellidae	4.40	5.60	7.20	0.00	0.40	1.20
Gammaridae	392.20	298.00	216.80	276.40	235.60	184.20
Niphargidae	0.00	0.80	0.00	0.00	0.00	0.00
Baetidae	91.00	41.20	4.40	17.80	164.00	4.80
Leptophlebiidae	0.20	0.00	1.20	0.00	0.20	0.00
Ephemeridae	7.40	2.40	19.60	4.20	2.60	4.00
Ephemerellidae	27.80	28.20	4.80	1.20	48.60	5.60
Caenidae	27.40	3.80	25.60	0.00	17.40	4.40
Leuctridae	11.60	0.40	0.80	0.40	6.60	0.00
Veliidae	0.00	0.00	1.60	0.00	0.00	0.00
Dytiscidae	0.00	0.40	0.40	0.00	0.00	0.00
Scirtidae	0.00	0.40	0.00	0.00	0.00	0.00
Elmidae	5.80	0.80	1.60	2.00	5.20	1.60
Sialidae	0.00	0.00	0.20	0.00	0.00	0.40
Rhyacophilidae	0.00	0.40	0.00	0.40	0.80	0.00
Glossosomatidae	29.00	2.00	4.40	202.40	38.40	14.80
Psychomyiidae	0.00	0.00	0.00	0.40	0.00	0.00
Polycentropodida	0.60	0.60	4.40	0.00	0.60	0.40
Hydropsychidae	0.20	0.00	0.00	0.00	0.40	0.00
Lepidostomatidae	0.60	0.00	0.00	0.00	0.00	0.00
Limnephilidae	7.80	2.80	4.60	0.60	1.40	3.20
Goeridae	0.20	0.00	0.00	1.80	0.00	0.00
Beraeidae	0.40	0.00	0.40	0.00	0.00	0.00
Sericostomatidae	0.80	0.80	0.40	0.00	0.00	0.00
Leptoceridae	8.60	2.00	0.00	12.80	4.20	0.40
Tipulidae	3.00	1.60	0.80	6.40	0.80	3.20
Psychodidae	0.40	0.00	0.40	0.00	0.00	0.00
Ptychopteridae	0.40	0.40	0.00	0.00	0.00	0.00
Dixidae	0.00	0.00	3.40	0.00	0.60	0.40
Ceratopogonidae	52.80	18.00	14.60	1.60	3.80	6.40
Simuliidae	54.40	5.20	4.80	2.80	124.00	2.00
Chironomidae	191.60	61.00	191.00	4.60	132.20	35.20
Empididae	2.40	0.00	1.60	3.20	0.80	0.80
Syrphidae	1.60	0.00	0.00	0.00	1.60	0.00

6.2 R. Kennet at Littlecote

6.2.1 Family richness

The River Kennet at Littlecote is characterised by *Ranunculus* growing on a gravel substratum and hence the 1970s and 1990s sampling programmes have been confined to these habitat types. In Table 6.3, the June 1999 results (in bold) have been placed alongside the data for June 1998 and 1997 (when sampling took place in July) and also the June 1975 and 1974 results.

Table 6.3 R. Kennet at Littlecote. Number of families of macroinvertebrates recorded on *Ranunculus* and gravel in July & December 1997, June 1998 and June 1999 (latter in bold). 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
1998	31	29	No data	No data	No data
1999	**30**	**34**	No data	No data	No data
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 June 1999, the number of families on *Ranunculus* was marginally lower than in June 1998 and July 1997, but the family richness on gravel was higher than recorded on any previous sampling occasion in summer.

6.2.2 Family composition and abundance data for 1998

Table 6.4 lists the 36 families of macroinvertebrates captured at Littlecote in June 1999 together with their mean densities on gravel and *Ranunculus*. The total of 36 families for June 1999 includes 14 non-insect and 22 insect families, compared to 32 families (12/20) in June 1998 and 35 families (12/23) in July 1997.

Overall, there were 31 families recorded at the site in both June 1998 and June 1999. However, the following differences were noted between the listing for the two years:

June 1998 only

Odonata: Calopterygidae

June 1999 only

Hydracarina
Crustacea: Niphargidae
Ephemeroptera: Heptageniidae
Ephemeroptera: Leptophlebiidae
Diptera: Empididae

Of the five families present in June 1999, but not in 1998, three of them (Hydracarina, Niphargidae and Empididae) were recorded in July 1997. In addition, although the mayfly families Heptageniidae and Leptophlebiidae were recorded in June 1999 but not in June 1998 or July 1997, they were found in samples taken in December 1997.

Table 6.4 R. Kennet at Littlecote, June 1999. Mean densities of macroinvertebrate families (nos per 0.05m^{-2}) based on 5 sampling units for each habitat.

Family name	Gravel	Ranunculus
Planariidae	5.60	3.00
Dendrocoelidae	0.20	0.40
Physidae	1.20	1.80
Planorbidae	0.20	0.20
Ancylidae	3.20	0.00
Sphaeriidae	2.40	3.60
Oligochaeta	71.20	85.20
Lumbricidae	2.60	1.00
Piscicolidae	0.60	3.20
Glossiphoniidae	3.20	1.20
Erpobdellidae	1.80	0.20
Hydracarina	1.60	0.60
Asellidae	0.20	0.00
Gammaridae	458.00	816.00
Niphargidae	0.00	1.00
Baetidae	57.80	209.60
Heptageniidae	0.20	0.00
Leptophlebiidae	0.00	0.40
Ephemerellidae	15.00	70.40
Caenidae	22.80	14.40
Leuctridae	5.20	4.20
Elmidae	12.00	13.40
Rhyacophilidae	4.60	3.20
Glossosomatidae	16.00	1.60
Psychomyiidae	0.20	0.00
Polycentropodidae	0.20	0.00
Hydropsychidae	2.40	1.60
Lepidostomatidae	4.20	20.20
Limnephilidae	1.80	3.60
Goeridae	6.40	0.60
Sericostomatidae	6.40	4.60
Leptoceridae	21.20	10.00
Tipulidae	4.20	1.00
Ceratopogonidae	3.80	10.20
Simuliidae	8.60	447.20
Chironomidae	92.80	364.80
Empididae	0.20	0.00

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

6.3.1 Family richness

At Savernake, *Schoenoplectus* and gravel were sampled on the lower site in June 1999, in order to retain conformity with the sampling regime adopted in June 1998, July 1997 and in the 1970s (Table 6.5).

In June 1999, the number of families recorded on *Schoenoplectus* increased from 26 (June 1998) to 31. On gravel, 31 families were recorded (30 in June 1998). A total of 34 families was recorded on the site in June 1999, compared with 32 in June 1998 and 33 in July 1997.

Table 6.5 R. Kennet at Savernake (Lower site). Number of families of macroinvertebrates captured on *Schoenoplectus* and gravel in July & December 1997, June 1998 and June 1999 (latter in bold). 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
1998	26	30	No data	No data	-
1999	**31**	**31**	No data	No data	-
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 6.6. Here, *Ranunculus* and gravel were sampled each summer between 1997 and 1999. In June 1999 both *Ranunculus* and gravel had higher family richness than in June 1998. A total of 34 families were captured on the site in June 1999, compared with 32 families in June 1998, and 33 families in July 1997. Thus, the upper site mirrored perfectly the changes in family richness previously observed on the lower site over the three summers. Despite this, there were some differences in faunal composition between sites and years.

Table 6.6 R. Kennet at Savernake (Upper site). Number of families of macroinvertebrates captured on *Ranunculus* and gravel in July & December 1997, plus June 1998 (the latter in bold). 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
1998	No data	27	23	No data	No data	No data	-
1999	**No data**	**28**	**29**	No data	No data	No data	-
1975	29	No data	29	32	31	31	37
1974	No data	29	27	No data	No data	No data	-

6.3.2 Family composition and abundance data for 1999

A list of the 34 families of macroinvertebrates recorded on the lower site at Savernake in June 1999, together with their mean densities on gravel and *Schoenoplectus* is presented in Table 6.7. The 34 families include 14 non-insects and 20 insect families compared to 32 families (13/19) in June 1998 and 33 families (14/19) in July 1997.

The following differences were noted between the families recorded in June 1998 and June 1999.

Lower Savernake - June 1998 only

Hemiptera:	Corixidae
Coleoptera:	Hydrophilidae

Lower Savernake – June 1999 only

Mollusca:	Physidae
Trichoptera:	Glossosomatidae
Trichoptera:	Lepidostomatidae
Diptera:	Empididae

Once again, it is important to emphasize that the absence of a family in the samples for a given year does not necessarily imply that a family was absent from the site, merely that it was sufficiently uncommon to be absent from the samples. Of the four families recorded in June 1999 but not in June 1998, three (Physidae, Glossosomatidae and Empididae))were recorded at the site in July 1997.

Table 6.8 gives a listing of the 34 families of macroinvertebrates and their mean densities on gravel and *Ranunculus* in June 1999. It includes 13 non-insect and 21 insect families compared to the 15/17 families in June 1998 15/18 families in July 1997. Overall, there were 26 families recorded at this site in both June 1998 and June 1999. However, the following additional families were recorded on one sampling occasion only.

Upper Savernake - June 1998 only

Mollusca:	Valvatidae
Mollusca:	Hydrobiidae
Mollusca:	Lymnaeidae
Mollusca:	Planorbidae
Hemiptera:	Corixidae
Coleoptera:	Hydrophilidae

Upper Savernake – June 1999 only

Mollusca:	Physidae
Mollusca:	Ancylidae
Coleoptera:	Haliplidae
Trichoptera:	Glossosomatidae
Trichoptera:	Hydropsychidae
Trichoptera:	Lepidostomatidae
Trichoptera:	Goeridae
Diptera:	Empididae

These listings of apparent change are more substantial than those observed on the lower site at Savernake and appear to involve the loss of some molluscs in June 1999 and the appearance of a number of families of Trichpotera (which had, nevertheless been recorded in July or December 1997). Note that all the changes observed on the lower site at Savernake were repeated on the upper site.

Table 6.7 **R. Kennet at Savernake (Lower site) June 1999. Mean densities of macroinvertebrate families (nos per 0.05 m^{-2}) based on 5 sampling units for each habitat.**

Family name	Gravel	Schoenoplectus
Planariidae	3.80	3.40
Dendrocoelidae	0.00	0.20
Physidae	0.40	0.40
Planorbidae	0.20	0.00
Ancylidae	15.80	1.00
Sphaeriidae	3.60	5.80
Oligochaeta	107.60	325.80
Lumbricidae	4.80	0.60
Piscicolidae	0.40	1.20
Glossiphoniidae	0.40	0.80
Erpobdellidae	2.20	4.40
Hydracarina	0.80	5.40
Asellidae	10.60	12.40
Gammaridae	228.20	146.40
Niphargidae	1.00	0.40
Baetidae	157.00	266.00
Ephemerellidae	16.80	35.00
Caenidae	1.60	0.40
Dytiscidae	0.40	0.00
Elmidae	4.00	6.40
Sialidae	0.00	0.80
Rhyacophilidae	1.80	1.80
Glossosomatidae	2.60	1.60
Polycentropodidae	1.20	0.20
Hydropsychidae	0.20	0.00
Lepidostomatidae	0.00	0.40
Limnephilidae	4.80	2.00
Goeridae	1.20	0.20
Sericostomatidae	1.40	1.20
Leptoceridae	8.20	1.00
Tipulidae	2.00	3.40
Ceratopogonidae	2.00	12.20
Simuliidae	8.00	434.20
Chironomidae	97.80	239.40
Empididae	0.40	0.20

Table 6.8 **R. Kennet at Savernake (Upper site), June 1999. Mean densities of macroinvertebrate families (nos per 0.05 m^{-2}) based on 5 sampling units for each habitat.**

Family name	Gravel	Ranunculus
Planariidae	4.00	3.80
Dendrocoelidae	0.00	0.40
Physidae	0.00	0.40
Ancylidae	8.00	3.80
Sphaeriidae	1.80	0.00
Oligochaeta	73.80	261.60
Lumbricidae	0.80	5.80
Piscicolidae	0.40	1.80
Glossiphoniidae	0.20	2.40
Erpobdellidae	2.20	4.40
Hydracarina	2.00	11.60
Asellidae	5.20	22.40
Gammaridae	155.40	125.40
Niphargidae	0.20	0.40
Baetidae	53.60	218.00
Ephemerellidae	26.80	95.40
Caenidae	2.20	3.20
Haliplidae	0.20	0.00
Dytiscidae	1.40	0.20
Elmidae	6.00	4.40
Rhyacophilidae	2.20	3.20
Glossosomatidae	0.60	0.00
Hydroptilidae	0.00	0.40
Polycentropodidae	0.40	0.00
Hydropsychidae	0.00	0.40
Lepidostomatidae	0.00	0.80
Limnephilidae	1.60	5.40
Goeridae	0.40	0.00
Sericostomatidae	1.20	1.20
Leptoceridae	1.20	1.00
Tipulidae	3.80	0.00
Ceratopogonidae	3.60	2.60
Simuliidae	1.80	197.60
Chironomidae	27.40	156.80
Empididae	2.00	1.20

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

7.1.1 R. Lambourn at Bagnor

Background information on this site through the 1970s and during the first year of resampling in 1997 was given in Wright *et al.* (1999a). In 1997, it was apparent that the shaded site had undergone substantial change since the 1970s due to the lack of the river management for trout fishing and the effects of the prolonged drought of 1996-97. Lack of management allowed the initial encroachment of marginal emergents on the baseline bank, and this process increased during the drought. In addition, lack of control of the bank-side trees and bushes on the far bank increased shading with some potential for restricting the growth of submerged vegetation.

In 1997, the poor growth of *Ranunculus* and the progressive build-up of silt was thought to be largely due to the drought. The reason for the limited area of *Berula* was less clear, but in view of the large areas of clean gravel, it was anticipated that both macrophytes would increase in area quite rapidly following the end of the drought. Although the discharge over the winter of 1997/98 was unexceptional, heavy rainfall in spring 1998 provided what appeared to be favourable conditions for the progressive recovery of the macrophytes and macroinvertebrate assemblages.

The results of the mapping and macroinverteberate sampling programme in June 1998 were reported in Wright *et al.* (1999b). The total area of the site increased, as expected, but each one of the three submerged macrophytes (*Berula*, *Ranunculus* and *Callitriche*) failed to undergo substantial increase in area. In addition, the continued high level of silt on site (26.8%) suggested that the accumulation of this fine material both at Bagnor and upstream would take time to be dispersed downstream. Shading of the site, both by trees and some emergent vegetation and the continued presence of silt may have held back growth of submerged macrophytes. A further possibility which was mentioned in Wright *et al.* (1999b) is the potential impact of signal crayfish. Adults are known to take both detritus and living macrophyte and the introduction of signal crayfish to previously crayfish-free waters has resulted in reduction of weed biomass in some areas (Hogger 1988, Elser, Junge & Goldman 1994).

By June 1999, the carpets of *Berula* had increased in total area to 20% of the site, but this is still little more than half of the mean cover observed during the 1970s (Table 5.1). *Ranunculus* occupied a total area of 7.7% in June 1999, again higher than on previous mapping occasions in the 1990s, but still well below the mean value of 13.7% for the 1970s. 'Other' marginal macrophytes remain important at 10.9% cover and are likely to remain so in the absence of active management for trout fishing, whilst the area of silt (22.0%) remains surprisingly high, given the return to the normal flow regime.

Additional mapping in future years will be required to determine whether these changes are moving towards an equilibrium state following the 1996-7 drought and whether this differs from the mix of habitats observed during the 1970s.

The macroinvertebrate sampling programme in the late 1990s is starting to provide information on whether the fauna of an unmanaged site during, and in the aftermath of a drought differs from the 1970s assemblage, when the river was intensively managed for trout and experienced a wide range of discharge conditions.

Macroinvertebrate family richness at Bagnor has remained fairly stable between the 1970s and late 1990s. Of the five habitats sampled in both time periods, 42 families were recorded in June 1997, 45 in June 1998 and 47 in June 1999. In the seven-year period 1971 plus 1974-79 when similar sampling protocols applied, the number of families captured on these same five habitats in June varied from 42 to 47 (Wright & Symes 1999c). Thus, in the late 1990s, the family richness has not deviated beyond the 1970s range and instream richness has increased in the aftermath of the 1996-97 drought. When the additional habitat encompassing emergent macrophytes is included, then the total number of families varied from 46 in June 1997, and 52 in June 1998 to 48 in June 1999.

Of equal or greater importance in terms of ecosystem functioning are the densities of the macroinvertebrates on the various habitat types. Some characteristic families of fast-flowing chalk streams such as mayflies in the Baetidae and blackfly larvae (Simuliidae) fell to very low densities in June 1997, the second summer of the recent drought. In a recent paper, Wright *et al.*(in press) calculated the 'weighted' mean densities of these families on the site in June for the period 1971-79 and also for 1997. Weighted mean densities take account of the densities of the families on each habitat but also the area of each habitat on the site, thereby giving the best estimate of the density of the family on the site as a whole. The combination of low densities of Baetidae and Simuliidae on macrophytes in 1997, and the fact that the area of available macrophyte was low, contribute to the low weighted mean densities observed in 1997.

The following summer (June 1998) there was clear evidence of a partial recovery (Wright *et al.* 1999b) with higher densities of Baetidae and, in particular, Simuliidae. However, the limited areas of some of the favoured habitats meant that for the study site as a whole, the numbers of some characteristic chalk stream invertebrates remained relatively low and would need more time for their population densities to approach the figures observed in the 1970s. In practice, the total area of submerged macrophyte on the site was higher in June 1999 (31.3%) than in June 1998 (13.8%), but there is clearly, some way to go before the cover of submerged macrophyte approaches the mean area of 60.3% recorded in the 1970s (see Table 5.1).

7.1.2 R. Kennet at Littlecote

In summer 1997, the discharge regime at Littlecote was greater than in the severe drought of 1976 and *Ranunculus* covered 44.2% of the 100 m site at the time of sampling in July 1997. As a result, it continued to provide suitable habitat for a wide range of macroinvertebrate families and this section of the river was not as severely affected as the two study sites at Savernake. The development of marginal emergents through the summer and into the following winter also provided both habitat and food resources for a wide range of macroinvertebrates, some of which may then have moved onto gravel and *Ranunculus*.

In June 1998, it was apparent that all marginal emergents had been removed by the high winter and spring flows, which had also provided good conditions for the spring growth of *Ranunculus*. The percentage of the site covered by *Ranunculus* was estimated at 71.5% cover despite the fact that a bar-cut had already taken place. In June 1999, after a return to the normal flow regime, *Ranunculus* grew well again and despite a bar-cut prior to estimation of the area of weed, *Ranunculus* still occupied approximately 61.2% of the site (see Table 5.2).

During the sampling period 1997-99, macroinvertebrate family richness, as recorded by combining the data for gravel and *Ranunculus*, varied from 35 families in July 1997 and 32 families in June 1998 to 36 families in June 1999. In view of the fact that *Ranunculus* continued to be an important habitat throughout the 1996/97 drought, families such as Baetidae and Simuliidae which are favoured by faster current speeds, were able to maintain modest populations in July 1997 and assume progressively higher densities on *Ranunculus* in June 1998 and June 1999. One notable family at this site, the Gammaridae, represented by *Gammarus pulex* developed very high population densities by June 1998. It is possible that the marginal vegetation which continued to increase in area until December 1997 may have been a nursery for gammarids which then moved into *Ranunculus* and gravel when the winter flows removed the *Nasturtium* and other marginals. By June 1999, densities had returned to the levels encountered in July 1997.

7.1.3 R. Kennet at Savernake

The River Kennet at Savernake has suffered progressive loss of *Ranunculus* below Marlborough for some years and in an attempt to promote regrowth, a combination of management techniques were used in the 1990s. These included allowing the river to run freely, use of current deflectors, removal of vertical boarding and reduction of channel width through the planting of marginal emergents etc.

At sites on the River Lambourn, there is observational evidence that in years of low discharge, 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 in low flow years by the presence of nutrients from Marlborough STW, and other diffuse sources resulting from agricultural activities within the catchment was raised in Wright *et al.*(1999a). In the same report it was noted that in summer 1997, the Littlecote study site was capable of supporting good growth of *Ranunculus* but a relatively similar discharge regime failed to promote growth of *Ranunculus* at Savernake, despite the various management protocols listed above. The question therefore arose as to whether water quality, in addition to water quantity, was relevant to this problem.

In 1997, *Schoenoplectus* was dominant at the lower site, but the total area of this macrophyte was much reduced compared to the 1970s. The new management regime with reduced water levels and faster current may have produced less than optimal conditions for this macrophyte. Alternatively, it is possible, though unproven, that surface algae suppressed the growth of the strap-like leaves or that swans or other wildfowl cropped it in the absence of abundant *Ranunculus*. Although small quantities of *Ranunculus* were present, the area was minimal and substantially lower than in 1974-75. Silt had also accumulated as a result of the two-year drought.

Prior to remapping the lower site in June 1998, three events had taken place overwinter. First, the far bank (opposite the mapping baseline) had been subject to management involving overall reduction in river width to further encourage faster current speeds for a given discharge regime. Second, phosphate stripping had commenced around November 1997 at Marlborough sewage treatment works. Finally, the two-year drought came to an end and in particular, the month preceeding mapping in June 1998 was notable for heavy rain and increased discharge.

In June 1998, it was immediately apparent that a remarkable change had taken place on this section of river. *Ranunculus* had undergone spectacular growth on the lower site during the preceding months and this, in combination with the discharge regime meant that water levels were very high. *Ranunculus* dominated the site with 43.6% cover in June 1998, compared to 0.9% in July 1997. This strongly suggests that, despite the poor performance of *Ranunculus* earlier in the 1990s, some root systems remained in place and were available to respond to the return of favourable conditions. In June 1999, after resumption of the normal flow regime *Ranunculus* remained dominant with 53.7% cover, whereas *Schoenoplectus* only occupied 6.3% of the site. In view of the fact that the river is now allowed to flow freely, in contrast to the 1970s when this section was canal-like, it seems unlikely that *Schoenoplectus* will resume its former dominant status (see Table 5.3).

On the upper site at Savernake, prior to 1997, efforts were made by the River Keeper to encourage the regrowth of *Ranunculus* by reducing the channel width and using current deflectors. In 1997, the optimum location for the growth of *Ranunculus* 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, making it possible for wildfowl to limit the density and progressive colonisation of this macrophyte.

In June 1998, growth of *Ranunculus* on the upper site was even more spectacular than on the lower site and the total area was mapped as 48.8% of the site. In June 1999, the area of *Ranunculus* was even higher at 56.5%. Even in the 1970s this site had good growth of *Ranunculus* because it was shallower and faster flowing than the lower site. However, the new management regime of allowing the river to flow freely together with the specific measures taken to encourage the growth of *Ranunculus* appear to have allowed it to dominate the site. In non-drought years in the 1970s it was also capable of dominating the site on occasions. Thus, in April and May 1974 growth of *Ranunculus* reached about 40% cover and required a major weed-cut in early June to reduce the volume of surface-flowering weed. Further growth then took place through the summer of 1974, 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*.

These results bring into focus the question of why growth of this macrophyte was reported to be poor in the mid-1990s when the discharge regime was apparently favourable for *Ranunculus*. In theory, heavy cropping of weed by waterfowl might restrict growth early in the season. Alternatively, if *Ranunculus* was restricted through smothering by epiphytic algae in spring, (despite the favourable discharge conditions) this might also limit its role later in the season. Unfortunately, in the absence of hard evidence, these suggestions remain speculative.

A superficial examination of macroinvertebrate family richness on the lower and upper Savernake sites in July 1997, June 1998 and June 1999 might suggest a high level of stability, despite the occurrence of the drought in 1996-97 and the subsequent resumption of the normal flow regime by 1999. When the total number of families recorded from the five macrophyte plus five gravel samples was computed for each sampling occasion on the lower site, there were 33 families in July 1997, 32 families in June 1998 and 34 families in June 1999. Surprisingly, the same number of families were also recorded on the upper site in each of these three years. However, these figures do mask some differences in family composition between years on a given site and also between sites. This is inevitable, in view of the limited number of quantitative samples taken for macroinvertebrates on each site at Savernake. Nevertheless, some families are favoured by drought conditions and others by conditions of high flow and where particular conditions influence the abundance of a family and the habitat(s) on which it occurs, this may affect the chance of capture.

Of greater interest were changes in the density of some of the families of macroinvertebrates. At the lower site, leeches in the family Glossiphoniidae and crustaceans in the family Asellidae occurred in significantly higher densities in July 1997 than in the mid-1970s within beds of *Schoenoplectus*. These families normally 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 abundance also suggests that changes in water quality were taking place. On the upper site, the densities of Asellidae were again significantly higher in July 1997 than in the mid-1970s whilst densities of Chironomidae were significantly higher on gravel (lower site) and *Ranunculus* (upper site) in summer 1997 compared to 1975. The reason for the higher densities of chironomid 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 contrast, at each of the two sites at Savernake, mayfly larvae in the family Baetidae were present in significantly lower densities in July 1997 than in the mid-1970s. 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* did provide adequate conditions for modest densities of larvae.

The quantitative sampling programme for macroinvertebrates undertaken in June 1998 followed the ending of the drought, the commencement of phosphate stripping, the aftermath of a wet spring and the spectacular re-growth of *Ranunculus*. On the lower site there were significant decreases in the abundance of three families (Glossiphoniidae, Erpobdellidae and Asellidae) normally associated with conditions of enrichment. Similar observations were made for the Glossiphoniidae, Asellidae and Chironomidae on the upper site. On each site there were significant increases in the abundance of Baetidae from the low populations recorded in July 1997.

In June 1999, with a typical seasonal discharge regime underway and abundant growth of *Ranunculus* once again, densities of Glossiphoniidae, Erpobdellidae and Chironomidae on both sites remained below the densities observed in July 1997, as did Asellidae in all but one instance. In the case of families such as Baetidae and Simuliidae, which normally respond positively to the resumption of normal or high discharge, densities either remained higher than in 1997 or continued to increase beyond the densities observed in June 1998 when densities started to recover. These are all encouraging signs, but there will be a need to examine the results for the 1970s and late 1990s in more detail in order to determine the extent of the recovery from the prolonged drought of 1996-97 and associated events.

7.2 Recommendations

The studies undertaken by the IFE in June/July and December 1997 were designed to re-establish each of the four sites first investigated in the 1970s, and to investigate the extent to which ecological changes had taken place. They also provided an opportunity to document the percentage cover of each major habitat type on each site and to record the densities of each family of macroinvertebrates during the height of a two-year drought. In June 1998, similar studies on each of these four sites revealed a number of post-drought changes, but it was also apparent that most sites still differed from their condition in the 1970s, for a variety of reasons.

The sampling programme in June 1999, the first year in which sampling had taken place in the 1990s under a normal discharge regime, revealed further changes in macrophyte cover at several sites and further modest changes in the macroinvertebrate fauna.

The general recommendation is that it is important to continue the current mapping and sampling programme at these sites because:

A) Long-term monitoring is necessary in order to record and interpret the scale of natural between-year variation and also the response to extreme events such as droughts.

B) Following the 1996/97 drought, changes were still taking place June 1998 and June 1999 with respect to macrophytes and/or macroinvertebrates at some sites. Further mapping and sampling will be required to determine whether some sites return to their 1970s baseline condition or establish a new equilibrium.

C) Continued monitoring of these sites can provide useful information on the value of particular management practices at some sites and the lack of management at others.

D) With each additional year of macroinvertebrate sampling, coupled with the opportunity to interrogate the 1970s database, there are many scientific opportunities to examine the persistence of species, variation in the structure of faunal assemblages and the impact of invasive species (e.g. signal crayfish). All these topics are relevant to the conservation of the chalk stream ecosystem and the retention of biodiversity.

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

R. Lambourn at Bagnor.

1. At this site it is important to continue to monitor the submerged macrophyte community to determine whether the total area of macrophyte will eventually increase to the levels observed in the 1970s. The current non-interventionist management

strategy at Bagnor has undoubtedly influenced the flora and further mapping will yield information of wider relevance to river management and conservation.

2. The area of silt remains high, despite increased flows over the winters of 1997/98 and 1998/99. Continued monitoring will help to determine whether this is due to a slow rate of wash-out after the 1996-97 drought or whether lack of active management of the site is a contributory factor.

3. It is also important to determine whether the densities of some characteristic chalk stream macroinvertebrates including Baetidae and Simuliidae will return to their pre-drought densities (expressed as weighted mean densities for the site).

4. Continued monitoring at Bagnor will provide an opportunity to keep a watching brief on the signal crayfish and whether it has a long-term impact on the site.

5. There would 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

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

R. Kennet at Savernake

7. The long-term decline of *Ranunculus* at Savernake was reversed in spring 1998 and *Ranunculus* remained the dominant macrophyte on both sites in 1999. Continued mapping is advisable to confirm the new equilibrium and document the fate of *Schoenoplectus*, assuming that the river is allowed to run freely and that water quality remains high.

8. Further studies on the macroinvertebrates are recommended to confirm long-term recovery after the 1996/97 drought. If the current management practice of allowing the river to flow freely is maintained, then the fauna may start to have more in common with the Littlecote site downstream, rather than Savernake as it was in the 1970s, when the river was managed as a deep, slow-flowing channel.

9. Finally, some river rehabilitation on the Upper Kennet was initiated as a Demonstration Project in autumn 1999 by Alconbury Environment Consultants with the approval of the Environment Agency. The work, which involves measures to increase velocities on the right hand side of the channel by a series of manipulations on the left hand side will reduce velocities on that side to encourage siltation and marginal vegetation encroachment. The IFE team has been informed of these developments and because the demonstration section appears to involve both sites at Savernake, the current IFE research programme can provide an ideal mechanism for recording the impact of these additional changes on the two Savernake study sites.

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