# EFFECTS OF PHYSICAL RESTRUCTURING OF CHANNELS ON THE FLORA AND FAUNA OF THREE WESSEX RIVERS.

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## *Executive Summary*


During the droughts of the late 1980s and early 1990s in southern England the resulting low flows together with heavy grazing pressure and abstraction resulted in a reported loss of fish habitat in many streams. Following concern by anglers and conservation groups in Wessex, consultants recommended a programme of channel restructuring (restoration) to restore fishable habitats and spawning areas. Between 1995 and 1999 therefore, habitat modification was undertaken on the River Piddle and Devil’s Brook, the Rivers Wylye and Till and the Sherston and Malmesbury reaches of the Bristol Avon. The techniques were mainly classified as “substrate redistribution” (bed re-profiling, weirs, flow diversion, narrowing) or “substrate augmentation” (introduction of gravel beds). Many reaches were fenced to exclude stock and reduce grazing pressure.

Between 1996 and 1998 surveys showed increased fish populations in restored reaches. Analysis of these data showed increases to be statistically significant for salmonids and some coarse fish in all three rivers. Tagging experiments showed that the most likely explanation for the increases was immigration from other reaches, a benefit for the recipient reaches, but with unknown consequences for the donor reaches. The effects of restoration on the species-richness and diversity of the fish fauna in these rivers was unknown. The actual carrying capacity of many reaches is also unknown and is probably obscured by the stock and capture process.

In 2000, surveys were commissioned by Wessex Water to assess the effects of the restoration work on other biota, namely plants and invertebrates and review other data. The aim was to provide a holistic view of the restoration work. Surveys were carried out at 22 sites during the summer of 2000. No baseline data were available and the flows were considerably better than in the drought years. For the comparative studies of restored and unrestored reaches therefore, control sites were selected from reaches known to be unrestored in the original work. 98 invertebrate samples were taken from 50m long restored and unrestored reaches. Margins and midstream habitats were sampled separately. 44 sweep net samples were taken from marginal vegetation to record selected adult insects. Plant species were recorded over 50m reaches of both banks and in the rivers.

Total species richness of plants was lower overall in restored than in unrestored reaches. This was a result of significantly lower numbers of bankside and terrestrial species in fenced reaches of the Piddle and Devils Brook. This effect was not as great in the other rivers. Trampled banks showed greater species richness than fenced reaches mainly because of the abundance of the more robust species in the fenced reaches and the absence of the mosaic of habitats found on trampled margins. Evidence from other sources also suggests that trampling by anglers or others with access to riverbanks may increase species richness. Aquatic species showed similar diversity in restored and unrestored reaches but the Sherston and Malmesbury Avons showed a generally lower abundance of *Ranunculus* spp. There was a non-significant difference in *Ranunculus* cover between unrestored and restored reaches though this was probably a result of better flows than in the dry years. In all streams the greatest influence on instream weed was shade.

There were no significant differences in invertebrate diversity between restored and unrestored reaches. Diversity of invertebrates in marginal river habitats was significantly greater than in midstream habitats and the species compositions differed. There were no separable effects of restoration on the marginal and midstream invertebrates. Analysis of individual sites and restoration methodologies indicated great variation in the degree of change in diversity, but there was no real consistency. Local invertebrate species composition was more likely to change if restoration increased scour and current velocities, as species characteristic of higher flows displaced those preferring slower waters and added to the total in the reach. Species accumulation curves showed a lower total number of species in unrestored midstream reaches than in the others. Total species numbers in restored reaches were 8 more than in all unrestored reaches. The causes of any differences in invertebrate diversity were probably lower substrate diversity in the unrestored midstream reaches though there may be some effect of variable taxonomic uniformity. No species new to the rivers were recorded.

The crayfish populations in the River Piddle may have benefited from restoration work, particularly where fencing has allowed marginal and trailing vegetation to increase. Surveys in the late 1990s and in 2000 found the highest numbers in the restored reaches. However, the data are not statistically testable. No crayfish were recorded in the Sherston or Malmesbury Avons in the most recent surveys despite re-introductions and recent records in reaches near to those sampled for invertebrates. Low population densities and poor dispersal may be the reasons for their absence from samples in these rivers. The absence was unlikely to be caused simply by inappropriate sampling methods as the same sampling methodology did catch crayfish in the River Piddle.

Significant correlations were found between aspects of physical diversity and biological scores (BMWP) number of taxa. Further, *Ranunculu*s abundance was also tentatively correlated with invertebrate diversity.

No effect could be detected on selected aerial insects though the data were sparse and not suitable for statistical treatment. Also, no conclusions could be reaches about effects of restoration on mammals as all the data were not suitable for proper statistical analysis. The Wiltshire data were, however, worthy of further analysis and this methodology should be adopted and adapted throughout the region. Evidence of otters and water voles requires clarification throughmore consistent study.

Management implications of the data and requirements are reviewed, the most important being :-

- the need for better objective holistic standards on which to assess conservation status the need for restoration at any scale in the rivers
- quantification of the true effects of restoration and other activities on the fish communities at reach and river scales
- quantification of effects of substrate re-distribution and channel state on Annex II species of fish
- quantification of effects of river-restructuring on salmonid spawning and survival
- improving scientific methodology for providing management information generally, but specifically for mammals and crayfish

- clarification of the precise role of *Ranunculus* in the distribution of predators, young salmonid survival and sedimentation
- clarification of the general role of *Ranunculus* and its management on the fauna of the rivers
- quantification with more detail of the relationship between habitat diversity, human disturbance and biological diversity

The criteria on which diversity are assessed and reviewed briefly and target models are outlined for alternative management strategies. A preliminary form of Conservation Standard  Index (CSI) for the streams is suggested for future management planning. It was considered that management for “diversity” probably requires continuous moderate disturbance from bankside trampling, angling and stocking and weed-cutting. Conservation for “naturalness” would require a more “hands-off “ strategy.

# Contents



 

# 1 Introduction

Following a series of severe droughts in England over the period from 1988 to 1992, low river flows and heavy marginal grazing by cattle resulted in reports of loss of fish habitat in many southern chalk streams (e.g. Hill & Langford, 1992; Environment Agency, 1996a; Summers *et al.*, 1997). To alleviate the losses a programme of physical habitat restoration was begun in 1994 at a number of sites in three main river systems in the Wessex region. The main aims were to restore physical diversity in the channels, create better refugia for large salmonids and other fish and create spawning areas for salmonids (Summers *et al.*, 1996; Summers *et al.*, 1997; Giles, 1997a,b; Cowx & Welcomme, 1998). The restoration projects investigated in this study were carried out between 1994 and 1999 in the River Piddle and Devils Brook east of Dorchester (Dorset), the River Wylye and River Till north of Salisbury (Wiltshire), and the Malmesbury and Sherston Avons near Malmesbury (Wiltshire, Avon) **(Figure 1).** The methodology was based on the restructuring of river channels using a variety of techniques including introduction of gravel, flow deflection, channel narrowing, bed re-profiling, bank fencing and bank staging.

The observations of channel morphology in the study streams were originally made in the early 1990s and were presented in a series of reports (e.g. Game Conservancy Trust, *undated*; Summers *et al.*, 1997; Giles & Summers, 1999). Details given below are mainly extracted from the detailed reports by these authors. In the summer of 2000, after allowing the channels to regain some equilibrium following restoration, a series of surveys were planned to assess the effects of the channel restructuring on the invertebrate and plant communities. This report describes the results of the invertebrate and plant surveys and summarises and reviews the results of the small mammal and fish surveys provided from earlier surveys (Satinet, 1998; Giles & Summers, 1999).

The key aims of this study were, therefore, as follows:

- to use data supplied from other studies to assess the success of the restoration work on the *target* species, crayfish, fish and small mammals:
- to quantify the effects of the restoration work on the diversity of *non-target* species of plants and macro-invertebrates using data from new surveys:
- to determine the factors mostly likely to affect diversity of *non-target* species:
- to assess overall management and conservation implications of the restoration and provide guidelines for future projects.

More specific questions posed within the overall assessment were:

- Is there a generic pattern of change detectable at treatment and reach scale as a result of the channel modifications?
- Is the pattern of change different in different rivers?
- Do different modification techniques produce different results?
- Are there species that benefit from channel modification?
- Is it possible to quantify the factors most influencing biological diversity in the streams?

 

- Are there targets that can be set to direct future restoration projects?

The null hypothesis was that these channel modifications have made no difference to the biota of the streams.

Quantifying the variables that most influence diversity may help predict effects of future channel modifications either for engineering management or for biological management of the streams. The data on small mammals and fish were originally collected for reasons other than the study of diversity (Satinet, 1998; Giles & Summers, 1999), and the interpretation of the implications for the diversity of those groups will be limited. The channel restructuring may alter the distribution of the more mobile species such as fish, or the age-classes or size-classes of any one species (e.g. Langford & Hawkins, 1997; Cowx &Welcomme, 1998; or Langford, 2000 for references). Species-richness may change if the physical restructuring alters access for migratory species, for example by the removal or installation of obstacles such as dams, weirs or hatches.

The report is in four sections: the historical and recent background, the new field studies, results from other studies and the overall management implications and recommendations.

## 2 Historical background

Since the early days of agriculture, stream channels have been deepened or straightened to improve land-drainage (Petts, 1984). Even before this, fishing weirs had begun the process of river modification by impounding river reaches and impeding the passage of migratory species (Haslam, 1991). The growth of river use for water-mills, water meadows, navigation, power generation, irrigation and water supply over almost 2000 years led to large scale channel modification in both small and large rivers throughout Britain (Langford, 1983; Petts, 1984; Haslam, 1991; Cowx & Welcomme, 1998). This modification usually took the form of removing natural substrates, reducing sinuosity, diverting channels, impoundment by weirs or locks and a reduction of the natural physical diversity of the habitats by removing riparian and instream vegetation. In many streams, channels with trapezoidal sections were created from the original, structurally diverse channels.

The chalk and limestone streams of southern England were subjected to major physical alterations over many centuries because of their relatively constant, reliable flow regimes and the natural fertility of the soils in their catchments. Modifications for large numbers of water mills and fishing weirs transformed these streams from a pattern of sinuous, anastomosed channels with riffle and pool sequences into chains of impoundments with highly engineered, deepened and straightened channels with more uniform depths, widths and bank structure (e.g. Solomon, 1997). The removal of riparian vegetation, mainly alder carr and woodlands to create water meadows and the subsequent control of flows to maintain the meadows also helped transform these streams from their natural state to the highly artificial condition which is the basis of their present physical and biological forms. Ultimately, abstraction for essential public water supply together with intensified land-drainage activity increased the artificial state of the streams over much of their length. These alterations when combined with a period of drought led to considerable concern about the ecological state of the streams in the late 1980s and early 1990s (Hill & Langford, 1992; Environment Agency, 1996a).

Most of the chalk and limestone river systems of southern England were little affected by the gross industrial pollution which destroyed the ecosystems of many rivers in the industrial Midlands and North (e.g. Hynes, 1960; Hawkes, 1962; see Whitton, 1975). Thus, despite incidents of pollution from farms and localised installations such as dairies (Hynes, 1960), poor water quality was rarely a consistent problem in most chalk and limestone streams (Casey & Ladle, 1976; Casey, 1981). While pollution abatement has been the major reason for the rehabilitation and restoration of ecosystems in midland and northern rivers, it has played a relatively small part in the strategies for rehabilitation of these southern streams.

Chalk streams have been of considerable interest to biologists and several of the study streams have been the subject of study for more than 40 years (e.g. Westlake, 1968; Westlake *et al.,* 1972; Casey & Ladle, 1976; Dawson, 1978; Ladle, 1990; Wright, 1990; Wright *et al.*, 1992; Ibbotson *et al.*, 1994; Prenda *et al.*, 1997).

Since the 1960s physical restructuring of river channels has been widely practised in the United States to compensate for low flows and earlier engineering modifications. In the 1980s similar restructuring schemes began to be fashionable in Europe including the United Kingdom. A variety of methodologies are employed, varying from reinstating substrates and sinuosity in the channel to replanting and restoration of marginal and riparian vegetation (e.g. Biggs *et al.*, 1998; Cowx & Welcomme, 1998). River restoration schemes have been monitored and guided in England and Wales by the creation of the River Restoration Centre (Anon, 1999), which is a focus for scientific collaboration and a centre of information.

## 3 Description of the rivers

### *3.1 The River Piddle and Devils Brook*

From a spring source near Alton Pancras in Dorset the River Piddle flows south and east to Poole harbour. In the upper reaches it is mainly a winterbourne or perched (flowing underground). The major aquifer is chalk though there are sands and gravels in the catchment. The middle reaches comprise a braided network of natural, water meadow and flood-relief channels (National Rivers Authority, 1995). The upper tributaries flow through chalk valleys characterised by pasture and woodland. The catchment is also within the Dorset Area of Outstanding Natural Beauty though it is essentially a landscape fashioned by human activity. The lower part of the catchment comprises acid and sandy soils with valley pastures and arable fields bordering the river. The lower floodplain is marsh and pasture. Land use here is mainly grassland, grazing land, cereals and wetland habitats. The Devils Brook is a small feeder flowing from the north to join the Piddle near Puddletown. Like most southern chalk streams the typical river substrate is chalk gravel with sand and silt in the margins and slower reaches. The river system has been heavily engineered over the centuries and much used for water mills, water meadows **(Plate 1)** and as a land drainage channel. The main study reaches were from near Athelhampton in the west to Throop in the east, and on the Devils Brook, upstream of Athelhampton (**Figure 2**). Details of sites are given in **Table 1.**

### *3.2 The Rivers Wylye and Till*

The Wylye is a chalk stream rising in springs in the Wiltshire green sands above Kingston Deverill **(Figure 3)**. It flows over Lower, Middle and Upper chalk to join the Nadder near Salisbury. The river is an important stocked and managed trout fishery and has been subjected to many physical changes as a result of its use for mills, water meadows and land drainage. The river is a winterbourne in its upper reaches and has dried out during severe droughts. Two main tributaries, the River Till and the Chitterne Brook are both winterbournes with flows affected by drought and water abstraction. Extensive channel modifications have been made to improve potential fish habitat along the Wylye and in some reaches the banks are armoured with plastic mesh (Nicospan) to improve angler access and reduce erosion. The main area studied was from Knook downstream to Wilton. Reaches of the Till where channel modifications were made were in the section from near Uppington House to Stapleford (**Table 1**). The natural substrates of the Wylye are mainly chalk, gravel, sand and silt. The natural pool-riffle sequence is relatively scarce, as it is in the Till **(Plate 2)**.

### *3.3 The Sherston and Malmesbury Avons*

The upper reaches of the Bristol Avon system drain limestone in the north and west, clays in the middle and chalk in the south-east (**Figure 4**). Much of the catchment is intensely agricultural and there is a human population of over 200,000 within the catchment area. Intense arable and livestock farming has led to major changes in channel morphology and sediment regime in the river, mainly as a result of land-drainage engineering and soil erosion from ploughed land. The areas of major restoration studied were in the section of the river from Pinkney to Malmesbury (Sherston Avon) and from Malmesbury to Great Somerford (Malmesbury Avon). Much of the river channel was deepened with steep engineered banks (**Plate 3**). The natural substrate in the free-flowing reaches of the Sherston Avon comprised small limestone plates of varying thickness from about 1cm to 5cm and diameter varying from about 10cm to 50cm (**Plate 4**). In the Malmesbury Avon, particularly at Great Somerford there were considerable quantities of natural gravel and pebbles typically varying from 1 to 5cm in diameter. These rivers are described collectively as “the Avons” in the following text.

## 4 Reported Problems And Remediation

### *4.1 Overgrazing and bank degradation*

Visual surveys and analyses of fish catch data indicated that the loss of fish and mammal habitat in the Piddle and Devils Brook was mainly caused by bank erosion and overgrazing by cattle, (e.g. Summers *et al.,* 1997; Giles & Summers, 1999; Game Conservancy Trust, *undated*). Siltation, excessive shading by trees, flood defence works and land-drainage activities leading to uniform channel morphology were listed as additional causes. Low flows exacerbated the effects of these mainly external factors. It was estimated that about 25km of river was exposed to grazing cattle. Consequently, bankside and instream vegetation was excessively cropped and the banks were heavily trampled and eroded. The result was “over-widening” of the channel, slower currents and heavier than expected sedimentation (see Game Conservancy Trust, *undated*). Similar problems in some reaches of the Wylye, Till and the Avons were noted but were generally less severe than in the Piddle.

The main remedial technique was to fence selected reaches and restrict cattle access to short sections or “cattle drinks”. Along the Devils Brook and River Piddle fencing was introduced “on a wide scale” to prevent cattle access to river margins, though it was recommended that some reaches were left unfenced to maintain a mosaic of wetland and riparian habitats (Giles & Summers, 1999). The survey in summer 2000 showed that, with the exception of the Devils Brook, this recommendation had not been followed and more reaches were fenced than had been expected. The Devils Brook was a rare exception. Reaches of the Avons and Wylye were also fenced, but not as extensively as the Piddle. Cattle access was restricted in many reaches of these rivers by riparian trees, undergrowth or steep banks. (**Plate 3**).

### *4.2 Channelisation and dredging*

Much of the original pool-riffle sequence, braided channels and backwaters have been lost in all the rivers as a result of the long-history of engineering work described previously. The lower reaches of the Sherston and Malmesbury Avons have been particularly affected by land-drainage and flood defence works and the channel has a relatively uniform cross section with engineered banks and a relative uniformity of depth. In the Lower Wylye access for angling and prevention of erosion by bank protection has led to a visual physical uniformity in some reaches.

Remedial techniques in the Wylye included replacement of gravel previously dredged from the channels and the excavation of areas to create pools. In the Devils Brook, Piddle, Wylye and Till, current deflectors and weirs were used to enhance scour to create pools. Where the bed was compacted, it was excavated to a depth of some 50cm at summer flows to create pools. Staked logs were added to some pools to increase potential cover for fish. In the Sherston Avon gravel banks, comprising 20-40mm aggregates, were introduced in some of the previously engineered reaches to add to substrate diversity and increase detectable currents in ponded reaches. In reaches of the Avons large “sarsen” stones were embedded in the channel margins (**Plate 5**) to create current diversity and backwaters. Bank alterations included pushing back some raised banks (bank-staging) to create narrow “floodplains” and areas where overbank flow would enhance wetland plants. In other reaches the channel was narrowed to create extra depth. In several reaches of the Wylye, bank protection was already in place before the later structural work, mainly using artificial materials such as artificial webbing (Nicospan) or treated wood. In some reaches small stands of marginal vegetation, usually Yellow Flag Iris (*Iris pseudacorus),* had been introduced.

### *4.3 Other problems*

Giles & Summers (1999) also listed siltation, impoundment, over-shading and water abstraction and low-flows as potential causes of the loss of fish habitat. They recommended reducing silt at source, though they did not suggest the method for preventing run-off from ploughed fields. They also recommended desilting gravels with high-pressure hoses to increase effective spawning areas for salmonids. This was reported to be carried out in reaches of the Sherston Avon.

Impoundment was alleviated by the permanent opening of hatches and sluices or by removing obstructions to allow free flow wherever possible.

Water abstraction was reduced by agreement between Wessex Water and the Environment Agency and flows subsequently increased.

Shading was mainly by goat willow and alder though other riparian trees were common in some reaches. Shade is considered the major factor limiting instream weed-growth, particularly *Ranunculus* (Dawson & Kern-Hansen, 1978) which is regarded as important to both fish and invertebrate diversity and biomass (Cowx & Welcomme, 1998). Pollarding and coppicing were carried out to increase light penetration to the channels in various reaches.

Apart from the physical problems, two other phenomena may affect the fish populations and fish diversity, namely overfishing and overstocking. Large numbers of catchable and smaller sized salmonids are introduced each year to many chalk stream reaches. The effect on indigenous salmonids and the smaller fish are unknown. Further, there is little information on the longer term distribution of stocked fish that are not caught by anglers. The wild trout populations were a major concern in the original restoration studies and much of the work was aimed at enhancing the habitat for these (Giles & Summers, 1999). Provision of angler access and ease of fishing is clearly one of the main reasons for the clearance of riparian trees and some areas of bank protection.

# 5 Potential limitations to remedial methods, alleviation and assessments

Habitat restoration is usually carried out with a target species or community in mind, and the implications for other communities are often a minor consideration (Cowx & Welcomme, 1998). In the Wessex rivers, for example, the stated aim was mainly to improve the habitat for wild trout, particularly in the Piddle and Wylye, and for salmonids and selected species of coarse fish in the Avons (Giles, 1997a,b; 1999a,b; Giles & Summers, 1999). Thus each design was aimed at creating either refugia or spawning habitat (or both) mainly for salmonids. The belief that *Ranunculus* beds are a vital component of a successful salmonid fishery was also the reason for the reduction of shading. Removal of riparian shade was also aimed at improving access for fly-fishing. The fact that trees are essential sources of allochthonous inputs to the rivers and a necessary component in the life-history of many insects (Harrison *et al.*, 2000) was not considered.

The extent of restoration toward “naturalness” is also limited. For example, the archetypal chalk stream was probably a heavily anastomosed network of shallow channels with marked riffle and pool structure flowing through marshland, dense carr or woodland. This pattern disappeared between 5000 and 200 years ago and restoration to this state would not meet contemporary agricultural, land-drainage or angling requirements. Thus restoration is aimed at returning to a state last observed around the late 19$^{th}$ century prior to intensive livestock farming, land drainage, high-water abstraction and large-scale flood-defence work. By this time the rivers had already been heavily modified and controlled. Thus any remedial measures are likely to have only limited physical effect in comparison with the effects of the major engineering carried out over the longer period.

The introduction of entirely artificial sediments such as 40mm aggregate (gravel) to the Sherston Avon to create spawning areas for salmonids increased the extent of substrate diversity. However, this substrate was alien to the river where the natural substrate was limestone plates (**Plate 5**) and its intrinsic conservation value was unknown and untested. Over several years natural flow variation would redistribute introduced gravel. Such gravel would also become covered with finer sediments and maintenance such as hosing or raking would be necessary to maintain spawning quality. This has already occurred in the Wessex rivers (Giles & Summers, 1999).

One of the problems with assessing the effects of river restoration work generally is that it is usually carried out with no consideration of experimental design for follow-up studies. Thus there have been no comparative tests of the success of the various methods of channel modification in the UK despite work on individual schemes (e.g. Biggs *et al.,* 1998; Cowx & Welcomme, 1998). Indeed Giles and Summers (1999) note that "*one of the shortcomings of this* (Wessex Rivers) *work was that ……… several habitat improvement techniques were applied on a given experimental section, so that interpreting which one did most good is impossible*".

A further complication was that restoration work stretched for some distance along each river with restored reaches interspersed with unrestored reaches. Further, techniques were sometimes specific to one river. For example, large stone deflectors were mainly used on the Sherston and Malmesbury Avons (Sarsen stones) but only on one reach of the Wylye studied (**Plate 6**). Thus their use could not therefore be statistically assessed as a generic technique for use on other rivers.

From careful inspection of the sites and from the measurements in the 2000 survey it was concluded that the channel restoration techniques could mainly be classified into two generic categories, *substrate redistribution* methods (narrowing, current deflection, bed re-profiling - Type A), and *substrate augmentation* (gravel introduction - Type B) (**Table 2**). These are the generic categories used to assess treatments later in this report. Unfortunately, the distribution of methods was not as suitable for comparison as expected. For example, most of the Type A methods were on the Piddle/Wylye systems and most of the Type B on the Bristol Avon system. Furthermore, only 6 of the sites could be categorised as Type B. Type C methods, mainly involving bankside treatments, had little direct effect on the channel.

Fencing was mostly used in conjunction with one of the two generic methods. Its effects as a separate factor were mainly tested by reference to the bankside flora. In all early reports (Giles, 1997a,b; 1999a,b; Giles & Summers, 1999; Game Conservancy Trust, *undated*) the importance of retaining marginal and midstream habitats, and hence floral diversity, by limiting fencing was stressed. In the event, however, fishery managers, anglers or landowners fenced more extensively than expected.

## 6 Spatial scales of change and definitions

The scale at which physical restructuring of river channels might be expected to alter biological diversity is rarely discussed (see Cowx & Welcomme, 1998; Maddock, 1999, Biggs *et al*, 1998). The three scales at which effects of restoration may be reflected in this study are defined in **Table 3**. Sampling was not designed to measure changes at the microhabitat scale and changes on the catchment scale were considered unlikely. The sampling units are also defined in **Table 3**.

Changes in substrates, velocities, sediments or weed cover would be expected to cause changes in the species composition of plants or invertebrates (Hynes, 1970, Ebrahimnezhad & Harper, 1997) on the *mesohabitat* scale (Armitage & Pardo, 1995) as species characteristic of the new conditions replace those of the previous habitat.

On the *reach* scale, the effect of physical changes and immigrant species may be to increase the overall species-richness and diversity if restoration introduced habitat features that did not previously exist in the reach. On the *river* scale, restoration could, in theory, lead to gains or losses of species from the river as a whole if habitats are created or destroyed in the process.

For the most part, habitat features in restored reaches are unlikely to be different to those already in the river. Therefore any species new to a reach would be expected to have originated elsewhere in the river and colonisation would be by downstream drift or upstream migration (e.g. Hynes, 1970). Changes in diversity at the reach scale and below would be a consequence of re-distribution within the river rather than immigration from elsewhere. However, the introduction of alien habitat features could, theoretically, allow the colonisation of species not normally found in the river, particularly if potential colonising species already exist in nearby habitats.

# 7 Methodology

## *7.1 Plants and invertebrates*

### 7.1.1 Site and reach selection

All the data were collected using standard methods with few variations (eg. Hynes, 1970; Haslam *et al*., 1982; Kent & Coker, 1992; Southwood & Henderson, 2000; Environment Agency, 1997b). The design was based on recommendations by Frake (1999). Sampling units are defined in **Table 3**.

Twenty-two sites were initially selected on the three rivers for the plant and invertebrate survey based on the original restoration schemes (Giles & Summers. 1999) and a preliminary site visit. **Table 1** lists the sites, map references and the types of channel modification employed. Detailed descriptions of each site are given in **Appendix 1**. Of the original 22 sites, 21 were eventually sampled - one site being sampled twice. Site 22 was rejected because of the lack of suitable access and a control reach. Selection of reference (control) reaches was difficult in some streams because the restoration work was distributed over some distance (Giles & Summers, 1999) and because other restoration work, particularly fencing, had been carried out subsequently along otherwise unrestored reaches. The criteria for selection of sampling sites are given in a later section (see 7.2.).

## *7.2 Sampling*

### 7.2.1 Selection of sampling reaches

Sampling reaches were selected by visual assessment. Heavily grazed and eroded reaches such as were found during the drought period (see Game Conservancy Trust, *undated*) were absent. Where unfenced reaches were found, the banks were so steep that cattle access was restricted to clearly delimited “drinks”. River crossings were also mostly fenced and access to the stream by cattle was generally restricted. The only comparable fenced and unfenced reaches were on the Devils Brook. (see **Table 1, Appendix 1 & Plate 1.**).

The original aim of the restoration techniques was mostly to introduce physical diversity to the channel. Therefore, morphological diversity was used as the main criterion for characterising the reaches prior to sampling. At each selected site a restored and unrestored reach each approximately 50m long was chosen for sampling. The reaches were usually less than 500m apart. The exception was at Wilton on the Wylye where the unrestored reach was about 1km downstream of the restored reach (see **Appendix 1**). Sampling reaches were selected using the criteria given in **Table 4**. Not all of these characteristics could be clearly separated at all sites and there was a gradation of physical characteristics resulting from of the managed nature of the chalk stream ecosystem and the more recent restoration work (Westlake *et al.*, 1972; Berrie, 1992). Where possible, the most recent evidence of channel modification was used to identify the reaches for sampling.

### 7.2.2 Physical measurements and data analysis

Physical variables measured in each 50m reach included width (m), depth (cm) and current velocity ($ms^{-1}$). Widths were measured at a minimum of three transects and the widest and narrowest points were included. Depths were taken from a minimum of five transects along the reach and at points approximately 50cm apart across each transect. Current velocities were taken at selected points in the reach to reflect the slowest and fastest currents. Only maximum velocity was used in analysis as this indicated the total range in the reach, the minimum always being near zero in the margins.

Information on the substrates was obtained from point-contact depth measurements (e.g. Binns & Eiserman, 1979; Bain *et al*., 1985, Langford, 2000) whereby the substrate under the measuring rod was recorded at the same time as the depth. Substrate composition (as % occurrence in point-contacts) was used as one of the physical habitat features listed in **Table 5**. Total weed cover and marginal instream vegetation cover was also estimated from these measurements in addition to visual assessments. The data were “layered” (Kent & Coker, 1992) so that more than one substrate could be recorded at any point. For example where aquatic weed was the uppermost contact but the weed was overlaying sand, then both weed and sand would be recorded as substrates. Invertebrates would be living in both substrates and to record only the uppermost layer would limit the physical data for further analysis. Weed cover is one of the features that provide hydraulic roughness, and a substrate on which invertebrates live (Hynes, 1970; Dawson & Robinson, 1984). Therefore it was considered as both a physical and biological component of the habitat.

### 7.2.3 Macrophytes

The presence of each species was recorded along the bankside and in the channel for each 50m reach (Kent & Coker, 1992; Southwood & Henderson, 2000). No attempt was made to quantify abundance. Species not readily identifiable in the field were either photographed or, if enough specimens were available, material was collected and identified in the laboratory.

A visual estimate of the total cover of *Ranunculus* spp. was made. In addition some indication of the percentage cover was shown by the point-contact method (see previous section) (Haury & Aidara, 1999; also see Langford, 2000 for references). Comparisons of the visual estimates of total weed cover and the estimates from the point-transect data gave median values of 31.4% (quartiles 14-39) and 35% (quartiles 10-65) respectively. The difference was not significant ($p>0.05$). Spearman-rank correlation gave a coefficient of 0.729 ($p=<0.001$) between the two estimates. This indicates that the two methods are relatively comparable as estimators though the interquartile ranges are wide. Kent & Coker (1992) noted that visual assessment of percentage cover, although somewhat subjective, is rapid and the subjectivity "*may be somewhat over-emphasised"*. The percentage scale follows the Domin categories but values are expressed as actual percentages rather than scalar values (Kent & Coker, 1992).

Although it is known that three species or sub-species of *Ranunculus* occur in the chalk streams no differentiation was made. Total cover of *Ranunculus* was considered as the primary consideration in assessing the effects of the restoration work. The major difficulty with estimates of abundance of *Ranunculus* is the degree and timing of the seasonal cutting back by river managers and quantitative estimates of abundance are difficult (e.g. Owens & Edwards, 1962; Westlake, 1968; Dawson & Kern-Hansen, 1978; Holmes, 1983a,b; Haslam, 1987; Westlake & Dawson, 1988; Haury & Aidara, 1999). At most sites there was no evidence of recent cutting though the presence of varying amounts of floating *Ranunculus* indicated that weed cutting was taking place upstream of some sites.

### 7.2.4 Invertebrates

*Field methods and sample analysis*

There is clear evidence that the invertebrate faunas of the midstream and marginal habitats of most rivers differ in both diversity and species composition (Langford, 1967,1996; Edwards & Brooker, 1992; Harrison, 2000). Thus to assess the relative effects of restoration in both marginal and midstream habitats it was necessary to sample the two separately. (**see Table 3)**.

To allow comparisons with data obtained from previous surveys, a modification of the 3-minute hand-net sampling routine specified for Environment Agency surveys (Environment Agency, 1997b) was used (Furse *et al.*, 1981; Wright *et al.*, 1992; Wright *et al.*, 1993).

Environment Agency methodology does not indicate how important the margins are as a proportion of the habitat in any reach but as marginal vegetation and roots are clearly an important habitat for some species (see Langford, 1996; Harrison, 2000) the sampling period was divided into two equal parts. Similarly the 1-minute manual search (Environment Agency, 1997b) was also divided into two equal periods. Thus the marginal and midstream habitats were sampled separately for a total of approximately 2 minutes each. Excluding the manual search, each separate margin and midstream sample typically included 3-4 separate kick-sweep sub-samples.

One set of samples, (margin and midstream) was taken in each 50m reach except at the site on the Devils Brook. This site was sampled twice, (June 28th, July 21st) covering two replicate restored and unrestored sections (see Summers *et al.*, 1997). On each occasion two separate mid-stream and two separate marginal samples were taken in each 50m reach giving a total of 16 samples for the two occasions. A full list of samples is given in **Appendix 2**.

The marginal vegetation was sampled for adult insects with a hand sweep net. Ten sweeps were made in restored and unrestored reach, five sweeps along each bank.

There are recorded populations of native crayfish (*Austropotamobius pallipes*) in both the Sherston Avon and the River Piddle (Giles & Summers, 1999; Spink & Frayling, 2001). Where individuals were collected they were recorded and returned to the habitat alive. Although stones were overturned and marginal substrates sampled during the surveys at each site no special inspection was made for crayfish and all those caught were collected as part of the normal sampling procedure.

Sorting of invertebrate samples was carried out to the standards indicated in document BT001 (Environment Agency, 1997b) and identification was to species level where feasible. All animals were picked from the sample rather than representatives of each taxon. Animals were identified to species level where possible with the keys available. Oligochaeta (worms), some Diptera (flies), Hydracarina (water mites), Ostracoda and Collembola (springtails) were not identified to species. Some Sphaeriidae (pea-shells) were identified to species but have not been verified by external experts. There was some variation in taxonomic uniformity because of size of specimens. The standardised list for families is that used in BT001 (EA 1997b). The list of species/higher orders is shown in **Appendix 4**.

External Audited Quality Control was carried out with a slight variation (under direction) from that given in BT001 in that samples were re-sorted and picked without returning the already sorted animals to the sample. The already sorted sample was then re-analysed and identification repeated and the AQC sample was then analysed and identification carried out. The two were added together to provide the quality control. The results of the AQC are shown in **Appendix 3.**

To assess the relative efficiency of the three sorters an internal AQC was used in addition to the original external AQC. Sorter 1 and 3 were subjected to internal audit and sorter 2 to the external audit. Mean taxon (family/species) score was 28 for sorter 2 and 28.3 for the external sorter. There was no significant difference ($p=0.082$). For the internal audit, sorters 1 and 3 processed samples from the Devils Brook and River Piddle, which represented low and high diversity sites respectively. There was no significant difference ($p>0.05$) between the numbers of taxa found by both sorters. For the River Piddle the mean numbers of BMWP taxa found by 1 and 2 respectively were 20.5 and 20.9. This shows a high level of consistency when checked against AQC by sorter 2 and indicates consistency between all three sorters. The differences between samples were therefore a result of the composition of the samples. Although sorting samples by removing all individuals is a longer process than “part” removal and abundance estimation of the remainder, it may lead to more consistent and efficient performance as far as numbers of taxa are concerned. Comparisons with data from Environment Agency surveys confirmed the consistency of the data.

*Data analysis*

The patterns of change in species richness or diversity caused by channel restructuring might be expected to be independent of the river and thus the sites are initially analysed as a single data set. Species distribution and composition, in contrast, may vary between rivers. Taxon richness is compared as a whole and for rivers separately.

Plant and invertebrate data were analysed by similar methods involving paired tests and analyses of variance. Species-richness was the main variable for the plant data but the invertebrate data were analysed using various diversity and taxon-richness indicators (Magurran, 1988; Southwood & Henderson, 2000). The indices used are described in **Table 6**.

Most of the historical invertebrate data were supplied as data sheets and are used here in the form of BMWP scores and subsequent surveys are likely to be at the same level. Thus, historical comparisons were made using the BMWP scores for continuity. Family level data can also be used as a surrogate for species-richness (Wright *et al.,* 1994). BMWP scores are also related strongly to some diversity indices.

Five measures were used to compare the diversity and biological quality of the sampled communities. Each measure provides different information to help interpret the changes in community diversity (**Table 6**). Estimates of predicted total taxon richness were also made using various estimators (Southwood & Henderson, 2000). Analysis was carried out using Pisces Conservation's software packages *Community Analysis Package* and *Species Diversity and Richness*. Ancillary scores such as the LIFE score for low flow indications (Extence *et al*. 1999) or Community Conservation Index (CCI) (Extence & Chadd, *pers.comm*) were not used here as they did not add to information on diversity in relation to restoration. However, they are suggested for future use in conservation management (see 12.1).

### 7.2.5 Fish and other vertebrates

The assessment of fish populations, before and after the restoration work, was carried out by the original contractors, The Game Conservancy Trust and Nick Giles Associates (e.g. Summers *et al.,* 1997; Giles, *undated;* Giles, 1997a *et seq;* Giles & Summers, 1999). The methodology outlined here is described more fully in these reports. The data used here were extracted from the surveys by the authors and partly re-analysed.

Electric fishing surveys were carried out at most of the sites before restoration work began (Summers *et al.*, 1997). General surveys were also carried out on the rivers on a number of occasions since 1995 (Environment Agency, 1996a,b; 1997a; Solomon, 1997) and follow-up studies were also made at specific restoration sites at intervals since 1996 (Summers *et al.,* 1997; Giles *&* Summers, 1999). Most of the surveys were specifically aimed at salmon (*Salmo salar*), sea-trout or brown trout (*S. trutta*) and particularly wild brown trout in some reaches (Giles & Summers, 1999). Other species sampled and recorded on the Avon reaches included grayling (*Thymallus thymallus*), barbel, (*Barbus barbus*), dace (*Leuciscus leuciscus*) and roach (*Rutilus rutilus*).

None of the surveys were carried out for the purposes of assessing community diversity. Thus, none of the data included quantified records of other species known to live in the streams, particularly bullheads (*Cottus gobio*) and brook lampreys

(*Lampetra planeri*) which are Annex IIa protected species under the European Habitats Directive (European Communities, 1992). Indeed, community studies of fish in southern UK rivers are scarce (e.g. Ibbotson *et al.*, 1994; Prenda *et al.*, 1997; Langford, 2000) and may exclude species such as the minnow (*Phoxinus phoxinus*), stickleback (*Gasterosteus aculeatus*) and eel (*Anguilla anguilla*) which can comprise a large proportion of the community by number or biomass (e.g. Townsend & Peirson, 1988; Ibbotson *et al.*, 1994; Prenda *et al.,* 1997; Langford, 2000). Recent fish surveys by the Environment Agency (Strevens pers.comm.) have produced distribution records of species such as bullheads and lampreys but to date quantitative data are scarce from these lowland rivers (e.g. Mann, 1971).

Electric fishing methodology has been described and discussed in many papers (e.g. Cowx 1983, 1990, Bohlin *et al.*, 1989). For these surveys standard methodology was used. Reaches of varying length were blocked by nets and subjected to at least two full passes using two operators (Summers *et al.*, 1997). Population numbers were estimated using the maximum weighted likelihood method (Carle & Strub, 1978) and densities calculated using either length of stream or wetted surface area.

During the invertebrate surveys in the summer of 2000, many bullheads were caught, recorded and released and a small number of lampreys were also noted. No special effort was made to sample fish or estimate abundance and the absence of a species from an invertebrate sample should not be interpreted as absence from the site.

Fish mobility is one of the factors which may be vital to the colonisation and community formation in restored and modified channels (Linnløkken, 1997). To obtain some information on the mobility of salmonids in the Wessex rivers, a series of tagging experiments were carried out over a 3km reach of the River Piddle (Summers *et al.*, 1997). Fish were caught, marked and replaced. Subsequent electric fishing surveys recorded numbers of tagged fish in their original reach and other locations over periods of 1-2 years.

### 7.2.6 Mammals

A survey of habitat suitable for otters (*Lutra lutra*) and their current population status was carried out in the Wylye catchment in 1997 and 1998 (Satinet 1998). Over 120 km of habitat were surveyed in detail and sightings reported. In addition, historical data were reviewed and recommendations for future introductions and habitat improvements made.

Surveys of other mammals have been carried out in the Wylye and Piddle over several years (e.g. Satinet, 1997 *et seq*). Detailed counts of signs of species such as water voles (*Arvicola terrestris*) have been made and are in the process of analysis. The methodology is based on the recording form shown in **Figure 5.** Droppings are also analysed for food constituents and habitat features recorded. Records for the River Piddle and Devils Brook originate from surveys by the Dorset Wildlife Trust (DWT, pers.comm).

# 8 Results

## *8.1 Vegetation*

### 8.1.1 Reach-scale comparisons

### 8.1.2 All restored and unrestored reaches

A total of 149 aquatic and bankside species of plants were identified from the 44 reaches surveyed. Full lists of species and frequencies of occurrence are shown for all rivers in **Appendix IV**. **Tables 7-12** show the records for each river and site. Paired t-tests on all the samples showed that there was a slight increase (10.5 to 11.4) in the mean species richness of aquatic plants in restored reaches but this was not significant ($p>0.05$) (**Figure 6**). In contrast there was a highly significant overall reduction in the mean species richness (17.9 to 14.8) ($p=0.006$) of bankside and terrestrial plants in the restored reaches (**Figure 6**).

### 8.1.3 Comparisons between and within rivers

Some differences were observed between rivers: species richness of both aquatic and terrestrial plants was lower in the River Piddle than in the Wylye or Bristol Avon (**Figure 7).** The difference between rivers was close to statistical significance ($p=0.051$) with the Piddle/Devils Brook showing the least species **(Table 13).**

Using the site data pooled for each river separately, there were found to be no significant differences in mean species richness of aquatic plants between restored and unrestored reaches (**Figure 8, Table 13**). On the Wylye and Bristol Avon there were no significant differences in mean species richness of bankside and terrestrial plants between restored and unrestored reaches. However, in the Piddle and Devils Brook sites there was a highly significant decline by some 6 species ($p<0.001$) in the mean number of bankside and terrestrial species between unrestored and restored reaches (**Figure 9)**.

### 8.1.4 Fenced and unfenced reaches

The effects of fencing and restricting cattle access are difficult to demonstrate from the data mainly because at most sites fencing, trees or the steepness of banks restricted cattle access anyway. The only sites capable of study were on the Devils Brook where fenced and unfenced reaches were contiguous. Here the species richness of aquatic plants was reduced slightly in the fenced areas but the species richness of the terrestrial plants at both sites was reduced by 5 and 8 species respectively when compared to their controls. At the fenced sites tall grasses (*Phalaris* sp.) and reeds dominated the plant communities on the banks. Strong root matrices of the reeds lined the immediate margin of the stream and created a more uniform habitat than the mosaic of small backwaters, hoof prints and muddy margins of the unfenced reaches. From photographs, however, it is clear that cattle had a much-reduced effect compared with their influence during drought when the stream margins were extremely heavily cropped (Game Conservancy Trust, *undated*).

 

Species not recorded from the fenced sites on the Devils Brook included Common Chickweed, Common Mouse-ear, Meadowsweet, Redshank, White Clover and Hard Rush (**Table 8).** Species not recorded from the unfenced reaches included Comfrey and Willows, though the latter were planted in the restored reaches. There were 24 species of plants recorded in the unrestored sites but not in the restored sites along the Piddle compared with only 6 species recorded only from restored reaches.

There is, therefore, strong evidence that fencing and the subsequent dominance of the more robust species has had a deleterious effect on the species richness of the bankside vegetation but little effect on the diversity of instream vegetation in the reaches of the Devils Brook. Fencing and absence of bankside disturbance by cattle may also be a major factor in the decline of species at other sites.

### 8.1.5 *Ranunculus* and instream weed cover

*Ranunculus* spp. was more or less ubiquitous in restored and control reaches of the Piddle/Devil's Brook and Wylye/Till systems (**Tables 7 and 9** ) but it was absent from some sites in the Sherston and Malmesbury Avons ( **Table 11**). The reasons for absence are not always clear. One possible reason was the limited lengths of the sampled reaches, but where no *Ranunculus* was seen in the sampled reach, a visual inspection was made over a longer reach and any presence noted. Over-deepening and over-widening for land drainage purposes leading to depositional conditions, (slow flow and mud/silt substrates), were the most likely reasons for the absence of *Ranunculus* at some sites.

**Figure 10** shows the average percentage cover of *Ranunculus* spp. in the three river systems in relation to restored and unrestored reaches. Although the restored reaches show a slight increase this is not statistically significant ($p>0.05$). A simple plot indicates a decreasing trend of cover in relation to the amount of shade at each site but the variation was large for all categories of canopy (**Figure 11**). Two-way analysis of variance using the percentage cover estimates demonstrated a significant difference between rivers ($p<0.001$) with the Avon sites showing significantly lower percentage cover values than the other two. Restored and unrestored reaches showed no significant differences.

### 8.1.6 Variations at individual sites

The general patterns along each river vary considerably. Using the total numbers of plants recorded (aquatic and bankside) there is a consistent pattern along the Piddle and Devils Brook with all sites showing larger numbers of species in unrestored reaches **(Figure 12)**. The Devils Brook sites show the greatest differences caused by the fencing as described above. At Park Farm there was access by cattle to one bank of the unrestored reach but also moderate shade, while at Briantspuddle the unrestored reach was in dense shade but there was no difference in the species-richness of the flora. In contrast, the abundance of *Ranunculus* was low.

Along the Wylye/Till no pattern was discernible. The adjacent sites at Hanging Langford and Little Wishford showed opposite trends in species richness between restored and unrestored sites as did the Great Wishford and Wilton sites **(Figure 13)**. At the Hanging Langford site, the unrestored reach was partly shaded, relatively deep and one bank was armoured with planking. The restored reach was also partly shaded, with variable depth, flow deflectors and fenced banks. The Little Wishford reaches were similar although the unrestored site was faster flowing and shallower than the restored site. At Wilton, the unrestored site was shallow with heavily degraded banks grazed by waterfowl. The restored site was fenced but deeper and slower.

The insertion of gravel banks along the Sherston Avon did not increase the species-richness of plants in any of the restored reaches **(Figure 14)**. The greatest increase between unrestored and restored reaches was at Kingsmead where the restored reaches were shallower, with a more variable current and substrate and trampled banks. Here the unrestored reaches showed higher species richness for both aquatic and bankside plants with the bankside habitat containing 12 more species than the restored reaches. At Great Somerford where the banks were much steeper and less accessible than in the restored reach the pattern was reversed. The only site where *Ranunculus* appeared after restoration was at Hyams farm where the installed gravel bed contained a small stand.

### 8.1.7 Comparisons on the river scale

There were considerable differences in species-richness between the rivers as shown by the species-accumulation curves (**Fig.15**). The Bristol Avon showed a higher total of both aquatic and bank side species than the two chalk streams. The Piddle was the least species rich. Using a 10 sample comparison, the Piddle contained 16 aquatic and 50 bankside species, the Wylye 22 and 51 respectively and the Avons 27 and 60 respectively. The Avon reaches comprised two geological areas, limestone for the Sherston Avon catchment and gravels and clays for the Malmesbury reaches and this may be the reason for the higher overall species richness of aquatic plants.

**Table 14** shows the number of plant species common to restored and unrestored reaches compared with those found in only one reach type along the three rivers.

The number of species specific to restored reaches is mostly smaller than that for unrestored reaches, though the numbers in the case of the Wylye/Till are similar. The species richness/site sampled ratios for the three rivers are Piddle/Devils Brook 12.7, Wylye/Till, 11.2 and the Sherston/Malmesbury Avons, 16.3. For aquatic species the ratios are 2.7, 2.7 and 5 and for bankside species the ratios are 8.6, 8.2 and 11.3 respectively. Thus the river system with the least fencing and the lowest abundance of *Ranunculus* sustains the highest numbers of bankside and aquatic plant species. This is important for future management.

### 8.1.8 Plant species distribution

The aquatic plant community of the chalk streams is essentially the crowfoot-starwort (*Ranunculus-Callitriche*) community as categorised by (Holmes, 1983a,b) and Rodwell (1995). In the limestone streams there was a higher tendency for starwort (*Callitriche* sp) and in some of the more ponded reaches, emergent species such as Branched Bur-Reed (*Sparganium erectum)* were more frequent.

The species recorded exclusively from either restored or unrestored habitat were mostly in low abundance or were single occurrences (**Tables 7 to 12)**. Along the

Wylye/Till the moss *Fontinalis antipyretica* was exclusive to three unrestored sites and the Pondweed (*Potamogeton crispus*) to one restored site. Among the terrestrial species Dog Rose (*Rosa canina*) was in three restored reaches but no unrestored reaches. All other exclusive records were either single or dual records. Along the Avons the exclusive aquatic species were mostly single occurrences except for Flote-grass, (*Glyceria fluitans*) which occurred in three restored reaches but not in unrestored reaches. Herb Robert (*Geranium robertianum*) and Ragwort (*Senecio* sp) occurred only at two restored and unrestored sites respectively but both are common along the river. There is clearly no species of aquatic or bankside plant that is entirely restricted to restored or unrestored reaches of the three rivers.

In the Sherston Avon, the tiny exotic floating fern *Azolla filiculoides* was recorded at sites below Easton Grey. This species does not form part of any specific community (Rodwell, 1995) and was not recorded in the Piddle and Wylye systems. The bankside communities were not categorised but the marginal communities of the Piddle and Wylye were characterised by *Glyceria fluitans*, particularly in the unfenced reaches. In the fenced reaches of the Devils Brook and other sites the tall grasses (e.g. *Phalaris arundinacea, Glyceria maxima*) dominated the bankside and to some extent the marginal flora.

To summarise, there is no evidence that the restoration work in the river channels has had major effects on the abundance and diversity of the aquatic vegetation on the sub-reach or reach scale within the river channels. There is, in contrast, consistent evidence that there has been a significant decline in species richness of bankside and terrestrial assemblages in some restored reaches of the rivers studied. Differences between rivers may be a result of the differences in management and access to the banks by cattle.

## *8.2 Macro-invertebrates*

### 8.2.1 Species richness and diversity

From 98 samples a total of 177 taxa were identified in 55 families or higher order groups **(Table 15)**. For this analysis Oligochaeta, Chironomidae and Hydracarina were not identified to species. The first two groups were mostly identified as far as family or sub-family level though the material has been retained in case further analysis is required. In the following section for comparisons with data from other sources analyses are carried out at family level. The full list of species/taxa is shown in **Table 15** and the numbers of each species/taxon identified from each river are shown in **Appendix 5.** The percentage compositions of the invertebrate samples at family level with marginal and midstream samples pooled for each reach are shown in **Tables 16** to **20**. Only those taxa comprising over 0.1% of the total are shown here. For the indices and analyses, the full list of all relevant taxa including those less abundant were used.

### 8.2.2 Reach scale comparisons

#### a) Marginal and midstream habitats

There were significant differences in taxon diversity and richness between the marginal and mainstream samples (**Table 21).** Using all the samples in a single rank-sum test, there was no significant difference in the Shannon-Wiener index (H') (p=0.067), or in the numbers of families present. There were significant differences in Simpson's D (p=0.03), Equitability (J') (p<0.001), BMWP (p=0.024), and ASPT (p<0.001).

The differences were mainly related to the differences in the proportional composition of the samples. For example, the Equitability (J') of the marginal samples was significantly higher than midstream samples indicating a more even percentage taxon composition. This accounts for the higher diversity (H') in the marginal samples (Magurran, 1988). The midstream samples typically had higher BMWP scores than the marginal samples (see Environment Agency, 1997b). The ASPT scores indicated that the reason for the lower BMWP in the margins, despite the similar numbers of taxa present, was that the taxa were generally lower scoring taxa, i.e. more tolerant of slower water and silt or mud conditions. This is evident from the list in **Table 22** where the families most abundant in marginal or midstream samples are listed (see EA 1997b)

Species accumulation curves (from species-level identification) for marginal and midstream samples (**Figure 16**) show a higher total by some 8 species for the marginal samples though, as with the families, the mean numbers of species per sample were not significantly different.

#### b) Comparisons between restored and unrestored reaches

Paired t-tests on all samples (midstream and margins combined) from restored and unrestored reaches showed no significant differences for any of the diversity indices or taxon-richness based on family level identification (**Table 23**). Further, separating marginal and midstream samples also showed no significant differences between restored and unrestored reaches (**Table 24**). Despite the lack of significance, mean values of all indices except ASPT were the same or slightly higher for midstream samples and the same or slightly lower for marginal samples in the restored reaches.

Using species-level data, there was no significant difference in mean species richness between restored and unrestored margins (31.0, 32.3, p=0.834) or between restored and unrestored midstream habitats (32.8, 30.1, p=0.861).

There were few families restricted to either restored or unrestored habitats (**Table 25**). The species restricted to one treatment type were typically the less abundant forms and none of the most numerous families occurred exclusively in either restored or unrestored reaches. Most of these restricted species also occurred in both habitats in the other rivers.

Using species level data and frequency of occurrence as the criterion, none of the midstream species showed marked preferences for either restored or unrestored habitats. Preference was assessed as occurring at least 5 times more frequently in one habitat than the other. Although 19 species were exclusively recorded once or twice in unrestored reaches and 51 species were exclusively found once or twice in restored reaches these did not fit the preference criterion set. . Of the 35 species exclusively recorded from unrestored margins, only *Pisidium* species, the mayfly *Habrophlebia fusca* and the cased caddis *Glyptophaelius pellucidula* were found 5 times more frequently than in the unrestored reaches. Flatworms (*Polycelis* cf *nigra)* and the cased caddis *Potamophylax latipennis* showed marked preferences for unrestored margins though 33 other species occurred exclusively at low frequencies (1 or 2 samples).

### c) Comparison of restructuring techniques

The effects of type A and Type B (see **Table 2**) restructuring methods were tested (**Table 26**). The number of samples of Type B (augmented) reaches was low (n=6) compared with the number of Type A (redistribution) reaches (n=17). None of the variables showed significant differences, although depth, invertebrate diversity and BMWP score were, on average, lower in the augmented reaches. These variables may have been biased to some extent by the lower overall species richness in the Sherston and Malmesbury Avons where most of the augmented reaches occurred. The results from the two techniques were therefore similar at the 50m scale and there was no significant difference in their effect on either substrate diversity or invertebrate diversity. The length of time between the physical changes and sampling was probably an important factor in the stabilisation of the substrate and the flora and fauna. A similar test on the percentage cover by instream weed showed averages of 50% and 25% in the Type A and Type B reaches respectively. The differences were most likely a result of the biased distribution of the sites and the low abundance of *Ranunculus* in the two Avon tributaries.

### d) Cumulative effects of restoration

Although it was predicted that there should be differences in composition of the invertebrate communities where the restoration work had altered the morphology of the river channel, effects on diversity are not always obvious. Taxa typical of faster waters may well replace those typical of slower waters where gravel riffles are created but not alter the overall diversity of the restored reach. When the species richness of the restored reach is added to that of the unrestored reach however, it might be expected that there would be an increase in the overall taxon richness of the combined reaches. Such species accumulation also occurs when replicate samples are taken at similar sites or in similar habitats (Magurran, 1988). The effects of the restoration on total species richness and diversity would be expected to exceed that of normal replication because of the addition of species more characteristic of the new habitat. Pooled data from restored and unrestored reaches at each site were compared with data pooled from adjacent unrestored and adjacent restored reaches. **Figure 17** shows the methods of pooling samples for comparisons.

**Figure 18** shows the results for the various habitats. There are no significant differences between samples from either pooled restored or pooled unrestored habitats and the samples summed from the pooled restored/unrestored reaches. The cumulative effects at family level are unaltered by the restoration.

Data from species identifications were used to construct species-accumulation curves (see Magurran, 1988; Southwood & Henderson, 2000) (**Figure 19**) for restored and unrestored reaches of all rivers. The data were subjected to 10 random iterations to reduce the effect of sample order on the calculations (see PISCES Conservation, 2000a,b). The lowest number of species was accumulated by the unrestored midstream samples. All other categories showed similar curves. The indication was that restoration increased the overall species richness of the midstream habitats on the larger scale. Using the data for all restored and unrestored reaches (**Figure 20**) the indication was that restoration resulted in a total increase of 8 invertebrate species overall in the three rivers.

Detailed scrutiny of the data shows that a large proportion of this increase was from one site at Throop on the River Piddle. Here some 53 species/taxa were identified in comparison to the average of 32 species/taxa. At this site the normal midstream fauna was augmented by species more characteristic of marginal habitats. Bed re-profiling and a varied midstream habitat with large beds of *Ranunculus* and other weeds clearly provided a complex habitat structure.

### 8.2.3 Comparisons between rivers

Two-way analysis of variance on invertebrate data from all reaches showed clear differences again between the rivers, but not between restored and unrestored reaches (**Table 27**).

There were differences between rivers for all the parameters except ASPT but only differences between the Piddle and Devils Brook and the Avons were significant. In all cases the Piddle showed the higher invertebrate diversity.

The total numbers of species identified from each river was significantly related to the numbers of sites sampled (p=0.008) and the number of samples taken (p=0.004).

Of the 177 species/taxa identified 38 were only recorded in one of the rivers. All others were found in at least two rivers. The Wylye contained most species and many of the single location records were from this river. Similarity analysis based on the data in **Appendix 5** showed that the Wylye and Sherston Avon were least similar and the latter separated out from all the others. Diversity ordering (see Southwood & Henderson, 2000) also indicated that the diversity of the Sherston Avon invertebrate community **(Figure 22**) was lower than all the others for all standard diversity measures.

### 8.2.4 Individual sites and comparisons with historical data

BMWP scores were used for comparing effects of restoration at individual sites and for comparisons with Environment Agency data. **Figure 23** shows the scores for the Devils Brook and Piddle sites. The scores from both sources are similar for relevant sites. The Devil's Brook site showed an increase in the score in the restored reach of about 8% but both reaches were within the range recorded in EA surveys. At Burleston, Park Farm and Southover the scores for restored reaches are lower than for unrestored reaches while at Briantspuddle and Throop the pattern was reversed.

Restoration techniques were similar at all sites with fencing being common to most restored reaches.

The scores for the Wylye sites **(Figure 24)** are compared with mean scores from surveys by the Environment Agency over 8 years. These scores differ little from historical EA data and being typically higher or similar. The summer 2000 surveys show higher scores than previously noted for sites in the middle and lower river but this may be a result of several factors including differences between locations, operators or techniques (see Wright *et al*, 1992). The scores in restored reaches are higher than the unrestored reaches at Stockton, Great Wishford and Wilton but lower at Yarnbury Court, Langford Fisheries and Hanging Langford. There is no consistency in the pattern.

Again in the Sherston and Malmesbury Avons, the scores are typically similar to the EA scores **(Figure 25).** However, at all sites except Great Somerford there was an increase in the BMWP score between unrestored and restored reaches. The greatest single increase at any site occurred at the Kingsmead site downstream of Malmesbury where the scores were 155 in the unrestored reach and 215 in the restored reach. This was one of the sites that showed the greatest difference visually (see **Plate A21, lower**). At Great Somerford, both scores were lower than the average EA score and the restored reach showed the lowest score of the survey.

## *8.3 Distribution of selected species*

### 8.3.1 Crayfish (*Austropotamobius pallipes*)

Both the River Piddle and the Sherston Avon are known habitats for the native crayfish (*A. pallipes*) (Giles & Summers, 1999; Spink & Frayling, 2001)). Spink & Frayling (2001) reviewed the status of the populations in the Sherston Avon following the effects of the crayfish plague (the fungus *Aphanomyces astaci*) in the 1980s and a serious pollution incident in 1998. Successive re-introductions have been made since the 1980s with the last in 1994. Surveys in 1998 and 1999 using quadrats, hand-nets and baited traps produced catches of between 0 and 23 individuals in 50m reaches of the Sherston Avon either at or adjacent to the sites of original introduction. In contrast, the invertebrate surveys in 2000 collected no crayfish from any of the sites on the Sherston and Malmesbury Avons, despite the fact that some survey sites were within 0.5-1km of the sites used by Spink & Frayling (2001). For example, the unrestored site (semi-natural) at Easton Grey was just downstream of a main introduction site as were the sites at Cowage Farm and Hyams Farm. The absence of any crayfish in the invertebrate samples is difficult to explain especially as the species was caught readily in the River Piddle using the same techniques. Possible explanations are as follows: **i)** the crayfish readily escaped hand-net sampling (not so in the Piddle); **ii)** the densities were too low and the chance of non-specific sampling was also low (not so in the Piddle); **iii)** the invertebrate sampling sites were too far from the original sites for the crayfish to have spread and no crayfish were present.

Without detailed comparisons of methods it is difficult to be conclusive but the evidence suggests that except for limited reaches crayfish densities are typically low in the Avon though the species appears to be surviving. Effects of river restoration on the species distribution could not be assessed.

In the River Piddle, non-specific sampling was relatively successful. Following the restoration work on the Piddle, Giles & Summers (1999) estimated crayfish numbers in fenced and unfenced reaches. From five reaches the mean densities of crayfish (per $100m^{-2}$) were 0.163 (SD:0.236) and 0.395 (SD:0.391) in unfenced and fenced reaches respectively **(Figure 26)**, though the difference was not significant ($p = 0.074$). Maximum densities were $0.9m^{-2}$. In the summer 2000 invertebrate surveys, crayfish were found in the reach from near Southover House to Throop. The numbers were small. The total from three unrestored reaches was 3 and from three restored reaches 19. The physical differences between the restored and unrestored sites were not consistent. In addition to these samples, a single specimen identified as *A. pallipes* was found in the Wylye at the unrestored site in Wilton.

There is therefore some slight evidence that stream restoration leads to an increase in *A. pallipes*, though the factors that lead to the increase are not known and the population distribution and abundance clearly requires further quantitative study.

### 8.3.2 Aerial insects and semi-terrestrial invertebrates

Sweep samples from river margins collected a wide variety of insects but only Odonata, Trichoptera, Ephemeroptera and Plecoptera were inspected. Observations during the surveys noted the numbers of aerial Odonata in the sampling reach.

The most common and obvious species of Odonata was *Calopteryx splendens* but this was not widespread and was limited to one reach of the Sherston Avon at Kingsmead and two reaches of the Wylye at Stockton and Langford Fisheries. One adult was taken in the sweep nets at Throop on the Piddle. No other species was noted in flight.

Larvae were not generally abundant. Single individuals of *C. splendens* and *Pyrrhosoma nymphula* were found at three sites along the Piddle and three sites along the Wylye. Neither were present in the Sherston Avon though both were found at Kingsmead and Great Somerford on the Malmesbury Avon.

The largest number of *C. splendens* larvae (21) was in a marginal sample taken from the restored reach at Briantspuddle on the Piddle. The group was not well represented in the samples and the streams are not generally a rich habitat for this species.

One adult stonefly (*Isoperla grammatica*) was collected at Throop. Only 8 adult mayflies were collected in 44 samples and there were insufficient to carry out any statistical analysis.

At the Avon sites only 7 adult Trichoptera were collected, 3 at unrestored and 4 at restored sites. At the Devils Brook and Piddle sites 11 specimens were collected 7 at unrestored and 4 at restored sites. At the Wylye and Till sites there was an imbalance in that of the 21 specimens collected 20 were collected at the unrestored sites. The presence of trees or other tall vegetation may be important for flying insects with aquatic stages.

The semi-aquatic snail *Succinea putris* was relatively abundant in sweep net samples along the Devils Brook and Piddle sites being slightly more frequent at restored sites but no more abundant overall. The species was scarce at the Avon sites and infrequent but locally abundant at the Wylye and Till sites. No specimens of the genus *Vertigo* (whorl snails) were recorded at any site.

## 8.4 Fish

### 8.4.1 Fish habitat changes

The overall effect of restoration work in the Devils Brook was to make the stream narrower and deeper. **Figure 27** shows the mean depths in reaches of the Devils Brook where active bed-profiling had created pools in comparison to unaltered control reaches (Summers *et al.*, 1997) where no pools existed. The primary effect of the physical modification was to increase depth variation from almost nil in a 20m reach to between 40 and 60cm. Impoundment of the water by vegetation accounted for the increase in minimum depth from about 15-25cm in the controls to 20-30cm in the altered reaches. Mean water width was reduced in the altered reaches such that control sites were about twice to three times the width of altered sites. The change in open channel width was a result of the increased abundance and encroachment by marginal vegetation (**see Plate 1**) as consequence of fencing and reduction of grazing pressure.

### 8.4.2 Habitat changes and fish abundance

The quantified data used here come from the River Piddle, the Devils Brook and the Sherston Avon (Summers *et al.,* 1996; Summers *et al*., 1997; and Giles & Summers, 1999). The paired t-tests on all data showed that there were significantly higher densities of 0+ (p=0.007*) and 1+ trout (p<0.001***) in the restored reaches of the Piddle and Devils Brook (n=11) than in the non-restored reaches (**Figure 28**) when the two habitats were sampled following channel restructuring.

Further, fencing appeared to produce the same effect (**Figure 29**) with a 2- to 3-fold difference in population estimates (p=0.005 and <0.001 respectively, n=13). In the Sherston Avon surveys the numbers of samples were much smaller (n=4). Only the differences for all fish (**Figure 30**) (p =0.023) and chub (p =0.03) (**Figure 31**) were significant but all other species (wild trout, salmon parr, grayling, dace and barbel) were not (**Figure 32**). Giles & Summers (1999) noted that pike were also caught in the surveys but these were generally removed in the interests of the salmonid fishery and no numbers are given. It is impossible therefore to assess whether potential predator numbers also increased as a result of the channel alterations. The authors also noted that overall numbers of juvenile wild trout and grayling fell in 1998 from the 1997 numbers in three reaches though the reasons were not clear.

In the Wylye, electric fishing surveys before and after restoration showed varying fish densities following restoration (Giles, 1999a,b). Wild trout adult numbers increased from about 3/100m$^{-2}$ in 1996 to almost 6/100m$^{-2}$ in 1998. Parr increased from approximately 5 to over 8/100m$^{-2}$ between 1996 and 1997 but fell to 3/100m$^{-2}$ in 1998 after a poor spawning winter. This clearly illustrates the relative effects of physical restoration and biological factors such as spawning success, survival and recruitment. Grayling showed similar patterns for adults and juveniles. Population density estimates showed considerable variation in both time and reach in the Hanging Langford section of the Wylye (Giles, 1999). Between 1997 and 1998 these ranged from a 225% increase to a 30.9% decline in adult grayling and 53-93% decline in juvenile trout. Adult trout showed an increase in populations ranging from 5-246% depending upon the reach.

The temporal and spatial variations in population densities are a function of natural reproductive success, survivorship and mobility. In heavily fished and managed salmonid rivers they may also be a function of the date and intensity of stocking and angling success rates. Thus data on total salmonid density may bear no relation to the natural carrying capacity and reproductive success of populations. The possibility of stocking with 0+ fish may also invalidate estimates of the success of natural populations. Against the background of such large fluctuations the effects of channel restructuring are difficult to assess. Evidence from annual fluctuation in densities suggests that any effects of restoration are minor compared with effects of spawning success and survival rates, irrespective of artificial introductions.

### 8.4.3 Fish diversity

Abundance, community composition and size distribution of fish are known to be related to channel morphology and habitat diversity (e.g. Egglishaw & Shackley, 1982; Ibbotson *et al.,* 1994; Prenda *et al.*, 1997; Langford & Hawkins, 1997; see Langford 2000). None of the regular fish surveys of the three rivers have included either quantitative or semi-quantitative estimates of the relative densities of all species. In some surveys (e.g. National Rivers Authority, 1995; Environment Agency, 1997a; Giles & Summers, 1999) species other than salmonids are noted or estimates of density made. For example in the Wylye (Environment Agency, 1997a) estimates of fish densities in a 100m reach included grayling, eels, chub, pike, perch, and bullhead in addition to the salmonids. At most sites grayling were the most abundant of the species recorded. Available records for the Piddle show the possible presence of about 20 species of which six or seven were regularly recorded in the fishery surveys (National Rivers Authority, 1995). Data for species other than Salmonidae in the Sherston and Malmesbury Avons originate from surveys before and after restoration work in the relevant reaches (Giles & Summers, 1999).

Shaw *et al.* (2000) reported relative densities of various species in a short-term study of the Wiltshire Avon near Stratford Sub-Castle, Salisbury. Here, in five reaches in different stages of morphological alteration, variations in both species distribution, abundance and diversity were not related to the degree of alteration though the most quantitative data indicated highest biomass of fish in the deepest and most channelised reach following restoration. The most numerous species was the minnow (*Phoxinus phoxinus*).

During the invertebrate surveys on the three rivers any fish caught were noted and returned to the river. Bullheads (*Cottus gobio*) were common and abundant at all sites in the Piddle and Wylye systems but less abundant in the Sherston Avon and Malmesbury Avon. Small numbers of *Lampetra planeri* were collected, mainly in the Devils Brook though single individuals were collected at sites on the Wylye and Malmesbury Avon. Giles (1999b) noted that lampreys colonised soil falling into the channel during topsoiling along the Wylye banks. There are no data on the densities of the species.

### 8.4.4 Causes of fish population changes

Following changes in channel morphology, colonisation by fish is most probably dependent on the mobility and the proximity of suitable individuals. Summers *et al.* (1997) showed variations in mobility of marked salmonids in the Piddle though it is difficult to relate the movements to restored and unrestored reaches. For example, marked 0+ fish were relatively static for the first 6 months after marking**. Figure 33a** shows that between 40 and 85% of marked fish remained in their original reach. However, after 1 year only between 5 and 22% were present and by 2 years this fell to always less than 10%. The extent of movement was also difficult to judge. Individuals were found between 1 and 3 km from their original reach but the number of recaptures was small. Fish may have been caught by anglers, eaten by predators or moved long distances out of range of the follow-up surveys.

The relative contributions of recruitment and immigration are difficult to distinguish from simple marking experiments. However, it is clear that the marked 0+ populations in reaches of the Piddle were augmented quickly by unmarked fish. Unmarked fish formed between 10 and 60% of the catches even after a few months (**Figure 33b**). The variations depended to some extent upon reach and season though this could not be validated statistically (Summers *et al.*, 1997). Between summer and autumn immigrant fish were relatively abundant and these would not have originated from localised spawning, but were more likely highly mobile individuals from nearby reaches (Solomon & Templeton, 1976; Linnløken, 1998). Data for older fish show that there was about 50% emigration from the original reach after 6 months (**Figure 34a**). Also, immigration accounted for about 10-35% of the local population. After a year the percentages were 30-45% respectively from two experiments (**Figure 34b)**. There are no data to show what proportion originated from stocking in the reaches studied.

The evidence indicates that increases in population densities in the short to medium term in newly restored reaches are almost certainly a consequence of movement of fish from other nearby reaches. The effects on the donor reaches are unknown though the indications from the experiments are that the mobility of fish would obscure any population density changes. The effects of channel alterations on ultimate population size are unknown and untested.

### 8.4.5 The historical context

Solomon (1997) reviewed the fisheries of the middle and lower Wylye and summarised opinion from land and fishery owners and managers and factual data from fishery surveys. He also reviewed the various factors that may have been involved in any changes in the rivers and fisheries, mainly land-drainage, agricultural practices and increases in angling pressure. A major factor in alteration of fish habitat perceived by observers was the reduction of *Ranunculus* sp. However, comments that *Ranunculus* cutting had been reduced from 5 days to 2.5 hours, and that before 1990 weed cutting was a major task but since 1990 little weed was cut, are confusing. The implication that weed is a beneficial factor but must be cut does not equate with complaints that the lack of weed is deleterious to the fishery. The hydraulic effects of weed and the potential effects on siltation would indicate that increased weed cover could be detrimental to spawning and the survival of 0+ fish. Effects on predation of deeper water and weed cover have not been tested.

The stocking of many reaches of these rivers with salmonids negates to a great extent any comparisons with historical data, mainly because it is not clear what proportion of the fish are indigenous. Solomon (1997) concluded that most fish below 28cm in length were derived from natural recruitment. In other rivers, notably the Hampshire Avon, however, angling clubs may stock with 0+ fish in some reaches (Shaw *et al.*, *unpublished information*). Most of the fish caught on the Wylye were introduced stock fish.

Data from regular fish surveys on the Wylye since the 1970s show that there have been considerable fluctuations in the densities of salmonids (Solomon, 1997), both spatially and temporally. Population estimates from a single reach (Norton Bavant) showed numbers of 0+ and older fish varying from 48 in 1992 to 159 in 1997. 0+ fish catches varied from nil to 40. Spatially, variations in numbers of 0+ fish ranged from a mean from 0.75 to 5.4/100m reach in 1991 and from 1.51 to 6.3 /100m reach in 1996, with one particular section of the river showing consistently higher densities. For older fish, the respective numbers were 3.6 to 5.3 fish/100m reach in 1991 and 2.9 to 8.9 in 1996. Solomon (1997) concluded that between the two years there was an increase in fish in the upper reaches caused by higher spawning and a decrease in the lower reaches caused by poor spawning success and survival. Data at five-year intervals do not confirm a steady trend. The overall conclusion is that there is considerable evidence of fish redistribution into restored reaches but no evidence to support either enhancement or decline of total fish stocks.

### *8.5 Mammals*

Detailed surveys for otters (*Lutra lutra*) and water voles (*Arvicola terrestris*) have been conducted over the past 3-4 years and are continuing (Satinet, 1997 *et seq;* Satinet, 1998). It was concluded that otters may have returned to the River Wylye though some habitat improvement and provision of artificial holts could allow more individuals to be supported. A population size of 3-5 individuals was suggested for the Wylye and its tributaries and drains. There is no truly quantitative assessment of occurrence and abundance and no assessment of the effects of channel restoration work.

The detailed surveys of water voles have produced data that might be compared on a quantitative or semi-quantitative basis (Satinet 1997, *et seq*). The general conclusions from the many reports are that there are moderate to good populations on parts of the River Wylye but the Till holds mostly poor populations. The healthiest (sic) population was found in a recently restored reach of the Wylye where “narrowing with willow logs and back-filling created backwaters dominated by watercress and sedges” (Satinet, 1997). In the Middle Wylye, 50m reaches showed almost 100% occurrence of water-voles and populations were considered to be strong.

In the River Piddle, otters have been observed at seven sites (Dorset Wildlife Trust, pers. comm.) but the scarcity of records may be a result of variable sampling effort. Water voles are reportedly scarce along the Piddle with a “patchy distribution”. Most are found in the upper reaches or in the more urbanised reaches such as Puddletown. The Devil’s Brook shows three areas where they were recorded in 1996/7.

 

The main problem with the small mammal data is that no statistical analyses are available though the data are collected on a reasonably quantitative basis for water voles in the Wiltshire area. There are no analyses of effects of restoration though it may be possible to analyse the Wiltshire data with respect to restored and unrestored reaches. The collection and analysis of these valuable data should be re-designed to provide usable management information.

# 9 Factors affecting biological diversity

## *9.1 The physical habitat*

### 9.1.1 Comparisons between restored and unrestored reaches

Given that the restructuring techniques were aimed at providing variety of physical habitat and that the sampling sites were selected visually based on the differences in habitat, it was expected that there would be measurable differences on the reach scale between the restored and unrestored sampling reaches. The limitations to the amount of physical data collected and the non-random (stratified) measurements argue that any analysis be viewed as showing general rather than precise comparisons. A summary of physical data is given for each site in **Table 28** together with selected biological data.

Paired t-tests were carried out on the untransformed physical data for all sites irrespective of river (**Table 29**). Overall, restored reaches showed little significant change, except that maximum current velocities were significantly higher ($p = 0.03$) and the number of substrate types identified was lower ($p = 0.02$) than in the unrestored reaches. Neither canopy nor in-stream weed cover showed significant differences between reaches.

There were no separate physical measurements from marginal and midstream habitats. Current velocities in the marginal habitats were almost all undetectable. In midstream habitats velocities ranged from 0.1 to 0.95ms$^{-1}$. Without detailed measurements even for spatial comparisons, average velocities are relatively meaningless but as most of the restoration techniques included channel narrowing, gravel introduction or flow deflection, maximum velocities should have increased after restoration in most restored reaches. Indeed, comparisons of the data from all reaches showed that there was a significant difference in the average maximum velocities between restored and unrestored reaches. In the restored reaches, the average maximum was 0.52 (SD 0.18) ms$^{-1}$ and in the unrestored reaches 0.41 (SD.0.14) ms$^{-1}$ ($p=0.018$). However, at 7 of the 22 sites the maximum velocity recorded was either the same or lower at the restored as compared to the unrestored reach.

### 9.1.2 Comparisons between restructuring techniques.

Using simple estimates of change (% differences from the original value) it is clear that there is no pattern that can be associated with a particular method of channel modification (**Table 30**). For example, changes in maximum depth in the 50m excavated reaches varied from –59% to +79% and in the augmented reaches –24% to +94%. Similar ranges are shown in most of the variables listed. The largest increases in maximum current velocities occurred at three augmented sites and one excavated site all in the Avon streams. At Pinkney and Easton respectively banks of aggregate in the river resulted in small areas of riffle in otherwise highly ponded reaches of the river. At Kingsmead, the site showing the greatest difference in current maximum velocities, the channel was significantly narrowed by a large sarsen stone deflector. This created a small fast riffle over about 10m. The largest decrease in maximum velocity was at Wilton on the Wylye though the sampling reaches here were some distance apart. The largest positive change in substrate diversity (as H', D and J') was recorded at this site though the number of substrate types was lower in the restored than the unrestored reach.

### 9.1.3 Comparisons between rivers

Two-way analysis of variances on the untransformed dimensional data showed significant differences in physical characteristics between rivers though not between treatments in these rivers (**Table 31**). There was no interaction for most variables and the differences between rivers and treatments are not dependent. The Wylye sites were generally the widest and deepest. The Devils Brook was the narrowest (**Figure 35**). Maximum current velocities were higher in the Till than in other rivers and there was a significant difference between restored and unrestored reaches. There was also a significant interaction. Thus the differences in maximum current velocity between treatments and rivers were dependent upon each other (**Table 31**). The effect of the restoration on current velocity depended upon the river.

Substrate diversity was also significantly different between rivers, with the Devils Brook showing a significantly lower diversity than the other streams (**Figure 36**). The Avon sites showed a higher number of substrate categories and diversity but the differences were not significant. Restored reaches showed a lower number of categories but taking the differences between rivers into account the differences were not significant. Both canopy and percentage weed cover were significantly different between rivers, and weed cover was significantly different between treatments (**Table 31)**. Overall, instream weed cover was higher, and canopy cover lower in the restored reaches. Lowest percentage weed cover was in the Sherston and Malmesbury Avons.

There were more substrate types in the Avons than in the other two rivers but habitat diversity as expressed by diversity indices was not significantly different between either rivers or habitat types (**Table 31**). Overall, restored reaches showed no measurable morphological differences from unrestored reaches.

## *9.2 Physical habitat and biological diversity*

Biological diversity is generally dependent on habitat diversity (e.g. Magurran, 1988; Cowx & Welcomme, 1998, Maddock, 1999) provided that other factors are equal. In the Wessex rivers water quality was not a major factor in this survey, though in the Sherston Avon a pollution incident in 1998 could have been a residual influence on the invertebrate fauna. Indeed most diversity indices were lower in the Avons than in the Wylye or Piddle though not lower than in Devils Brook where water quality was high. Historically, diversity was similar, so the assumption is that the river had more or less recovered from the pollution by summer 2000.

There were no significant correlations between any of the physical variables shown in **Table 28** and the species-richness of aquatic plants. Neither was there any correlation between species-richness of bankside plants and tree-canopy. There was a non-significant negative correlation between the species-richness of aquatics and current velocity (CC= -0.25, p=0.092, n=48). For weed cover, particularly *Ranunculus,* there was a highly significant negative correlation with canopy category and no other correlation. Clearly, shade is the strongest single influence on the abundance of *Ranunculus* spp. However, the overall low incidence of *Ranunculus* at the Avon sites is not related to shade, though clearly shade influences the extent of cover as in the other rivers. There is evidence here that *Ranunculus* is more abundant in the restored reaches. The species-composition suggests that the Sherston and Malmesbury Avons are not natural *Ranunculus* habitats though the species-richness is similar to that of the Wylye system.

There is strong evidence that fencing significantly affects the species-richness of the riparian flora. This is evident mostly along the River Piddle and Devil's Brook where comparisons were most viable. The causes are the reduction in trampling by cattle, which reduces habitat variability, together with the increased growth of dense coarse grasses that overwhelm the smaller species. The effects of fencing are probably the most significant of all the restoration methods.

There is no significant correlation between physical habitat diversity and invertebrate diversity when both are measured by the Shannon-Wiener (H') and Evenness (J') indices (**Table 32**). However, there is a significant correlation between *Ranunculu*s (weed) cover and these indices, showing that the presence of high weed cover may enhance invertebrate diversity. Also there are significant correlations between the numbers of physical or structural features in the channel and the number of families and BMWP scores. This suggests that to retain diversity in the fauna, it is necessary retain a wide variety of substrates and features within any reach rather than install uniform habitats such as aggregate or gravel. However, the insertion of gravel substrates in a non-gravel reach will allow species new to that reach to colonise. An example is the gravel bed at Easton Grey on the Sherston Avon where stoneflies (Leuctridae) and freshwater limpets (Ancylidae) colonised the gravel bed but not the upstream, ponded, reach.

The factors leading to apparent increases in crayfish in restored reaches are not known and should be investigated for future schemes.

As far as fish are concerned, increased depth appears to be the major variable responsible for the influx of larger fish (Egglishaw & Shackley, 1982; Linnløkken, 1997; Langford & Hawkins, 1997; Langford, 2000). Cover is also an important factor (Heggenes, 1988; Cowx & Welcomme, 1998), but depth and cover are generally correlated in most rivers. Cover can be undercut banks, riparian vegetation, instream weed or debris of various descriptions but for cover to be effective, the depth must be adequate.

Increased depth is, in contrast, disadvantageous to smaller fish, particularly salmonids (Egglishaw & Shackley, 1982; Linnløkken,1997; Langford & Hawkins, 1997; Langford, 2000). The 0+ fish are typically less abundant in pools than riffles mainly because of predation; shallow waters are essential for the survival of these fish. There is a general paucity of shallow riffles inaccessible to larger fish in all the streams studied, though surveys did show increased numbers of 0+ salmonids in restored reaches. There is a general need to investigate the distribution and survival of the post-spawning phases of salmonids particularly in view of stocking rates and densities in many reaches.

The effectiveness of *Ranunculus* beds as structural features for fish is difficult to define. Clearly they provide cover for several species including bullheads, salmonids and others. They also provide cover for predators such as large chub, pike or large salmonids in the deeper waters, though the annual removal of the weeds will alter the effectiveness of the cover.

The effects of the insertion of gravel beds on the hydraulics in some reaches are unclear. For example, at Easton Grey and Pinkney on the Sherston Avon, the gravel banks traverse the river and act as "dams" at low flow periods. This has undoubtedly led to increased siltation upstream. At Easton Grey there was 27-45 cm. depth of mud/silt upstream of the gravel bed and about 5cm depth of riffle over the gravel. The effectiveness of the gravel beds as spawning and nursery habitats has not been measured and the gravel has to be cleaned of silt to allow fish to spawn (Giles & Summers, 1999). In other reaches the gravel beds have not caused the same impoundment effect. The critical factors are the distribution of the gravel and height of the gravel bank above the original bed. At low flows it is predicted that the introduced gravel beds would dry out completely.

The data for small mammals is inconclusive. The effects of restoration have not been measured though the data for water voles collected by Wiltshire Wildlife Trust (Satinet 1997 *et seq*) may be used to assess the differences along different reaches. Whilst the records of otters are encouraging there are no statistically valid data to assess whether restoration has affected the distribution and density of the species. Further scientific studies are needed to establish the effectiveness of the restoration work in relation to mammals in the three river systems.

## 10 Management implications

There are three major categories of river rehabilitation; restoration of water, recovery from pollution and restoration of physical structure. There is ample evidence for the biological effects of the first two but the biological effects of the last are equivocal. Large-scale physical rehabilitation such as restoration of flow or restoring connectivity with flood-plains and flood-plain waters has shown overall increases in the biological diversity of the fluvial system (Biggs, *pers. comm*). Effects of relatively small-scale physical restructuring of channels on biological diversity are unclear and in most cases the data do not show obvious patterns. This is the case with the restoration and restructuring of the Wessex channels. However, the success of the work needs to be judged on its targets before wider implications are assessed.

Many of the activities such as fencing, bank armouring and removal or trimming of riparian trees and weed control are related to ease of angling and optimising access for anglers. Fencing is also necessary for the safety of smaller animals on pasture land. Further, increasing bank height, dredging and channel straightening have in the past been regarded as necessary for land-drainage and flood-control. Clearly for practical and commercial purposes these are necessary activities and any effects on the flora and fauna must be considered in this context.

The management implications and possible strategies for each aspect of the flora and fauna and for associated activities are considered separately in this section.

## *10.1 Fish and Fisheries*

### 10.1.1 Fish density and production

There are clear indications that the re-profiling and deepening of channels, particularly in the Piddle catchment, resulted in increases in fish densities in the restored areas when compared with unrestored areas. However, the localised increases were almost certainly a result of immigration from other reaches of the river system. There would be a corresponding emigration of fish from donor reaches though there is no evidence of the distances over which such movements would occur. The mobility of the fish in general would also obscure effects of the migration on donor reaches. There is also evidence from mobility experiments that a good proportion of fish stocked into restored (or unrestored) reaches hold some affinity with the release point for 6-12 months.

There is no evidence from any similar rivers that channel restructuring has caused an increase in fish numbers or fish production. Indeed, the evidence from other studies is of similar migratory effects (e.g.Linnløkken 1997). Overall, historical evidence indicates that natural population fluctuations and artificial introductions probably outweigh any effects of restoration on this scale.

For rivers with intensive angling activities, such as the Wylye, the density and frequency of stocking negates any attempts to assess the natural capacity of the rivers and the natural population dynamics of the salmonids. It is also possible that the deepening of the rivers and increases in laminar flow caused by bank armouring increases depth and reduces the potential survival of smaller fish. Deeper water, slower flow and dense cover produced by dense *Ranunculus* beds may also enhance predation by providing cover for piscivorous fish.

The effects of installation and redistribution of gravel beds have not been quantified. Verbal reports indicate that the gravel beds in the Bristol Avon reaches and in the Wylye have been used by salmonids for spawning. There are no scientific data. No fish were observed on these beds during the invertebrate and plant surveys and there was no evidence of redds. However, as the surveys were in June and July the gravel could have been redistributed by scour or gravel cleaning. At Pinkney, there was evidence of sewage fungus on the gravel bed upstream of the bridge. Sewage fungus needs both organic material and riffle velocities for survival.

The management strategies for natural fish populations would be different from those pursued by the commercial angling (put-and take) strategies and these are discussed after the following section.

### 10.1.2 Fish diversity and conservation

Despite many partial studies and surveys of fish stocks and species over many years the viability and population dynamics of species in the larger chalk streams studied here seems poorly known. For example, there are few readily available published longer-term studies of the dynamics of the salmon population in the Piddle or Wylye and few studies of total fish mobility between reaches. The effects of stocking densities on the indigenous salmonids, if there are truly indigenous populations, have not been quantified. Quantitative data on the abundance and distribution of the non-salmonid species are scarce. Although it is known from both invertebrate and fish surveys that the BAP species such as bullhead and brook-lamprey are widespread in some streams, data on densities and habitat availability have not been quantified, except in isolated locations. The occurrence of salmon fry and parr is better known but data are not readily comparable from year to year and reach to reach. Angler catch-statistics have not been analysed for this work.

There are no quantitative data on the true composition of the fish community from any of the rivers that can be used as a guide for future conservation and diversity management. The management strategy for natural fish communities would be to return the channels as near as possible to their natural state, that is, braided, unimpounded, heavily shaded and with a wide variety of substrates. Also, artificial introductions would cease. Clearly this is not possible with current commercial priorities. However, where reaches are not fished commercially and necessary land drainage is not vital, consideration should be given to allowing banks to degrade and trees to grow unhindered. Recent research showing fish to use flooded fields and small ditches also suggests that access to the floodplain could be used to increase spawning and foraging space for non-salmonid fishes.

Where angling returns are a major commercial consideration, provision of easy access and fishing space plus the introduction of large numbers and high densities have implications for the indigenous fish and for the flora and fauna. These will have to over-ride conservation requirements in certain reaches until pressure for more natural fisheries causes changes in commercial strategies. There is no evidence that physical alteration of channels or marginal areas increases fish production overall though clearly there are localised benefits that may have repercussions in adjacent reaches. No quantitative data are available to show the overall benefits of restoration on the fish populations and there is a need to assess the effects of some restoration techniques that deepen channels on the survival of small salmonids and bullheads.

## *10.2 Conservation of plants and invertebrates*

### 10.2.1 Plant communities and *Ranunculus* spp.

The over-riding factor dictating the abundance of instream flora is the availability of light. No other factor exercises such influence, though some evidence suggests that a current velocity between 0.35 and 0.45$ms^{-1}$ is also optimal. The single most effective management for *Ranunculus* or other weed is therefore the control of riparian trees, their density and height. Clearly the reduction of light will depend on the width of the river in relation to the extent of the trees. The abundance of marginal vegetation will also depend on shade.

The species-richness of instream plants is not as dependent on shade. Where dappled light occurs, a variety of plants can grow and *Ranunculus* may be better controlled to allow floral diversity. There were clear differences in species composition and abundance of instream plants between the chalk and limestone based streams but the overall effect of shade was similar in both. The instream plant community of the Bristol Avon tributaries was not based on abundant *Ranunculus,* which may not be naturally endemic to this habitat.

Fencing or restriction of trampling by stock or by anglers (Chatters, 1996; Goulder, 2001) can lead to reductions of species-richness of riparian plants. Fencing along the Piddle has been particularly effective and it is clear that 100% fencing may lead to the loss of a few bankside species. It is difficult to specify the species at most risk, however, as the species composition of the flora differs with the reach. The increase in coarse grasses may be one cause of the reduction of some smaller species.

For conservation of riparian diversity, therefore, access to banks and river margins should be as free as possible within the limits of stock safety. This would have the effect of spreading trampling along the whole available riparian zone and not concentrating stock in smaller areas. All other factors considered, the removal of all fencing along all river banks would probably be the optimal strategy for plant diversity. During times of drought and low flows it may be necessary to provide some control of access but there is no evidence that short-term cropping of instream weed, particularly *Ranunculus,* has any effect on the longer-term dynamics. Indeed the heaviest cropping of *Ranunculus* is by fishery managers and this is generally believed to be beneficial to later growth.

One of the limitations to this study is that no comparable data were obtained during the droughts or before the restoration work began. Thus for the 2000 survey, flows were average or above and cattle access was less. It is thus difficult to make fully valued judgements on the efficacy of some management strategies.

The policy of encouraging possible *Ranunculus* growth in the limestone streams may be based on a wrong premise in that it is not naturally abundant in many reaches though small beds occur on introduced gravel beds. Consideration should be given to establishing the appropriate community for the streams. However, it is clear that there is some *Ranunculus* in the system and small patches were found growing on installed gravel banks and in faster flowing restored reaches.

The overall policies and strategies for management of instream vegetation are confusing to the objective observer and need some clear guidance backed by available quantitative data. The implementation of weed control could, perhaps, be much simplified by a more logical approach and better scientific data.

### *10.3 Macro-invertebrates*

The overall evidence shows that the diversity and species richness of macro-invertebrates has been little altered by the physical restructuring of the channels for fishery purposes. Marginal habitats, overhanging grasses, trailing vegetation, backwaters with mud and silt substrates are most important for groups such as beetles, dragonflies and some molluscs that may be of most interest to conservation organisations. These areas also provide cover for the larger fishes. Such marginal habitats can be influenced by restoration schemes, in that bank restructuring may cause short-term loss of the vegetation (Baattrup-Pedersen *et al*, 2000). These Wessex surveys suggest, however, that given time to equilibrate, re-colonisation is complete at least in unfenced reaches..

Midstream invertebrate communities seem little altered by restoration though the overall species accumulation curve shows that unrestored midstream habitats may show lower diversity. Unrestored reaches showed overall lower physical diversity. The increased taxon richness in restored reaches may be related to one or two sites where the restoration methods introduced different features such as a riffle into a ponded reach or a ponded habitat into a faster flowing reach. Most of the new species in particular habitats occurred in small numbers, often as single specimens and may not have been true residents of the reach.

One Red Data Book species was tentatively identified in these surveys. A small number of specimens of the rare pea-shell *Pisidium tennuiliatum* were reported from the River Wylye, but further specimens will be required to confirm the identification. BAP species such as the indigenous crayfish (*A. pallipes)* were given some special attention but not specialised sampling. No specimens of *Vertigo* spp.(whorl-snails) were recorded from the river or the marginal vegetation.

The crayfish populations were mainly found in the River Piddle between Southover and Throop. Most were found in restored reaches but there are no data to show the reasons for this. One specimen found in the Wylye was in the most degraded reach of any of the rivers surveyed, namely the unrestored reach at Wilton. (This has since been the subject of a restoration project).

No crayfish were found at the Sherston Avon sites, despite introductions over the past few years and the recording of specimens by others in nearby reaches. The reason was most likely that some introduced populations did not survive and that where they did, their mobility was limited.

There were clear differences in the diversity and species composition of the macro-invertebrate faunas of the chalk and limestone based streams but no difference in the general pattern of effects of restoration. The overall species-richness and diversity were related to the variety of substrate types and to some extent on the presence of instream vegetation. Fencing was not apparently a direct factor though it clearly affects marginal substrates. The method of restoration was not significant overall.

The ideal conservation strategy for macro-invertebrate species-richness therefore would be to encourage substrate diversity by allowing natural bank degradation, development of backwaters, trampling of margins and extensive marginal and trailing vegetation. Moderate instream vegetation would add to the species-richness. This is similar to the ideal management strategy for fish species diversity but not for ideal fishery management, farm stock control, land-drainage and flood-control.

### *10.4 Mammals*

The data for small mammal populations is neither sufficiently scientific nor adequate to assess effects of river restoration schemes. The exception may be the extensive studies of water vole distribution and the abundance of signs along the Wylye. This work has great potential for further analysis that was not possible for this report. The indications are that otters and water voles are present along reaches of the chalk streams with the latter being abundant along the Wylye. The data gathering here demands more scientific rigour and analysis. More knowledge of the quantitative relationship between the species and the river resources is necessary to plan for future introductions or immigrations.

# 11 Alternative management strategies

## *11.1 The problem*

The major problem with chalk-stream ecosystems is the poor knowledge of their original state and little agreement about targets for the future. The main question is *"Can we continue to use chalk streams for all their commercial purposes and retain high biological diversity?"* The answer is probably "yes". Indeed for maximum diversity some degree of continuous disturbance by human activity may be necessary.

The more difficult question is perhaps *" What should we be aiming for and how do we assess conservation value and balance it with commercial necessity ?"* This is not an original question but there may be methods by which objective assessments can be made for the future.

Chalk streams are essentially artificial systems and have been so for many centuries and yet there is a high species richness of plants, invertebrates and fish and this continues despite the commercial and regulatory uses. Diversity is generally regarded as a function of moderate disturbance in habitats. Thus it may be that the levels of disturbance from their primordial state have allowed the levels of diversity seen today, and the original streams actually had a lower diversity.

The representation of "diversity" is complex. Conservation bodies generally call "species-richness" diversity and this view is probably shared by all regulatory organisations. Thus "the more species present the better the environment". However, "naturalness" may be a better conservation objective and this may not be related to the highest diversity. In fact, completely undisturbed habitats may contain climax communities with a relatively low diversity. Examples are some New Forest streams and high mountain streams that have small numbers of species. Chemistry may also limit diversity, for example natural acidity limits stream faunas at high altitudes. Whatever the habitat, the number of species it will contain will be limited to a set maximum determined by various physical, chemical and biological factors.

The scale on which to assess diversity also needs defining and this is the reason why differing scales are considered in this report. Comparing restored and unrestored reaches does not give a complete representation. The more realistic comparison is from the summation of at least two reaches or from a total summation of all the samples from each river and all rivers. Even so, total species richness is related to the number of samples taken. Thus the asymptotic value of an accumulation curve plus a projected ultimate species number may be the targets for any habitat. The use of indices to a maximum value may also be a useful target. For example the BMWP score, which is based partly upon numbers of taxa and their "quality" value, may be used to set "diversity" targets and the EQI indices used to assess the extent to which they are met. To this end the relationship between species-richness, diversity and BMWP must be clarified for these streams.

The other criterion for assessing diversity is the rank-log abundance curve. Most communities fit one of the established models. For example, the invertebrate communities of the chalk streams fit a “truncated-log-normal” model where there are a few abundant species, a larger number of moderately abundant species and a small number of scarce species. The Bristol Avon streams do not fit any standard model and may represent highly disturbed communities that have not yet recovered their equilibrium state. Such a model may therefore be the criterion on which the diversity of stream faunas is judged. As long as the sampled community fits the model, the species composition may be immaterial. The problem here is that value weightings are given to species based on a criterion such as rarity and the presence of such species biases the criteria.

Species-composition is, therefore, an important criterion in the present system. Thus the presence of one specimen of a valued species can overbalance the value of the habitat. The application of such criteria to streams may be unwise and impractical. For example, stream faunas typically comprise a suite of abundant species characteristic of the habitat. The less abundant species, particularly those with one or two specimens may be rare in the particular reach because they are transient or accidental occurrences. These are thus a product of the particular time of sampling and their typical habitat may be upstream of the reach or in a side stream, pond or wetland habitat from which they have been displaced. Small numbers of specimens do not therefore imply rarity *per se* but only rarity in that habitat. The habitat may therefore become protected from alteration by default. Any habitat where a rare species is found in small numbers therefore should be thoroughly investigated over a reasonable time period before scheduling.

The status of many “rare” and RDB species in any case requires revision. It is likely that many are not in fact rare but are in other habitats that have not been investigated and only appear as transients or accidentals in regularly sampled habitats.

For the future overall aquatic diversity in any river reach might be better assessed by the total species-richness of the whole aquatic and wetland system, river, flood-plain pools, water-meadow carriers, drains, ditches and temporarily flooded areas but to date this has not been achieved for the streams studied.

### *11.2 Management targets and strategies*

At the time the restoration work was carried out there was clearly some considerable concern about the loss of habitat and biological diversity. It is thus unfair to make value judgements on any of the projects or the overall strategy with hindsight. This work and other data should be used to assist in planning the future of the stream systems whatever their uses.

It could be argued that the optimal strategy for the management the streams to suit all uses and purposes is that which operates at present. Consultation, co-operation and compromise probably produce a system that meets the requirements of all concerned groups through piecemeal projects in the stream system. However, much of the management is based on experience and intuition with limited quantitative scientific and survey data. Thus, situations arrive such as that with fencing reducing plant species-richness. This, of course, may be reversed by opening up fenced banks, but there may be opposition from the vested interests, which may have been forestalled by prior studies.

The potential difficulties of assessing the true effects of the restoration on fish were partly addressed but the difficulties were not clearly stated in reporting documents. Mobility experiments in fact partly accentuated the fact that fish movements may account for increases in densities and the potential losses from other reaches were not quantified. In fact, there are few authoritative studies of the effects of restoration schemes on fish populations and most show re-distribution of present stocks as the main feature.

The *Ranunculus* management strategy is confusing and clearly requires simplification and clarification. This survey and a recent review may help formulate a clear policy based on applicable scientific data. The relationship of *Ranunculus* to the fishery needs clarification before targets can be truly set.

The macro-invertebrate communities are probably the least affected by any of the restoration projects and probably least affected on the river scale by any of the activities for which the river is used. Crayfish, as a special case, may have always had a naturally limited distribution which historical research may clarify.

There are clearly two alternative holistic strategies for the streams, one based purely on conservation, the other on mixed uses. These can be simply defined as "hands-off" and "piecemeal" management. The former is impractical and the latter is probably the present strategy, more pragmatic and consultative. The ultimate strategy also depends on whether the criterion for conservation management is "diversity" or "naturalness" as they may not be compatible.

Management for "diversity" is probably best based on the present system whereby reaches are specified for different purposes and uses and managed differently. Indeed the continuous disturbance by human activity may be a necessary process to maintain diversity. The weak point in management is that objective holistic targets are difficult to set and are not monitored as a rule. Simple targets for species richness could be based on the available data and simple surveys prior to physical alteration. For example a BMWP target of 200 with an ASPT of 6 could be a set target for invertebrate communities in any reach of the Wylye. Combined with a species (taxon)-richness target of 30 and the possible presence of any BAP species this would give a workable model. The incorporation of a target LIFE score and Community Conservation Index (Extence and Chadd, *pers. comm*) would enhance the targets. For instream plant cover and species-richness similar models could easily be applied. Different targets could be set for different streams even based on the type of data used here. For fish, surveys of different reaches could provide both diversity and community models and target species, which could act as standards for different reaches. The basic structure of the model could also be set from a standard rank-abundance model.

Management for naturalness, in designated reaches, would involve no physical management practices apart from the removal of all bank protection and armouring. Trees should be allowed to re-grow as tall as is natural and sediments should remain undisturbed. Target habitats could be based partly on archaeological evidence, possibly paleo-ecology using cores from the floodplain, and partly on data from habitats that are already semi-natural such as reaches of the Piddle with little *Ranunculus* and high shade density. BMWP scores, other indices and target species would be set as for other reaches. **Table 33** shows a suggested model for the "Conservation Standard Index" for a hypothetical reach.

The composition of the habitat necessary to reach the targets would be based on regression models or correlation matrices of physical and biological data already available plus reviews and possible surveys of a small range of habitats. It is clearly necessary for a holistic standard to be derived, though it is too late for many of the reaches that have been restored without prior investigation.

# 12 Conclusion

Following the droughts of the early 1990s, heavy grazing and low flows caused reported losses of fish habitat in many streams and rivers in the Wessex region. A programme of restoration of river channels was recommended by consultants, commissioned by the Environment Agency, funded by Wessex Water and carried out in three rivers, under the direction of the Game Conservancy Trust and Nick Giles Associates. The aim was to restore habitats and cover for several species of fish, improve fishing and provide spawning areas mainly for salmonids. Techniques used included fencing, bed re-profiling, gravel bed installation, river narrowing, flow diversion and bank staging. The projects began in 1995 in the River Piddle catchment, the Wylye catchment and in reaches of the Bristol Avon. Follow-up surveys assessed the success of the restoration work on fish and crayfish.

In the summer of 2000, Wessex Water commissioned a series of surveys to assess the effects of the fishery restoration on the diversity of the invertebrate faunas and the vegetation of the rivers and margins. The surveys were carried out for Wessex Water by Pisces Conservation Ltd, with advice from Nick Giles Associates. Data supplied by the Environment Agency, the Dorset and Wiltshire Wildlife Trusts and English Nature were analysed and reviewed and fish catch data supplied to Wessex Water were also reviewed. The main conclusions were as follows:-

## *12.1 Invertebrates:-*

- Over 175 species/taxa of invertebrates and 150 species of aquatic and terrestrial plants were recorded in the surveys
- The Bristol Avon sites were different from the Piddle and Wylye sites in both diversity and composition of the flora and fauna
- Marginal samples showed a higher species richness than samples from midstream habitats
- The significant differences in diversity and species composition between rivers did not influence the overall pattern of effects of restoration
- There were no significant adverse effects of the fish habitat restoration on the overall diversity and taxon-richness of invertebrates in either river
- Effects at individual sites varied from small decreases in diversity to large increases in diversity between unrestored and restored reaches and there was no consistent pattern

- Species accumulation curves for the whole dataset for all three rivers indicated up to a total of 8 species of invertebrates more in the restored reaches than in the unrestored reaches but the effect was mainly a result of data from one or two sites
- Separate species accumulation curves for marginal and midstream faunas showed that the lowest number of species/taxa occurred in the unrestored midstream samples.
- Tests of the two main categories of restoration methodology showed no significant differences in effects on the invertebrate fauna
- The largest differences between restored and unrestored reaches were where the changes in channel morphology were most obvious, for example at one site (Kingsmead) in the Malmesbury Avon where a shallow riffle had been created within a slower reach
- The main factors determining invertebrate diversity were the number of substrate types and physical features in the reach and the abundance of instream vegetation.
- A small number of specimens tentatively identified as the rare pea-shell species *Pisidium tennuiliatum* were found in the Wylye though the species awaits confirmation of its identification.
-

### *12.2 Vegetation:-*

- There were marked differences in the species richness of plants between the rivers with the Bristol Avon reaches showing the highest numbers of species
- There were no significant changes in the species diversity of the instream vegetation caused by restoration
- Abundance of *Ranunculus* was not significantly different in restored and unrestored reaches though the flows were better than during drought periods and no data exist from that time
- The main influence on the abundance of instream vegetation was shade from riparian trees
- There were significant declines in the number of bankside plant species present in restored reaches, mainly along the Piddle and its tributary the Devils Brook. Effects in the other rivers were not significant.
- The major factor appeared to be reduced disturbance from grazing and trampling by stock caused by fencing off river banks.
- The loss of diversity was probably a result of strong growth of tall, vigorous grass species and the loss of the habitat mosaic caused by stock
- A moderate amount of trampling by cattle or anglers, or grazing by stock would seem to benefit floral diversity
- No single species was consistently excluded by fencing

### *12.3 Fish:-*

- Data supplied showed that there were significant increases in salmonid and other fish densities in restored reaches though numbers of replicate samples were generally low

- Marking experiments and other published data indicate strongly that any increases in density were caused by immigration into restored reaches by fish already in the system
- Marking experiments also showed that 10-30% of introduced fish stayed in their place of introduction for up to 1 year.
- There are no data from which to assess effects of fish mobility from donor reaches into newly restored reaches
- Bullheads were common and abundant in the Wylye and Piddle systems though less so in the Bristol Avon reaches.
- Brook lampreys were recorded in small numbers from the Piddle and Wylye though they are known to be abundant in some reaches
- There are few quantitative data on the diversity and structure of fish communities of the streams on which to base conservation management
- In some reaches stocking and angling obscure the natural population sizes of salmonids and the potential natural composition of the fish community
- The total ecology and composition requires reviewing and further investigation for proper fishery and conservation management.

### *12.4 Crayfish:-*

- Data so far indicate that river restoration along the Piddle may have advantages for natural crayfish populations but no specimens were found in the Sherston Avon despite recent re-introductions.
- The reasons may be the limited mobility of the species and the relative positions of sampling and introduction points.

### *12.5 Mammals:-*

- Data supplied indicate that otters are present in some reaches but the data are not quantifiable and not readily comparable
- Excellent records show an abundance of water voles along the Wylye but there are no comparisons of restored and unrestored reaches

### *12.6 Management:-*

- Management implications of the invertebrate and plant surveys suggest that present piecemeal management of reaches based on a strategy for the whole river may be most suitable for the rivers with their present uses and demand pressures
- Maintenance of high species “diversity” may in fact depend on the presence of continuing disturbances such as cattle trampling, gravel cleaning, tree-removal or pollarding and channel alteration.
- In contrast if “naturalness” rather than “diversity” becomes the criterion, management techniques would need to change to a more “hands-off” strategy.
- The put and take nature of the fisheries in some reaches obscures the natural fish community structure but is necessary for commercial purposes.
- The literature suggests that deeper water such as produced by some restoration methods, favours larger fish to the detriment of smaller fish.

The effects are not clear in these rivers and should be clarified for population management.
- A “Conservation Status Index” is suggested for the objective holistic assessment of reaches and future management, based on more consistent measurements and comparable scientific data.

### *12.7 Recommendations*
It is clear that despite the research and concentration of effort on the lowland streams in the region over the years there are many areas in which scientific knowledge is lacking, particularly with regard to effects of management of fisheries, uses of the streams and their ecological history. The following include some of the more obvious areas and the list is by no means complete. It is suggested that consideration should be given to the following:-

- Quantification of the true distribution of stocked fish and the catch/stock budgets in relation to “natural” populations
- Quantification of the population structure of the fish communities in stocked and unstocked streams including Annex II species
- Assessment of the success of spawning and survival of salmonids in restored and unrestored reaches
- Quantification of the crayfish populations in restored and unrestored reaches and identification of the main beneficial factors
- Quantification of effects of *Ranunculus* abundance on predatory species and predation on small salmonids
- Quantification of effects of deepening and channelising reaches on distribution, abundance and survival of small salmonids
- Distribution and abundance of lampreys and bullheads in relation to restoration techniques and substrate diversity
- Quantification of effects of *Ranunculus* and other weed species on invertebrate diversity
- Quantification of abundance of small mammals in relation to restoration and physical features of rivers.
- Quantification of the true bio-diversity of the river and its floodplain waters, including pools, cut-offs and water-meadow channels and feeders for future conservation management. This may be more important than the diversity of the river channel alone.
- Development of more objective and quantitative methods for assessing conservation value of rivers and associated waters for which the CSI is proposed as a starting point.

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## Table 1. Sampling site locations, restoration status and treatment data for reaches of Wessex streams surveyed in 2000

| RIVER | SITE | OS REFERENCE | MAP NUMBER | SITE CODE | Date sampled | Restoration Status | Fencing | Grazing Status | TREATMENT | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Bed changes | Bank treatment | Gravel intro. | Flow deflection |
| **Devils Brook** | **Athelhampton** | SY775954 | **I** | **DAU** | 28.6.2000 | Unrestored | Unfenced | 4 | | | | |
| | ***(Bardolf Manor)*** | | | **DAR** | 28.6.2000 | Restored | Fenced | 0 | **X** | **X** | | **X** |
| | | | | **DAU** | 28.6.2000 | Unrestored | Unfenced | 4 | | | | |
| | | | | **DAR** | 28.6.2000 | Restored | Fenced | 0 | **X** | **X** | | **X** |
| | | SY775953 | **IA** | ***DAaU*** | 21.7.2000 | Unrestored | Unfenced | 4 | | | | |
| | | | | ***DAaR*** | 21.7.2000 | Restored | Fenced | 0 | **X** | **X** | | **X** |
| | | | | ***DAaU*** | 21.7.2000 | Unrestored | Unfenced | 4 | | | | |
| | | | | ***DAaR*** | 21.7.2000 | Restored | Fenced | 0 | **X** | **X** | | **X** |
| **River Piddle** | **Burleston** | SY778942 | **II** | **PBU** | 28.6.2000 | Unrestored | Partly | 1 | | | | |
| | | | | **PBR** | 28.6.2000 | Restored | Fenced | 0 | **X** | **X** | | **X** |
| | **Park Farm** | SY780939 | **III** | **PPU** | 28.6.2000 | Unrestored | Partly | 3 | | | | |
| | | | | **PPR** | 28.6.2000 | Restored | Fenced | 0 | **X** | **X** | | **X** |
| | **Southover** | SY794942 | **IV** | **PSU** | 30.6.2000 | Unrestored | Partly | 1 | | | | |
| | | | | **PSR** | 30.6.2000 | Restored | Fenced | 0 | **X** | **X** | | **X** |
| | **Briantspuddle** | SY815935 | **V** | **PNU** | 28.6.2000 | Unrestored | Fenced | 0 | | | | |
| | | | | **PNR** | 28.6.2000 | Restored | Partly | 1 | **X** | **X** | | **X** |
| | **Throop** | SY829934 | **VI** | **PTU** | 30.6.2000 | Unrestored | Fenced | 0 | | | | |
| | | | | **PTR** | 30.6.2000 | Restored | Fenced | 0 | **X** | | | **X** |
| **River Wylye** | **Knook** | ST935423 | **VII** | **WKU** | 11.7.2000 | Unestored | Partly | 0 | | | | |
| | | | | **WKR** | 11.7.2000 | Restored | Partly | 1 | **X** | | **X** | **X** |
| | **Stockton** | ST980388 | **VIII** | **WSU** | 11.7.2000 | Unrestored | Partly | 1 | | | | |
| | | | | **WSR** | 11.7.2000 | Restored | Partly | 1 | **X** | **X** | | **X** |
| | **Yarnbury Court** | SUO12387 | **IX** | **WYU** | 12.7.2000 | Unrestored | Partly | 0 | | | | |
| | | | | **WYR** | 12.7.2000 | Restored | Partly | 0 | **X** | **X** | **X** | |
| **River Till** | **Uffington House** | SU073384 | **XI** | **TUU** | 12.7.2000 | Unrestored | Partly | 0 | | | | |
| | | | | **TUR** | 12.7.2000 | Restored | Fenced | 0 | **X** | **X** | | **X** |
| | **Stapleford** | SU080376 | **X** | **TSU** | 12.7.2000 | Unrestored | Fenced | 0 | | | | |
| | | | | **TSR** | 12.7.2000 | Restored | Fenced | 0 | **X** | **X** | **X** | **X** |
| **River Wylye** | **Langford Fisheries** | SU043371 | **XII** | **WLU** | 20.7.2000 | Unrestored | Partly | 0 | | | | |
| | | | | **WLR** | 20.7.2000 | Restored | Partly | 0 | **X** | | **X** | **X** |
| | **Hanging Langford** | SUO37375 | **XIII** | **WAU** | 20.7.2000 | Unrestored | Partly | 0 | | | | |
| | | SU012387 | | **WAR** | 20.7.2000 | Restored | Fenced | 0 | **X** | **X** | | **X** |
| | **Little Wishford** | SU068863 | **XIV** | **WGU** | 20.7.2000 | Unrestored | Partly | 2 | | | | |
| | | | | **WGR** | 20.7.2000 | Restored | Unfenced | 0 | **X** | **X** | | **X** |
| | **Wilton** | SU099315 | **XV** | **WWU** | 20.7.2000 | Unrestored | Unfenced | 0 | | | | |
| | | SU084323 | | **WWR** | 20.7.2000 | Restored | Fenced | 0 | **X** | **X** | | **X** |
| **Sherston Avon** | **Pinkney Bridge** | ST867868 | **XVI** | **SPU** | 13.7.2000 | Unrestored | Unfenced | 0 | | | | |
| | | | | **SPR** | 13.7.2000 | Unrestored | Unfenced | 0 | | | **X** | |
| | **Easton Grey** | ST885870 | **XVII** | **SEU** | 14.7.2000 | Unrestored | Partly | 1 | | | | |
| | | ST882869 | | **SER** | 14.7.2000 | Restored | Fenced | 0 | | | **X** | **X** |
| | **Cowage Farm** | ST906862 | **XVIII** | **SCU** | 13.7.2000 | Unrestored | Partly | 3 | | | | |
| | | | | **SCR** | 13.7.2000 | Restored | Partly | 1 | | | **X** | |
| | **Hyams Farm** | ST804870 | **XIX** | **SHU** | 13.7.2000 | Unrestored | Partly | 2 | | | | |
| | | | | **SHR** | 13.7.2000 | Restored | Partly | 1 | | | **X** | |
| **Malmesbury Avon** | **Kingsmead** | ST959843 | **XX** | **MKU** | 14.7.2000 | Unrestored | Partly | 0 | | | | |
| | | | | **MKR** | 14.7.2000 | Restored | Partly | 0 | **X** | | | **X** |
| | **Great Somerford** | ST968833 | **XXI** | **MGU** | 13.7.2000 | Unrestored | Unfenced | 1 | | | | |
| | | | | **MGR** | 13.7.2000 | Restored | Unfenced | 1 | **X** | | | **X** |

**Table 2. Categories of restoration techniques used in three Wessex rivers.**

| CATEGORY | DESCRIPTION | PROCEDURES |
|---|---|---|
| **Type A** | **Substrate redistribution** | |
| | Active | Excavation, bed profiling, |
| | Passive | Weirs, flow-deflectors, narrowing |
| **Type B** | **Substrate augmentation** | |
| | Active | Gravel introduction |
| **Type C** | **Bank and marginal** | |
| | Active | Staging, levelling, re-seeding, coppicing pollarding |
| | Passive | Fencing |

**Table 3. Definitions of habitat and sampling terms used in the text**

***Definitions of spatial scales*** **:-**

- *mesohabitat*, (Armitage & Pardo, 1995) defined as an area of gravel, weed bed, leaf or silt deposits that can be readily identified from visual observation
- *reach* (see Maddock, 1999), a length of river channel defined for specific reasons,
- *river*, the whole length of the channel from source to confluence with the sea or a larger watercourse.

***Definitions of sampling units*****:-**

- *Site*, the length of river containing the sampled reaches, restored and unrestored.
- *Sampling reach*, the 50m length of river (restored or unrestored) over which each sample of invertebrates was taken and each set of plant observations was made.
- *Sample*, each individual collection of invertebrates from the margin and midstream habitats of each sampling reach.
- *Midstream sample*, the sample from the 50m length of restored or unrestored channel habitat sampled for invertebrates and plants, usually reaching from about 0.5m away from the right bank to 0.5m away from the left bank and not including any trailing or marginal vegetation.
- *Marginal sample*, the sample from the 50m length of restored or unrestored channel habitat sampled for invertebrates and plants. Typically this extended from the wetted marginal substrates to about 0.5m from each bank and included marginal vegetation.
- *Combined sample*, the results of the midstream and marginal samples pooled for each reach.

### Table 4. Criteria on which sampling reaches were selected

| |
|---|
| ***Restored reaches:-*** |
| • *Physical discontinuities clearly observable in the stream and flow caused by the* |
| • *Presence of installed obstructions, flow deflectors, logs, boulders, gravel banks* |
| • *Obvious evidence of or information on, channel deepening or narrowing, armoured banks* |
| • *Fencing, bank staging, coppicing, tree clearance or pollarding* |
| ***Unrestored reaches**:-* |
| • *Physical uniformity and absence of artificial installations as far as possible.* |
| • *No fencing or evidence of unrestricted cattle access (rare)* |
| • *Presence of dense riparian woodland or tree canopy* |
| • *Bank erosion* |
| • *Obvious ponding, over deepening, evidence of dredging and heavily engineered banks* |

### Table 5. Physical variables and substrate categories used for physical characterisation of sampling reaches in Wessex streams

| Symbol | PHYSICAL VARIABLES | Descriptions /comments |
|---|---|---|
| | **Width (m)** | Water width, 3-5 transects |
| | **Depth (cm)** | Water surface to substrate surface. 5-7 transects, 50cm intervals |
| | **Current velocity ($ms^{-1}$)** | 5-10 measurements at 60%depth (non-random) |
| | **SUBSTRATA** | |
| **G** | **Gravel** | Approximately 5-40mm diameter |
| **D** | **Sand** | 0.05-3mm particles |
| **M** | **Silt/mud** | 0.004-0.6 mm particles |
| **Y** | **Clay** | Solid clay with plasticene consistency |
| **S** | **Submerged wood** | Logs/branches over 5cm diameter |
| **R** | **Roots** | Tree roots submerged in water |
| **T** | **Twigs** | Twigs banks, deposits |
| **U** | **Undercut banks** | Undercuts up to 50cm above water surface |
| **A** | **Artificial banks/substrates** | Bank protection, culverts, |
| **W** | **Instream weed** | Weed beds in the channel, free of margins |
| **V** | **Marginal vegetation** | Contiguous with margins |
| **O** | **Overhanging vegetation** | Weeds, grasses, brambles etc trailing in water |
| **N** | **Large stones/boulders** | Mostly sarsen stones, current deflectors |
| **F** | **Fine gravel, coarse sand** | Mostly under weed beds |

**Table 6. Brief descriptions of indices used to describe invertebrate diversity**
(see Magurran, 1988; Southwood & Henderson, 2000)

| ***Diversity Index*** | **Comments** |
|---|---|
| ***Shannon-Wiener (H')*** | An index based on both the number of taxa in a sample and the proportional abundance of each taxon. It indicates diversity as a function of both taxon-richness and relative abundance. It usually falls between 1.5 and 3.5 for good quality samples. It rarely exceeds 4.5. |
| ***Equitability (J')*** | An evenness index, showing whether the sample is heavily biased by one or more taxa. Used with H' it can indicate whether the index value is a result of the number of taxa present or a result of uneven abundance. |
| ***Simpson's D*** | An index based on the probability that a second individual from a sample should be of the same species as the first. It sometimes gives a clearer picture of diversity than other indices. |
| ***Taxon (species) richness*** | The number of taxa (families/species) in a sample. Here the number of BMWP "families" and the number of identified taxa are shown. |
| ***BMWP Score*** | An index derived from weighted scores for each specified taxon identified. The weighted score depends on the estimated tolerance of the taxon to disturbance e.g. pollution. Used for comparisons with EA data |
| ***ASPT Score*** | An index derived by dividing the BMWP score by the number of taxa. It is basically a measure of water quality. Used for comparisons with EA data. |

**Table 7. Presence-absence matrix for aquatic and emergent species at sites along the Devil's Brook and River Piddle. June/July 2000**

| | - | Devils Brook (Athel) | | Devils Brook (Athel) | | Burleston | | Park Farm | | Southover | | Briantspuddle | | Throop | | Total Occurrences | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species Name** | **Code** | **Unres.** | **Res** | **Unres.** | **Res** | **Unres.** | **Res** | **Unres.** | **Res** | **Unres.** | **Res** | **Unres.** | **Res** | **Unres.** | **Res** | **No. of sites** | **Unres.** | **Res** |
| | | **DAU** | **DAR** | **DAaU** | **DAaR** | **PBU** | **PBR** | **PPU** | **PPR** | **PSU** | **PSR** | **PNU** | **PNR** | **PTU** | **PTR** | **Occurring** | | |
| Blue water-speedwell, *Veronica anagallis-aquatica* | VerAna | 1 | 1 | 1 | 1 | 1 | 1 | | | | | 1 | | | 1 | ***7*** | ***4*** | ***4*** |
| Branched Bur-reed, *Sparganium erectum* | SpaEre | | | | | | | | | | | | | | 1 | ***1*** | ***0*** | ***1*** |
| Brooklime, *Veronica beccabunga* | VerBec | 1 | 1 | 1 | 1 | | 1 | | | | | | | | | ***4*** | ***2*** | ***3*** |
| Common Duckweed, *Lemna minor* | LemMin | | | 1 | 1 | | 1 | | | 1 | 1 | | 1 | | 1 | ***7*** | ***2*** | ***5*** |
| Common water crowfoot *Ranunculus spp.* | Ran.spp | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | ***13*** | ***7*** | ***7*** |
| Fool's Water-cress, *Apium nodiflorum* | ApiNod | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | ***12*** | ***6*** | ***7*** |
| Hemlock Water-dropwort, *Oenanthe crocota* | OenCro | | | | | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | ***9*** | ***5*** | ***4*** |
| Water Figwort, *Scrophularia aquatica* | ScrAqu | 1 | | | | | 1 | | 1 | | | | | 1 | | ***3*** | ***2*** | ***2*** |
| Water forget-me-not, *Myosotis scorpioides* | MyoSco | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 | | ***10*** | ***6*** | ***5*** |
| Water mint, *Mentha aquatica* | MenAqu | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | ***12*** | ***6*** | ***7*** |
| Water starwort, *Callitriche* sp. | CalSp | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | ***5*** | ***3*** | ***3*** |
| Water-cress, *Rorippa nasturtium-aquaticum* | RorNas | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | | 1 | ***10*** | ***4*** | ***7*** |
| Yellow flag iris, *Iris pseudacorus* | IriPse | 1 | | | 1 | 1 | | | | | 1 | | | 1 | 1 | ***5*** | ***3*** | ***3*** |
| Float-grass, *Glyceria fluitans* | GlyFlu | 1 | | 1 | 1 | | 1 | | 1 | 1 | 1 | 1 | | | 1 | ***8*** | ***4*** | ***5*** |
| Reed-grass, *Phalaris arundinacea* | PhaAru | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | | 1 | | | | | ***7*** | ***3*** | ***5*** |
| Reed sweet-grass, *Glyceria maxima* | GlyMax | | | | | | 1 | | | 1 | 1 | | | 1 | 1 | ***5*** | ***2*** | ***3*** |
| Common Spike-Rush, *Eleocharis palustris* | ElePal | | | 1 | | | | | | | | | | | | ***1*** | ***1*** | ***0*** |
| Greater Pond Sedge, *Carex riparia* | CarRip | | | | 1 | | | | | | | 1 | 1 | 1 | 1 | ***5*** | ***2*** | ***3*** |
| Moss, *Fontinalis antipyretica* | FonAnt | | | | | | | | | | | | | | 1 | ***1*** | ***0*** | ***1*** |
| **Number of species** | | **12** | **9** | **12** | **13** | **10** | **13** | **5** | **9** | **9** | **11** | **6** | **7** | **8** | **13** | **20** | **18** | **19** |

## Table 8. Presence-absence matrix for bankside and terrestrial plants recorded from sites along the Devil's Brook and River Piddle. June/July 2000

| Species name | Code | Devils Brook (Athel) | | Devils Brook (Athel) | | Burleston | | Park Farm | | Southover | | Briantspuddle | | Throop | | Total Occurrences | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unres. DAU | Res DAR | Unres. DAaU | Res DAaR | Unres. PBU | Res PBR | Unres. PPU | Res PPR | Unres. PSU | Res PSR | Unres. PNU | Res PNR | Unres. PTU | Res PTR | No. of sites Occurring | Unres | Res |
| Alder, *Alnus glutinosa* | AlnGlu | | | | | | | | | | | | | 1 | | ***1*** | ***1*** | ***0*** |
| Almond Willow, *Salix triandra* | SalTri | | | | | | | | | | 1 | | | | | ***1*** | ***0*** | ***1*** |
| Ash, *Fraxinus excelsior* | FraExc | | | | | | | 1 | | 1 | | 1 | 1 | | | ***4*** | ***3*** | ***1*** |
| Bittersweet, *Solanum dulcamara* | SolDul | | 1 | 1 | 1 | | | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | ***10*** | ***5*** | ***5*** |
| Bramble, *Rubus fruticosus* agg. | RubFru | | | 1 | | | | 1 | | 1 | | 1 | | 1 | | ***5*** | ***5*** | ***0*** |
| Buckthorn, *Rhamnus catharticus* | RhaCat | | | | | | | | | | | 1 | | | | ***1*** | ***1*** | ***0*** |
| Cleavers, *Galium aparine* | GalApa | | 1 | | | | | | 1 | | | 1 | 1 | 1 | 1 | ***6*** | ***2*** | ***4*** |
| Comfrey, *Symphytum officinale* | SymOff | | | | | 1 | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | ***8*** | ***4*** | ***4*** |
| Common Chickweed, *Stellaria media* | SteMed | | | 1 | | | | | | | | | | | | ***1*** | ***1*** | ***0*** |
| Common Marsh Bedstraw, *Galium palustre* | GalPal | | | 1 | 1 | | | | | | | | | | | ***2*** | ***1*** | ***1*** |
| Common Mouse-ear, *Cerastium holosteoides* | CerHol | 1 | | 1 | | | | | | | | | | | | ***1*** | ***2*** | ***0*** |
| Common Ragwort, *Senecio jacobaea* | SenJac | | | 1 | | | | 1 | 1 | | | | | | | ***3*** | ***2*** | ***1*** |
| Common Valerian, *Valeriana officinalis* | ValOff | | | | | 1 | | | | | | | | | 1 | ***2*** | ***1*** | ***1*** |
| Creeping buttercup, *Ranunculus repens* | RanRep | | | | | 1 | 1 | 1 | 1 | | | | | | | ***4*** | ***2*** | ***2*** |
| Creeping Cinquefoil, *Potentilla reptans* | PotRep | | | | | | 1 | 1 | | | | | | | | ***2*** | ***1*** | ***1*** |
| Dock, *Rumex* sp. | RumSp | | | | | | | | | | | | | 1 | | ***1*** | ***1*** | ***0*** |
| Dog Rose, *Rosa canina* agg. | RosCan | | | | | | | 1 | | | | | 1 | | | ***2*** | ***1*** | ***1*** |
| Douglas Fir, *Pseudotsuga menziesii* | PseMen | | | | | | | | | | | 1 | | | | ***1*** | ***1*** | ***0*** |
| Fleabane, *Pulicaria dysenterica* | PulDys | 1 | | | | 1 | | 1 | | | | | | | | ***2*** | ***3*** | ***0*** |
| Goat Willow, *Salix caprea* | SalCap | | | | | 1 | | 1 | 1 | 1 | | | 1 | 1 | 1 | ***7*** | ***4*** | ***3*** |
| Great Willowherb, *Epilobium hirsutum* | EpiHir | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | ***8*** | ***4*** | ***4*** |
| Grey Willow, *Salix cinerea* ssp *atrocinerea* | SalCin | | | | 1 | | | | | | | | | | | ***1*** | ***0*** | ***1*** |
| Ground-elder, *Aegopodium podagraria* | AegPod | | | | | | | | | | | 1 | | | | ***1*** | ***1*** | ***0*** |
| Guelder-rose, *Viburnum opulus* | VibOpu | | | | | | | | | 1 | 1 | | | 1 | | ***3*** | ***2*** | ***1*** |
| Gypsywort, *Lycopus europaeus* | LycEur | | | | | | | | 1 | 1 | 1 | | | 1 | | ***4*** | ***2*** | ***2*** |
| Hawthorn, *Crataegus monogyna* | CraMon | | | 1 | | | | | | 1 | | | 1 | | | ***3*** | ***2*** | ***1*** |
| Hazel, *Corylus avellana* | CorAve | | | | | | | 1 | | | | | | | | ***1*** | ***1*** | ***0*** |
| Hedge Bindweed, *Calystegia sepium* | CalSep | | | | | 1 | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | ***8*** | ***4*** | ***4*** |
| Hedge Woundwort, *Stachys sylvatica* | StaSyl | | | | | | | | 1 | | | | | | | ***1*** | ***0*** | ***1*** |
| Hemp Agrimony, *Eupatorium cannabinum* | EupCan | | | | | 1 | | 1 | | | | 1 | | 1 | 1 | ***5*** | ***4*** | ***1*** |
| Herb Robert, *Geranium robertianum* | GerRob | | | | | | | | | | | 1 | | 1 | | ***2*** | ***2*** | ***0*** |
| Hoary Plantain, *Plantago media* | PlaMed | | | 1 | | | | | | | | | | | | ***1*** | ***1*** | ***0*** |
| Hogweed, *Heracleum spondylium* | HerSpo | | | | | | | | | | | 1 | 1 | | | ***2*** | ***1*** | ***1*** |
| Hop, *Humulus lupulus* | HumLup | | | | | | | | | | | 1 | | 1 | | ***2*** | ***2*** | ***0*** |
| Ivy, *Hedera helix* | HedHel | | | | | | | 1 | | 1 | | 1 | 1 | 1 | 1 | ***6*** | ***4*** | ***2*** |
| *Lonicera nitida* | LonNit | | | | | | | | | | | 1 | | | | ***1*** | ***1*** | ***0*** |
| Marsh Dock, *Rumex palustris* | RumPal | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | | | 1 | 1 | ***9*** | ***5*** | ***5*** |
| Marsh Ragwort, *Senecio aquaticus* | SenAqu | 1 | | | | | | 1 | | | | | | | | ***1*** | ***2*** | ***0*** |

## Table 8. Continued

| Species name | Code | Devils Brook (Athel) | | Devils Brook (Athel) | | Burleston | | Park Farm | | Southover | | Briantspuddle | | Throop | | Total Occurrences | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unres. DAU | Res DAR | Unres. DAaU | Res DAaR | Unres. PBU | Res PBR | Unres. PPU | Res PPR | Unres. PSU | Res PSR | Unres. PNU | Res PNR | Unres. PTU | Res PTR | No. of sites Occurring | Unres | Res |
| Marsh Thistle, *Cirsium palustre* | CirPal | | | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 | | | ***8*** | ***3*** | ***5*** |
| Marsh Woundwort, *Stachys palustris* | StaPal | | | | | | | | | 1 | | | | | 1 | ***2*** | ***1*** | ***1*** |
| Meadowsweet, *Filipendula ulmaria* | FilUlm | 1 | | | | | 1 | | 1 | | | | 1 | 1 | | ***4*** | ***2*** | ***3*** |
| Nettle, *Urtica dioica* | UrtDio | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | ***11*** | ***6*** | ***6*** |
| Oak, *Quercus robur* | QueRob | | | | | | | | | | | | 1 | 1 | | ***2*** | ***1*** | ***1*** |
| Osier, *Salix viminalis* | SalVim | | | | | | | 1 | | | | | | | | ***1*** | ***1*** | ***0*** |
| Pale Persicaria, *Polygonum lapathifolium* | PolLap | | | | | 1 | | | | | | | | | 1 | ***2*** | ***1*** | ***1*** |
| Poplar, *Populus* sp. | PopSp | | | | | | | 1 | | | | | | | | ***1*** | ***1*** | ***0*** |
| Prickly Sow-Thistle, *Sonchus asper* | SonAsp | | | | | | | 1 | 1 | | | | | | | ***2*** | ***1*** | ***1*** |
| Purple-loosestrife, *Lythrum salicaria* | LytSal | | | | | | | | 1 | | | | | | 1 | ***2*** | ***0*** | ***2*** |
| Redshank, *Polygonum persicaria* | PolPer | | | 1 | | | | | | | | | | | | ***1*** | ***1*** | ***0*** |
| Silverweed, *Potentilla anserina* | PotAns | 1 | | 1 | 1 | 1 | 1 | 1 | | | | | | | | ***5*** | ***4*** | ***2*** |
| Skullcap, *Scutellaria galericulata* | ScuGal | | | | | | | | | | | | | 1 | | ***1*** | ***1*** | ***0*** |
| Sloe, *Prunus spinosa* | PruSpi | | | | | | | | | 1 | | | | | | ***1*** | ***1*** | ***0*** |
| Sycamore, *Acer pseudoplatanus* | AcePse | | | | | | | 1 | | | | | | | | ***1*** | ***1*** | ***0*** |
| Tufted Vetch, *Vicia cracca* | VicCra | | | | | | | | | | | | | 1 | | ***1*** | ***1*** | ***0*** |
| White Clover, *Trifolium repens* | TriRep | 1 | | 1 | | 1 | | 1 | | | | | | | | ***3*** | ***4*** | ***0*** |
| Wild Angelica, *Angelica sylvestris* | AngSyl | | | | | | | | | 1 | | | | | | ***1*** | ***1*** | ***0*** |
| Willow, *Salix* sp. | SalSp | | 1 | | | | | | | | | | | | | ***1*** | ***0*** | ***1*** |
| Wood Avens, *Geum urbanum* | GeuUrb | | | | | | | | | | | | 1 | | | ***1*** | ***0*** | ***1*** |
| Hard Rush, *Juncus inflexus* | JunInf | 1 | | 1 | | | | | | | | | | | | ***1*** | ***2*** | ***0*** |
| Horsetail, *Equisetum* sp. | EquSp | | | | | | 1 | | | | | | 1 | 1 | | ***3*** | ***1*** | ***2*** |
| **Number of species** | | **9** | **3** | **14** | **6** | **11** | **7** | **21** | **15** | **13** | **8** | **16** | **15** | **20** | **13** | ***60*** | ***54*** | ***36*** |

## Table 9. Presence-absence matrix of aquatic and emergent plants from sites along the Rivers Wylye and Till. June/July 2000

| | | Knook | | Stockton | | Yarnbury Court | | Langford Fisheries | | Hanging Langford | | Till Uffington | | Till Stapleford | | Little Wishford | | Wilton | | Total No. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Emergent/Aquatic Species** | | **Unres** | **Res** | **Unres** | **Res** | **Unres** | **Res** | **Unres** | **Res** | **Unres** | **Res** | **Unres** | **Res** | **Unres** | **Res** | **Unres** | **Res** | **Unres** | **Res** | **of sites** | **Unres** | **Res** |
| Blue Water-speedwell, *Veronica anagallis-aquatica* | VerAna | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 16 | 7 | 9 |
| Branched Bur-reed, *Sparganium erectum* | SpaEre | | | | | | | 1 | 1 | 1 | 1 | | | | | | 1 | | 1 | 6 | 2 | 4 |
| Brooklime, *Veronica beccabunga* | VerBec | | | | | | | | | | | 1 | 1 | 1 | | 1 | | | 1 | 5 | 3 | 2 |
| Canadian Pondweed, *Elodea canadensis* | EloCan | | 1 | | | | | 1 | | | | | | | | | | | | 2 | 1 | 1 |
| Common Duckweed, *Lemna minor* | LemMin | 1 | | | | | | | 1 | 1 | | 1 | | | | | | | | 3 | 3 | 1 |
| Common water crowfoot, *ranunculus spp.* | Ran spp. | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 17 | 9 | 9 |
| Curled Pondweed, *Potamogeton crispus* | PotCri | | | | | | | | | | | | | | | | | | 1 | 1 | 0 | 1 |
| Fool's Water-cress, *Apium nodiflorum* | ApiNod | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | | | 12 | 6 | 7 |
| Hemlock Water-dropwort, *Oenanthe crocota* | OenCro | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 15 | 8 | 8 |
| Lesser Pondweed, *Potamogeton pusillus* | PotPus | | | | | | | | | 1 | | | | | | | | | 1 | 2 | 1 | 1 |
| Monkey Flower, *Mimulus guttatus* | MimGut | | | | | | | 1 | 1 | | 1 | 1 | | 1 | | | 1 | | 1 | 7 | 3 | 4 |
| Spiked Water-milfoil, *Myriophyllum spicatum* | MyrSpi | | | | | | | | 1 | 1 | 1 | | | | | | | 1 | 1 | 5 | 2 | 3 |
| Unbranched Bur-reed, *Sparganium emersum* | SpaEme | | | | | | | 1 | | 1 | | | | | | | | | 1 | 3 | 2 | 1 |
| Water Figwort, *Scrophularia aquatica* | ScrAqu | 1 | 1 | 1 | | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | | 1 | | 1 | 12 | 7 | 6 |
| Water forget-me-not, *Myosotis scorpioides* | MyoSco | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 16 | 8 | 9 |
| Water Mint, *Mentha aquatica* | MenAqu | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 15 | 8 | 8 |
| Water-cress, *Rorippa nasturtium-aquaticum* | RorNas | 1 | 1 | | 1 | | | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 12 | 6 | 7 |
| Water-starwort, *Callitriche* sp. | CalSp | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | 1 | 1 | 1 | 1 | 13 | 7 | 7 |
| Yellow Flag Iris, *Iris pseudacorus* | IriPse | 1 | 1 | | | | | | | | | | | | 1 | | 1 | | 1 | 4 | 1 | 4 |
| Common Reed, *Phragmites communis* | PhrCom | 1 | | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | 5 | 4 | 2 |
| Greater Pond Sedge, *Carex riparia* | CarRip | | | | | 1 | | | | 1 | | | 1 | | | 1 | 1 | | | 5 | 3 | 2 |
| Moss, *Fontinalis antipyretica* | FonAnt | 1 | | | | | | | | | | | | 1 | | | | 1 | | 2 | 3 | 0 |
| Reed sweet-grass, *Glyceria maxima* | GlyMax | | 1 | | | | 1 | | 1 | 1 | 1 | | 1 | | | | 1 | | 1 | 8 | 1 | 7 |
| Reed-grass, *Phalaris arundinacea* | PhaAru | | 1 | 1 | 1 | | 1 | | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | | 1 | 12 | 4 | 8 |
| **Number of species** | | **12** | **13** | **8** | **9** | **8** | **9** | **14** | **14** | **17** | **13** | **12** | **12** | **11** | **9** | **10** | **14** | **7** | **18** | **24** | **23** | **23** |

## Table 10. Presence-absence matrix for all bankside and terrestrial plants recorded at sites along the Rivers Wylye and Till. June/July 2000

| Species Name | - | Knook | | Stockton | | Yarnbury Court | | Langford Fisheries | | Hanging Langford | | Till Uffington | | Till Stapleford | | Little Wishford | | Wilton | | Total No. Occurr. | Unres. | Res |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unres | Res | Unres | Res | Unres | Res | Unres | Res | Unres | Res | Unres | Res | Unres | Res | Unres | Res | Unres | Res | | | |
| Alder, *Alnus glutinosa* | AlnGlu | | | | 1 | | | | 1 | 1 | 1 | | | | | | | | | 4 | 1 | 3 |
| Ash, *Fraxinus excelsior* | FraExc | 1 | | | | | | 1 | | 1 | | | 1 | | | | | 1 | | 4 | 4 | 1 |
| Bittersweet, *Solanum dulcamara* | SolDul | | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 16 | 7 | 9 |
| Black Medick, *Medicago lupulina* | MedLup | | | | | | | | | | | | | | | | | | 1 | 1 | 0 | 1 |
| Bramble, *Rubus fruticosus* agg. | RubFru | | | | | | | | | 1 | 1 | | | 1 | 1 | | | | | 4 | 2 | 2 |
| Cleavers, *Galium aparine* | GalApa | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | | 1 | 1 | 1 | 1 | | 1 | | 1 | 12 | 6 | 7 |
| Comfrey, *Symphytum officinale* | SymOff | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | | | 1 | | | | 1 | | | | 8 | 6 | 3 |
| Common Mouse-ear, *Cerastium holosteoides* | CerHol | | | | | | | | | | | | | | | 1 | | | | 1 | 1 | 0 |
| Common Valerian, *Valeriana officinalis* | ValOff | | | | | | | | | | 1 | | | | | | | | | 1 | 0 | 1 |
| Crack Willow, *Salix fragilis* | SalFra | | | | | | | | | | | | | | | | 1 | | | 1 | 0 | 1 |
| Creeping Buttercup, *Ranunculus repens* | RanRep | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | | 1 | 1 | | 1 | 14 | 7 | 8 |
| Creeping Cinquefoil, *Potentilla reptans* | PotRep | | | | | | | | | | | 1 | | | | | | 1 | | 2 | 2 | 0 |
| Cut-leaved Crane's-bill, *Geranium dissectum* | GerDis | | | | | | | | | | | | | | | | | | 1 | 1 | 0 | 1 |
| Daisy, *Bellis perennis* | BelPer | | | | | | | | | | | | | | | | | | 1 | 1 | 0 | 1 |
| Dog Rose, *Rosa canina* agg. | RosCan | | | | | | | | 1 | | 1 | | 1 | | | | | | | 3 | 0 | 3 |
| Dogwood, *Thelycrania sanguinea* | TheSan | | | 1 | | | | | | | | | | | | | | | | 1 | 1 | 0 |
| Elder, *Sambucus nigra* | SamNig | 1 | 1 | | | | | | | 1 | 1 | | 1 | | 1 | | | | | 5 | 2 | 4 |
| Elm, *Ulmus procera* | UlmPro | | | | | | | | | 1 | | | | | | | | | | 1 | 1 | 0 |
| Fen Bedstraw, *Galium uliginosum* | GalUli | | | | | | | 1 | | | | 1 | | | | | | | | 2 | 2 | 0 |
| Fleabane, *Pulicaria dysenterica* | PulDys | | | 1 | 1 | 1 | | 1 | 1 | | | | | | | 1 | | 1 | 1 | 8 | 5 | 3 |
| Goat Willow, *Salix caprea* | SalCap | | | 1 | 1 | 1 | | | | | | | | 1 | | | | 1 | | 5 | 4 | 1 |
| Great Willowherb, *Epilobium hirsutum* | EpiHir | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 15 | 8 | 8 |
| Greater Plantain, *Plantago major* | PlaMaj | | | | | | | | | | | | | | | | | 1 | 1 | 2 | 1 | 1 |
| Grey Poplar, *Populus canescens* | PopCan | | 1 | | | | | | | | | | | | | | | | | 1 | 0 | 1 |
| Grey Willow, *Salix cinerea* ssp *atrocinerea* | SalCin | | | | | | | 1 | 1 | 1 | 1 | | | | | | | | | 4 | 2 | 2 |
| Ground Ivy, *Glechoma hederacea* | GelHed | 1 | | | | | | | | | | | | | | | | | | 0 | 1 | 0 |
| Guelder-rose, *Viburnum opulus* | VibOpu | | | 1 | | | | | | | | | | 1 | | | | | | 2 | 2 | 0 |
| Gypsywort, *Lycopus europaeus* | LycEur | | | | 1 | | | 1 | 1 | 1 | | 1 | | 1 | | 1 | | 1 | 1 | 9 | 6 | 3 |
| Hawthorn, *Crataegus monogyna* | CraMon | 1 | | 1 | | | | | 1 | | 1 | | 1 | 1 | 1 | | | | | 6 | 3 | 4 |
| Hedge Bindweed, *Calystegia sepium* | CalSep | | | 1 | | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 | | 1 | | 1 | | 10 | 7 | 3 |
| Hedge Woundwort, *Stachys sylvatica* | StaSyl | | | | | | | | | | | 1 | | | | | | | | 1 | 1 | 0 |
| Hemp Agrimony, *Eupatorium cannabinum* | EupCan | | 1 | | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | 1 | | | | 1 | | 10 | 6 | 4 |
| Herb Robert, *Geranium robertianum* | GerRob | 1 | 1 | | | | | | | | | | | | 1 | | | | | 2 | 1 | 2 |
| Hop Trefoil, *Trifolium campestre* | TriCam | | | | | | | | | | | | | | | 1 | | | | 1 | 1 | 0 |
| Hornbeam, *Carpinus betulus* | CarBet | | | | | | | | 1 | | | | | | | | | | | 1 | 0 | 1 |
| Ivy, *Hedera helix* | HedHel | 1 | 1 | | | | | | | | | | | | 1 | | | 1 | | 3 | 2 | 2 |
| Knotgrass, *Polygonum aviculare* agg. | PolAvi | | | | | | | | | | | | | | | | | 1 | | 1 | 1 | 0 |
| Marsh Dock, *Rumex palustris* | RumPal | 1 | | 1 | 1 | | | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 13 | 8 | 6 |

## Table 10. Continued

| Species Name | - | Knook | | Stockton | | Yarnbury Court | | Langford Fisheries | | Hanging Langford | | Till Uffington | | Till Stapleford | | Little Wishford | | Wilton | | Total No. Occurr. | Unres. | Res |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unres | Res | Unres | Res | Unres | Res | Unres | Res | Unres | Res | Unres | Res | Unres | Res | Unres | Res | Unres | Res | | | |
| Marsh Thistle, *Cirsium palustre* | CirPal | 1 | 1 | | | 1 | | 1 | 1 | 1 | | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 12 | 7 | 6 |
| Marsh Woundwort, *Stachys palustris* | StaPal | | | | 1 | | | | 1 | 1 | 1 | | | | | 1 | 1 | 1 | | 7 | 3 | 4 |
| Meadow Buttercup, *Ranunculus acris* | RanAcr | | | | | | | 1 | | | | | | | | 1 | 1 | | | 3 | 2 | 1 |
| Meadow Vetchling, *Lathyrus pratensis* | LatPra | | | | | | | | | | | | | | | 1 | | | | 1 | 1 | 0 |
| Meadowsweet, *Filipendula ulmaria* | FilUlm | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | 14 | 7 | 8 |
| Medium-flowered Winter-cress, *Barbaraea intermedia* | BarInt | | | 1 | | | | | | | | 1 | | | | | | | | 2 | 2 | 0 |
| Nettle, *Urtica dioica* | UrtDio | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 17 | 9 | 9 |
| Osier, *Salix viminalis* | SalVim | 1 | 1 | | | | | | | | | | | | | | | | | 1 | 1 | 1 |
| Pale Persicaria, *Polygonum lapathifolium* | PolLap | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | 1 | 1 | 11 | 6 | 6 |
| Prickly Sow-Thistle, *Sonchus asper* | SonAsp | | | | | | | 1 | | | | 1 | | | | | | | 1 | 3 | 2 | 1 |
| Purple Willow, *Salix purpurea* | SalPur | | | | | | | | 1 | | | | | | | | | | | 1 | 0 | 1 |
| Purple-loosestrife, *Lythrum salicaria* | LytSal | 1 | | | | | | | | | | | | | | | 1 | | | 1 | 1 | 1 |
| Ragwort, *Senecio* sp. | SenSp | | | | | | | | | | | | | | | | 1 | | 1 | 2 | 0 | 2 |
| Red Bartsia, *Odontites verna* | OdoVer | | | | | | | | | | | | | | | | | | 1 | 1 | 0 | 1 |
| Ribwort Plantain, *Plantago lanceolata* | PlaLan | | | | | | | | | | | | | | | 1 | | 1 | | 2 | 2 | 0 |
| Selfheal, *Prunella vulgaris* | PruVul | | | | | | | | | | | | | | | 1 | | | | 1 | 1 | 0 |
| Shepherd's Purse, *Capsella bursa-pastoris* | CapBur | | | | | | | | | | | | | | | | | 1 | | 1 | 1 | 0 |
| Silverweed, *Potentilla anserina* | PotAns | | | | 1 | | | | | | | | | | | 1 | | 1 | 1 | 4 | 2 | 2 |
| Sloe, *Prunus spinosa* | PruSpi | | | | | | | | | | | | 1 | | | | | | | 1 | 0 | 1 |
| Spear Mint, *Mentha spicata* | MenSpi | | | | | | | | | | | | | | | | | 1 | | 1 | 1 | 0 |
| Spindle, *Euonymus europaeus* | EuoEur | | | | | | | | | | | | 1 | | | | | | | 1 | 0 | 1 |
| Square-stalked St John's Wort, *Hypericum tetrapterum* | HypTet | | | | | | | | | | | 1 | | | | 1 | | | 1 | 3 | 2 | 1 |
| Sycamore, *Acer pseudoplatanus* | AcePse | 1 | | | | | | | | | | | | | | | | 1 | | 1 | 2 | 0 |
| Teasel, *Dipsacus fullonum* | DipFul | | | | | | | | | | | | 1 | | | | | | | 1 | 0 | 1 |
| White Clover, *Trifolium repens* | TriRep | | | | | | | | | | | | | | | 1 | | 1 | | 2 | 2 | 0 |
| White Willow, *Salix alba* | SalAlb | | 1 | | | | | | | | | | | | | | | | | 1 | 0 | 1 |
| Wild Angelica, *Angelica sylvestris* | AngSyl | | | | | | | | | 1 | | | 1 | | | 1 | 1 | | | 4 | 2 | 2 |
| Willow, *Salix* sp. | SalSp | | 1 | | | | | | | | | | 1 | 1 | 1 | 1 | | 1 | | 6 | 3 | 3 |
| Yarrow, *Achillea millefolium* | AchMil | | | | | | | | | | | | | | | | | 1 | 1 | 2 | 1 | 1 |
| Common Horsetail, *Equisetum arvense* | EquArv | | | | | | | | 1 | | | | | 1 | | | | | | 2 | 1 | 1 |
| Hard Rush, *Juncus inflexus* | JunInf | | | | | | | | 1 | | | 1 | 1 | | | 1 | | | 1 | 5 | 2 | 3 |
| Marsh Horsetail, *Equisetum palustre* | EquPal | | | | | | | | | | | | | | | | 1 | | | 1 | 0 | 1 |
| Perennial Rye-grass, *Lolium perenne* | LolPer | | | | | | | | | | | | | | | | | 1 | | 1 | 1 | 0 |
| Round-fruited Rush, *Juncus compressus* | JunCom | | | | | | | | | | | | | | | | 1 | | | 1 | 0 | 1 |
| Soft Rush, *Juncus effusus* | JunEff | | | | | | | | 1 | | 1 | | | | | | | | | 2 | 0 | 2 |
| Toad Rush, *Juncus bufonius* | JunBuf | | | 1 | | | | | | | | | | | | | | | | 1 | 1 | 0 |
| Tussock Grass, *Deschampsia caespitosa* | DesCae | | | | | | | | 1 | 1 | | | | | | 1 | 1 | | | 4 | 2 | 2 |
| **Number of species** | | **18** | **17** | **15** | **15** | **12** | **7** | **17** | **24** | **20** | **17** | **19** | **19** | **16** | **13** | **25** | **17** | **26** | **21** | **75** | **59** | **58** |

## Table 11. Presence-absence matrix for aquatic and emergent plants recorded at sites along the Sherston and Malmesbury Avons. June/July 2000

| | | Pinkney | | Easton Grey | | Cowage Farm | | Hyams Farm | | Kingsmead | | Great Somerford | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Aquatic/Emergent Species** | | **Unres** | **Res** | **Unres** | **Res** | **Unres** | **Res** | **Unres** | **Res** | **Unres** | **Res** | **Unres** | **Res** | **Total No. Occurr** | **Unres.** | **Res.** |
| Blue Water-speedwell, *Veronica anagallis-aquatica* | VerAna | 1 | 1 | | | 1 | 1 | 1 | 1 | | | | | **5** | **3** | **3** |
| Blunt-fruited Water-starwort, *Callitriche obtusangula* | CalObt | | | | | 1 | | | | | | | | **1** | **1** | **0** |
| Brooklime, *Veronica beccabunga* | VerBec | 1 | 1 | 1 | 1 | 1 | | | | | | | | **4** | **3** | **2** |
| Bulrush, *Schoenoplectus lacustris* | SchLac | | | | | 1 | | | 1 | 1 | 1 | 1 | | **5** | **3** | **2** |
| Common Reed, *Phragmites communis* | PhrCom | | | | | | | | | | | 1 | | **1** | **1** | **0** |
| Common water crowfoot *Ranunculus spp.* | Ran spp. | 1 | | 1 | 1 | 1 | | | 1 | | | 1 | 1 | **6** | **4** | **3** |
| Common Water-starwort, *Callitriche stagnalis* | CalSta | | | | | 1 | | | | | | | | **1** | **1** | **0** |
| Duckweed, *Lemna minor* | LemMin | | 1 | 1 | 1 | | | | | | | | 1 | **4** | **1** | **3** |
| Fool's Water-cress, *Apium nodiflorum* | ApiNod | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | 1 | **9** | **4** | **6** |
| Hemlock Water-dropwort, *Oenanthe crocota* | OenCro | | | | | | | | | 1 | 1 | | 1 | **3** | **1** | **2** |
| Indian Balsam, *Impatiens glandulifera* | ImpGla | | | | 1 | | | | | | | | 1 | **2** | **0** | **2** |
| Intermediate Water-starwort, *Callitriche intermedia (C. hamulata)* | CalInt | | | | | 1 | | | | | | | | **1** | **1** | **0** |
| Marsh-marigold, *Caltha palustris* | CalPal | 1 | 1 | | 1 | | | | | | | | | **2** | **1** | **2** |
| Pondweed, *Potamogeton* sp. | PotSp | | | | | | | | | 1 | | | | **1** | **1** | **0** |
| Unbranched Bur-reed, *Sparganium emersum* | SpaEme | | | 1 | 1 | | | 1 | | | | | | **3** | **2** | **1** |
| Water Dock, *Rumex hydrolapathum* | RumHyd | | | | | | | | | | 1 | | | **1** | **0** | **1** |
| Water forget-me-not, *Myosotis scorpioides* | MyoSco | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 | **9** | **5** | **5** |
| Water Mint, *Mentha aquatica* | MenAqu | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | **8** | **5** | **4** |
| Water Starwort, *Callitriche* sp. | CalSp | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | | | | **6** | **3** | **4** |
| Water-cress, *Rorippa nasturtium-aquaticum* | RorNas | 1 | 1 | 1 | 1 | 1 | | | | | | | | **4** | **3** | **2** |
| Water-milfoil, *Myriophyllum* sp. | MyrSp | | | | | | | | | 1 | 1 | 1 | 1 | **4** | **2** | **2** |
| Yellow Flag Iris, *Iris pseudacorus* | IriPse | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | | 1 | 1 | | **8** | **5** | **4** |
| Yellow Water-lily, *Nuphar lutea* | NupLut | | | | | 1 | | | | | | | | **1** | **1** | **0** |
| Aquatic moss, *Fontinalis antipyretica* | FonAnt | 1 | 1 | 1 | | | | 1 | 1 | 1 | | | | **5** | **4** | **2** |
| Brown alga | BroAlg | 1 | 1 | | | | | | | 1 | | | | **2** | **2** | **1** |
| Water Fern, *Azolla filiculoides* | AzoFil | | | 1 | 1 | | | | | | | | | **2** | **1** | **1** |
| Flote-grass, *Glyceria fluitans* | GlyFlu | | | | 1 | | | | 1 | | 1 | | | **3** | **0** | **3** |
| Hard rush, *Juncus inflexus* | JunInf | | | | | 1 | | | | | | | | **1** | **1** | **0** |
| Reed Grass, *Phalaris arundinacea* | PhaAru | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **11** | **6** | **6** |
| Reed sweet-grass, *Glyceria maxima* | GlyMax | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | **7** | **4** | **3** |
| **No. of species** | | **13** | **13** | **13** | **15** | **15** | **7** | **10** | **12** | **11** | **9** | **7** | **8** | **29** | **26** | **19** |

## Table 12. Presence-absence matrix for bankside and terrestrial plants recorded at sites along the Sherston and Malmesbury Avons. June/July 2000

| Terrestrial Species | - | Pinkney | | Easton Grey | | Cowage Farm | | Hyams Farm | | Kingsmead | | Great Somerford | | Total No. of sites occur. | Unres. | Res. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unres | Res | Unres | Res | Unres | Res | Unres | Res | Unres | Res | Unres | Res | | | |
| Alder, *Alnus glutinosa* | AlnGlu | | | 1 | | 1 | 1 | | | | | | | **3** | **2** | **1** |
| Ash, *Fraxinus excelsior* | FraExc | | | 1 | 1 | 1 | | | | | | | 1 | **4** | **2** | **2** |
| Bindweed, *Calystegia sepium* | CalSep | 1 | 1 | | 1 | 1 | | | | 1 | 1 | 1 | 1 | **7** | **4** | **4** |
| Bittersweet, *Solanum dulcamara* | SolDul | | | 1 | | 1 | | 1 | 1 | 1 | 1 | | | **6** | **4** | **2** |
| Bramble, *Rubus fruticosus* agg. | RubFru | | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 | | **8** | **5** | **3** |
| Bristly Oxtongue, *Picris echioides* | PicEch | 1 | | | | | | | | | | | | **0** | **1** | **0** |
| Buckthorn, *Rhamnus catharticus* | RhaCat | | | | | | | 1 | | | | | | **1** | **1** | **0** |
| Charlock, *Sinapis arvensis* | SinArv | | | | | | | | | | 1 | 1 | 1 | **3** | **1** | **2** |
| Cleavers, *Galium aparine* | GalApa | 1 | 1 | 1 | 1 | | | | 1 | 1 | | | | **5** | **3** | **3** |
| Comfrey, *Symphytum officinale* | SymOff | 1 | 1 | | 1 | 1 | | 1 | | 1 | | 1 | 1 | **7** | **5** | **3** |
| Common Horsetail, *Equisetum arvense* | EquArv | | | 1 | | | | | | | | | | **1** | **1** | **0** |
| Common Marsh Bedstraw, *Galium palustre* | GalPal | 1 | | | 1 | | 1 | 1 | | | | | | **3** | **2** | **2** |
| Common Valerian, *Valeriana officinalis* | ValOff | | | | | | | | | 1 | | | | **1** | **1** | **0** |
| Cow Parsley, *Anthriscus sylvestris* | AntSyl | 1 | | | | | | | | | | | | **1** | **1** | **0** |
| Creeping Buttercup, *Ranunculus repens* | RanRep | 1 | 1 | | 1 | 1 | | | | 1 | 1 | | 1 | **6** | **3** | **4** |
| Creeping Cinquefoil, *Potentilla reptans* | PotRep | | | | | | | | | | 1 | | | **1** | **0** | **1** |
| Creeping-Jenny, *Lysimachia nummularia* | LysNum | | 1 | | | | | | | | | | | **1** | **0** | **1** |
| Cut-leaved Crane's-bill, *Geranium dissectum* | GerDis | 1 | | | | | | | | 1 | | | | **1** | **2** | **0** |
| Daisy, *Bellis perennis* | BelPer | | | | | | | | | | 1 | | | **1** | **0** | **1** |
| Dandelion, *Taraxacum* sp. | TarSp | | | | | | | | | 1 | | | 1 | **2** | **1** | **1** |
| Dog Rose, *Rosa canina* agg | RosCan | | | | 1 | | 1 | | 1 | 1 | | | | **4** | **1** | **3** |
| Dog's Mercury, *Mercurialis perennis* | MerPer | | | 1 | | | | | | | | | | **1** | **1** | **0** |
| Elder, *Sambucus nigra* | SamNig | | | | | 1 | | | | | | | | **1** | **1** | **0** |
| Goat Willow, *Salix caprea* | SalCap | | | | | | 1 | | | 1 | | | | **2** | **1** | **1** |
| Great Willowherb, *Epilobium hirsutum* | EpiHir | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **11** | **6** | **6** |
| Greater Burdock, *Arctium lappa* | ArcLap | | | | 1 | | | | | | | | | **1** | **0** | **1** |
| Greater Plantain, *Plantago major* | PlaMaj | | | | | | | | | | | | 1 | **1** | **0** | **1** |
| Grey Poplar, *Populus canescens* | PopCan | | | | | | | | | 1 | | | | **1** | **1** | **0** |
| Ground Ivy, *Glechoma hederacea* | GleHed | 1 | | | | | | | | 1 | | | | **1** | **2** | **0** |
| Guelder-rose, *Viburnum opulus* | VibOpu | | | 1 | | | | | | | | | | **1** | **1** | **0** |
| Gypsywort, *Lycopus europaeus* | LycEur | | | | | | | | | 1 | 1 | | | **2** | **1** | **1** |
| Hawthorn, *Crataegus monogyna* | CraMon | | | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | **8** | **4** | **4** |
| Hazel, *Corylus avellana* | CorAve | | | 1 | | | | | | | | | | **1** | **1** | **0** |
| Hemlock, *Conium maculatum* | ConMac | | | | | | | | | 1 | | | | **1** | **1** | **0** |
| Hemp Agrimony, *Eupatorium cannabinum* | EupCan | | | | | | | | | 1 | | | 1 | **2** | **1** | **1** |
| Herb Robert, *Geranium robertianum* | GerRob | 1 | | 1 | | | | | | | | | | **1** | **2** | **0** |
| Hogweed, *Heracleum spondylium* | HerSpo | 1 | | | | | | | | 1 | | | 1 | **2** | **2** | **1** |
| Horsetail, *Equisetum* sp. | EquSp | | | | | | | | | | | 1 | 1 | **2** | **1** | **1** |

## Table 12. Continued

| Terrestrial Species | | Pinkney Unres | Pinkney Res | Easton Grey Unres | Easton Grey Res | Cowage Farm Unres | Cowage Farm Res | Hyams Farm Unres | Hyams Farm Res | Kingsmead Unres | Kingsmead Res | Great Somerford Unres | Great Somerford Res | Total No. of sites occur. | Unres. | Res. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ivy, *Hedera helix* | HedHel | 1 | | 1 | 1 | | 1 | | | | | | | **3** | **2** | **2** |
| Lady's Bedstraw, *Galium verum* | GalVer | 1 | | | | | | | | | | | | **1** | **1** | **0** |
| Marsh Dock, *Rumex palustris* | RumPal | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **11** | **6** | **6** |
| Marsh Thistle, *Cirsium palustre* | CirPal | | 1 | 1 | 1 | | 1 | 1 | | 1 | 1 | 1 | 1 | **9** | **4** | **5** |
| Marsh Woundwort, *Stachys palustris* | StaPal | | 1 | | | | | | | | | | | **1** | **0** | **1** |
| Meadow Vetchling, *Lathyrus pratensis* | LatPra | | | | | | 1 | | | | | | | **1** | **0** | **1** |
| Meadowsweet, *Filipendula ulmaria* | FilUlm | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | **7** | **4** | **4** |
| Nettle, *Urtica dioica* | UrtDio | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **11** | **6** | **6** |
| Nipplewort, *Lapsana communis* | LapCom | 1 | | | | | | | | | | | | **1** | **1** | **0** |
| Oxeye Daisy, *Chrysanthemum leucanthemum* | ChrLeu | | | | | | | | | 1 | 1 | | | **2** | **1** | **1** |
| Pale Persicaria, *Polygonum lapathifolium* | PolLap | | | | | | | | | 1 | | | 1 | **2** | **1** | **1** |
| Purple-loosestrife, *Lythrum salicaria* | LytSal | | | | 1 | | 1 | 1 | 1 | 1 | 1 | | 1 | **7** | **2** | **5** |
| Ragwort, *Senecio* sp. | SenSp | 1 | | | | | | | | 1 | | | | **1** | **2** | **0** |
| Red Campion, *Silene dioica* | SilDio | 1 | | | | | | | | | | | | **1** | **1** | **0** |
| Self-heal, *Prunella vulgaris* | PruVul | 1 | 1 | | | | | | | 1 | | | | **2** | **2** | **1** |
| Shining Crane's-bill, *Geranium lucidum* | GerLuc | 1 | | | | | | | | | | | | **1** | **1** | **0** |
| Smooth Hawksbeard, *Crepis capillaris* | CreCap | | | | | | | | | | 1 | | | **1** | **0** | **1** |
| Spindle, *Euonymus europaeus* | EuoEur | | | 1 | | | | | | | | | | **1** | **1** | **0** |
| Square-stalked St John's- wort, *Hypericum tetrapterum* | HypTet | | 1 | | | | | | | | | | | **1** | **0** | **1** |
| Tansy, *Chrysanthemum (Tanacetum) vulgare* | ChrVul | | | | | | | | | 1 | 1 | 1 | 1 | **4** | **2** | **2** |
| Teasel, *Dipsacus fullonum* | DipFil | | | | | | | | | 1 | 1 | | | **2** | **1** | **1** |
| Tufted Forget-me-not, *Myosotis caespitosa* | MyoCae | 1 | | | | | | | | | | | | **1** | **1** | **0** |
| Upright Hedge-parsley, *Torilis japonica* | TorJap | | | | | | | | | 1 | 1 | | | **2** | **1** | **1** |
| Walnut, *Juglans regia* | JugReg | | 1 | | | | | | | | | | | **1** | **0** | **1** |
| Water Figwort, *Scrophularia aquatica* | ScrAqu | | 1 | 1 | 1 | | 1 | | | 1 | | | | **5** | **2** | **3** |
| White Clover, *Trifolium repens* | TriRep | | 1 | | | | | | | | | | | **1** | **0** | **1** |
| White Dead-nettle, *Lamium album* | LamAlb | 1 | | | | | | | | | 1 | | | **1** | **1** | **1** |
| Wild Angelica, *Angelica sylvestris* | AngSyl | | 1 | 1 | 1 | | 1 | | 1 | | | | | **5** | **1** | **4** |
| Willow, *Salix* sp | SalSp | | 1 | | | 1 | | | 1 | | | | | **3** | **1** | **2** |
| Wood Club-rush, *Scirpus sylvaticus* | SciSyl | | | | | | | | | 1 | | | | **1** | **1** | **0** |
| **No. of species** | | 24 | 19 | 20 | 17 | 14 | 16 | 12 | 11 | 32 | 20 | 10 | 18 | **67** | **56** | **45** |

### Table 13. Results of paired t-tests on species richness of plants in restored and unrestored reaches of three Wessex rivers.

| River | Habitat | Treatment | N | Mean | 1SD | p(sig) |
|---|---|---|---|---|---|---|
| **Piddle** | *Aquatic* | *Unrestored* | *7* | 8.9 | 2.7 | 0.11(NS) |
| | | *Restored* | *7* | 10.7 | 2.4 | |
| **Wylye** | *Aquatic* | *Unrestored* | *9* | 11.0 | 3.2 | 0.24(NS) |
| | | *Restored* | *9* | 12.3 | 3.0 | |
| **Avons** | *Aquatic* | *Unrestored* | *6* | 11.5 | 2.8 | 0.62(NS) |
| | | *Restored* | *6* | 10.7 | 3.1 | |
| **Piddle** | *Bankside* | *Unrestored* | *7* | 16.1 | 5.2 | <0.001*** |
| | | *Restored* | *7* | 10.6 | 4.9 | |
| **Wylye** | *Bankside* | *Unrestored* | *9* | 18.7 | 4.5 | 0.2(NS) |
| | | *Restored* | *9* | 16.7 | 4.8 | |
| **Avons** | *Bankside* | *Unrestored* | *6* | 18.7 | 8.4 | 0.53(NS) |
| | | *Restored* | *6* | 16.8 | 3.2 | |

*** = highly significant

### Table 14. Numbers of plant species common and specific to restored and unrestored reaches in three Wessex rivers.

| RIVER | No. Species Common | No. restored only | No. unrestored only |
|---|---|---|---|
| **Piddle/Devils Brook (Aquatic)** | 16 | 1 | 2 |
| **Piddle/Devils Brook (Bankside)** | 30 | 6 | 24 |
| **Wylye/Till (Aquatic)** | 22 | 1 | 1 |
| **Wylye/Till (Bankside)** | 38 | 18 | 19 |
| **Sherston/Malmesbury Avons (Aquatic)** | 20 | 3 | 7 |
| **Sherston/Malmesbury Avons (Bankside)** | 35 | 11 | 22 |

## Table 15 Full list of species/taxa and classification for invertebrates from three Wessex Rivers

| | | | |
|---|---|---|---|
| **COELENTERATA** | **HIRUDINEA** | **HEMIPTERA** | **TRICHOPTERA** |
| Hydrida | Piscicolidae | Mesoveliidae | Psychomyidae |
| *Hydra sp.* | *Piscicola geometra* | *Velia caprai* | *Tinodes waeneri* |
| **PLATYHELMINTHES** | Glossiphoniidae | Corixidae | *Psychomyia pusilla* |
| Planariidae | *Glossiphonia complanata* | *Hespercorixa sahlbergii* | *Lype reducta* |
| *Polycelis nigra* | *Helobdella stagnalis* | *Corixa sp.* | Rhyacophilidae |
| *Polycelis tennuis* | *Theromyzon tessulatum* | *Corixa dorsalis* | *Rhyacophila dorsalis* |
| *Dugesia polychroa* | *Hemiclepsis marginata* | *Sigara falleni* | *Agapetus fuscipes* |
| *Dendrocoelidae* | Erpobdellidae | *Callicorixa praeusta* | Polycentropidae |
| *Dendrocoelum lacteum* | *Erpobdella octoculata* | *Micronecta poweri* | *Cyrnus trimaculatus* |
| **MOLLUSCA** | **CRUSTACEA** | Notonectidae | *Polycentropus flavomaculatus* |
| Neritidae | Asellidae | *Notonecta sp. (larvae)* | Hydropsychidae |
| *Theodoxus fluviatilis* | *Asellus meridianus* | Nepidae | *Hydropsyche siltalai* |
| Lymnaeidae | *Asellus aquaticus* | *Nepa cinerea* | *Hydropsyche instabilis* |
| *Lymnea truncatula* | Gammaridae | **EPHEMEROPTERA** | *Hydropsyche angustipennis* |
| *Lymnea palustris* | *Gammarus pulex* | Ephemeridae | *Hydropsyche pellucidula* |
| *Lymnea glabra* | *Crangonyx pseudogracilis* | *Ephemera danica* | Limnephilidae |
| *Lymnea stagnalis* | Astacidae | Baetidae | *Limnephilus auricula* |
| *Lymnea auricularia* | *Austropotamobius pallipes* | *Cloeon dipterum* | *Limnephilus rhombicus* |
| *Lymnea peregra* | **INSECTA** | *Centroptilum luteolum* | *Limnephilus lunatus* |
| Succinidae | **MEGALOPTERA** | *Centroptilum pennulatum* | *Glyphotaelius pellucidus* |
| *Succinea putris* | Sialidae | *Procloeon bifidum* | *Anabolia nervosa* |
| Planorbidae | *Sialis lutaria* | *Baetis fuscatus* | *Drusus annulatus* |
| *Planorbis albus* | **ODONATA** | *Baetis vernus* | *Halesus radiatus* |
| *Planorbis planorbis* | Agriidae | *Baetis rhodani* | *Halesus digitatus* |
| *Planorbis vortex* | *Calopteryx splendens* | *Baetis fuscatus* | *Potamophylax latipennis* |
| *Planorbis spirorbis* | Coenagriidae | Heptageniidae | *Micropterna sequax* |
| *Planorbis leucostoma* | *Pyrrhosoma nymphula* | *Ecdyonurus dispar* | *Micropterna lateralis* |
| *Planorbis contortus* | **COLEOPTERA** | *Heptagenia sulphurea* | Odontoceridae |
| *Planorbis carinatus* | Gyrinidae | *Heptagenia lateralis* | *Odontocerum albicorne* |
| *Menetus dilatatus* | *Orectochilus villosus* | Leptophlebiidae | Molannidae |
| Physidae | *Gyrinus urinator* | *Paraleptophlebia submarginata* | *Molanna angustata* |
| *Physa fontinalis* | *Gyrinus minutus* | *Habrophlebia fusca* | Leptoceridae |
| Valvatidae | *Gyrinus spp (larvae)* | Ephemerellidae | *Arthripsodes cinereus* |
| *Valvata macrostoma* | Haliplidae | *Ephemerella ignita* | *Arthripsodes bilineatus* |
| *Valvata piscinalis* | *Haliplus sp.* | Caenidae | *Ceraclea dissimilis* |
| Hydrobiidae | *Haliplus lineatocollis* | *Caenis rivulorum* | *Mystacides longicornis* |
| *Potamopyrgus jenkinsi* | *Haliplus ruficollis* | *Caenis luctosa* | *Mystacides azurea* |
| *Bithynia tentaculata* | *Brychius elevatus* | *Caenis macrura* | *Ylodes conspersus* |
| *Bithynia leachii* | Dytiscidae (indet) | **DIPTERA** | Goeridae |
| Zonitidae | *Helophorus avernicus* | Pyychopteridae | *Silo nigricornis* |
| *Zonitoides sp* | *Helophorus brevipalpis* | *Ptychoptera contaminata* | Sericostomatidae |
| Ancylidae | *Coelambus nigrolineatus* | *Pericoma sp.* | *Sericostoma personatum* |
| *Ancylus fluviatilis* | *Platambus maculatus* | Tipulidae | Brachycentridae |
| *Ancylus lacustris* | *Stictotarsus duodecimpustulatus* | *Tipula sp.* | *Brachycentrus subnubilis* |
| Sphaeriidae | *Potamonectes depressus elegans* | *Dicranota sp.* | Hydroptilidae |
| *Sphaerium lacustre?* | *Hygrotus quinqelineatus* | *Pedicia sp.* | *Hydroptila sp.* |
| *Sphaerium corneum* | *Hyphydrus ovalis* | Empididae | *Oxyethira sp.* |
| *Pisidium sp.* | *Agabus bipustulatus* | Tabanidae | Lepidostomatidae |
| *Pisidium obtusale?* | *Agabus undulatus* | Dixidae | *Lepidostoma hirtum* |
| *Pisidium pulchellum* | *Agabus paludosus* | Ceratopogonidae | **PLECOPTERA** |
| *Pisidium casertanum* | *Graptodytes flavipes* | Chironomidae | Nemouridae |
| *Pisidium amnicum* | *Laccornis oblongus?* | Tanypodinae | *Nemoura sp.* |
| *Pisidium nitidum* | *Laccophilus minutus?* | Orthocladiinae | Leuctridae |
| *Pisidium tennuilatum* | *Hygrotus vesiculosus?* | Tanytarsini | *Leuctra geniculata* |
| *Pisidium milium* | *Oreodytes septentrionis* | Simuliidae | *Leuctra hippopus* |
| **ANNELIDA** | *Oreodytes sanmali* | *Simulium sp.* | *Leuctra moselyi* |
| Oligochaeta | Hydroporini (larvae) | *Simulium equinum* | Perlodidae |
| Naididae | *Hydroporus striolus* | *Simulium costatum* | *Isoperla grammatica* |
| *Stylaria lacustris* | Helodidae | *Simulium reptans* | |
| Tubificidae | *Helodes marginata* | *Simulium ornatum* | **NEMATODA** |
| *Aulodrilus pluriseta* | Elminthidae | *Simulium morsitans* | **HYDRACARINA** |
| Lumbriculidae | *Elmis aenae* | *Simulium dunfellense* | **COLLEMBOLA** |
| Lumbricidae | *Limnius volkmari* | | **OSTRACODA** |
| *Eiseniella tetraedra* | *Oulimnius tuberculatus* | | |
| | *Riolus subviolaceus* | | **PISCES (FISH)** |
| | Chrysomelidae | | Cottus gobio |
| | *Donacia sp.* | | Gasterosteus aculeatus |
| | *Laccobius spp (larvae)* | | *Lampetra spp.* |

### Table 16. Percentage composition by family from restored and unrestored reaches of the Devils Brook, Dorset. (see Table 1 for locations of sites and Appendix 1 for site descriptions and treatments)

| Percentage composition | *DBATUI* | DBATR2 | *DBATU3* | DBATR4 | *DBATU1a* | DBATR2a | *DBATU3a* | DBATR4a |
|---|---|---|---|---|---|---|---|---|
| | *Unres* | *Res* | *Unres* | *Res* | *Unres* | *Res* | *Unres* | *Res* |
| **Agriidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Ancylidae** | *0.0* | 2.6 | *0.6* | 0.6 | *0.3* | 0.8 | *0.1* | 0.7 |
| **Asellidae** | *1.6* | 5.8 | *3.4* | 5.0 | *4.4* | 2.4 | *0.4* | 3.7 |
| **Astacidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Baetidae** | *4.1* | 8.7 | *9.2* | 10.6 | *11.0* | 6.1 | *8.1* | 6.0 |
| **Brachycentridae** | *0.3* | 0.4 | *0.0* | 0.8 | *0.1* | 0.2 | *0.2* | 0.0 |
| **Caenidae** | *0.0* | 0.0 | *0.0* | 0.0 | *1.1* | 3.2 | *0.0* | 0.3 |
| **Chironomidae** | *10.4* | 11.9 | *7.7* | 4.7 | *3.2* | 7.8 | *1.3* | 5.7 |
| **Chrysomelidae** | *0.0* | 0.0 | *0.6* | 0.1 | *0.0* | 0.0 | *0.0* | 0.1 |
| **Coenagriidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Corixidae** | *0.0* | 0.0 | *0.1* | 0.0 | *0.4* | 0.0 | *0.0* | 0.3 |
| **Dendrocoelidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Dixidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Dytiscidae** | *1.3* | 1.4 | *0.0* | 1.2 | *1.9* | 0.8 | *1.0* | 2.2 |
| **Elminthidae** | *2.9* | 0.6 | *0.0* | 0.6 | *0.0* | 0.2 | *0.3* | 0.3 |
| **Empididae** | *0.2* | 0.0 | *0.0* | 0.4 | *0.0* | 0.0 | *0.1* | 0.3 |
| **Ephemerellidae** | *12.1* | 18.0 | *12.1* | 22.7 | *22.5* | 24.7 | *22.7* | 11.7 |
| **Ephemeridae** | *1.1* | 0.5 | *0.5* | 0.6 | *0.2* | 0.4 | *0.5* | 1.2 |
| **Erpobdellidae** | *1.7* | 1.5 | *0.2* | 0.8 | *1.3* | 0.0 | *0.3* | 1.2 |
| **Gammaridae** | *4.4* | 9.3 | *12.8* | 23.1 | *11.7* | 29.5 | *5.8* | 26.1 |
| **Glossiphoniidae** | *1.7* | 0.1 | *0.6* | 0.9 | *0.2* | 0.3 | *0.2* | 0.9 |
| **Goeridae** | *1.9* | 0.1 | *0.0* | 0.0 | *0.8* | 0.2 | *0.0* | 0.0 |
| **Gyrinidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Haliplidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Helodidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Heptageniidae** | *0.5* | 0.0 | *0.0* | 0.3 | *0.1* | 0.4 | *0.1* | 0.4 |
| **Hydrida** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Hydrobiidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Hydroporini** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.3* | 0.4 |
| **Hydropsychidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Hydroptilidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Lepidostomatidae** | *0.0* | 0.2 | *0.2* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Leptoceridae** | *0.0* | 0.0 | *0.1* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Leptophlebiidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.2 | *0.0* | 0.0 |
| **Leuctridae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.8 | *0.1* | 0.0 |
| **Limnephilidae** | *6.5* | 2.8 | *3.6* | 4.7 | *1.5* | 1.5 | *1.1* | 7.5 |
| **Lymnaeidae** | *1.7* | 4.4 | *2.3* | 3.8 | *2.3* | 1.3 | *0.6* | 2.5 |
| **Mesoveliidae** | *0.0* | 0.0 | *0.1* | 0.0 | *0.0* | 0.0 | *0.1* | 0.0 |
| **Molannidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Nepidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Neritidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Notonectidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Odontoceridae** | *0.2* | 0.2 | *0.0* | 0.8 | *0.1* | 0.2 | *0.0* | 0.1 |
| **Oligochaeta** | *3.7* | 6.8 | *7.7* | 4.6 | *10.0* | 0.1 | *0.7* | 4.4 |
| **Perlodidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Physidae** | *1.9* | 1.0 | *1.5* | 1.2 | *2.8* | 0.5 | *0.4* | 1.5 |
| **Piscicolidae** | *0.3* | 0.0 | *0.0* | 0.3 | *0.1* | 0.4 | *0.1* | 0.3 |
| **Planariidae** | *0.0* | 1.5 | *0.1* | 1.5 | *0.0* | 0.2 | *0.0* | 0.3 |
| **Planorbidae** | *1.0* | 1.0 | *2.3* | 3.2 | *1.1* | 0.4 | *0.2* | 4.0 |
| **Polycentropodidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Psychomyiidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Ptychopteridae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.0 |
| **Rhyacophilidae** | *0.2* | 0.0 | *0.0* | 0.4 | *0.0* | 0.0 | *0.2* | 0.3 |
| **Sericostomatidae** | *0.0* | 0.2 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Sialidae** | *0.0* | 0.2 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Simuliidae** | *35.4* | 16.4 | *33.0* | 4.5 | *21.9* | 16.2 | *52.4* | 14.5 |
| **Sphaeriidae** | *1.2* | 2.5 | *0.3* | 0.3 | *0.3* | 0.2 | *0.1* | 0.0 |
| **Succinidae** | *0.6* | 0.4 | *0.0* | 0.3 | *0.0* | 0.1 | *0.0* | 0.0 |
| **Tabanidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Tipulidae** | *0.4* | 0.9 | *0.0* | 0.4 | *0.2* | 0.2 | *0.3* | 0.9 |
| **Valvatidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Zonitidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |

***Margin and midstream samples pooled***

## Table 17. Percentage composition by family from restored and unrestored reaches of the River Piddle

| *Family/Taxon* | *Burleston* | | *Park Farm* | | *Southover* | | *Briantspuddle* | | *Throop* | |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Status*** | ***Unres*** | **Res** | ***Unres*** | **Res** | ***Unres*** | **Res** | ***Unres*** | **Res** | ***Unres*** | **Res** |
| **Agriidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.2* | 1.4 | *0.1* | 0.0 |
| **Ancylidae** | *0.3* | 0.0 | *1.7* | 0.6 | *1.6* | 0.5 | *0.1* | 0.1 | *1.3* | 1.9 |
| **Asellidae** | *4.9* | 9.9 | *0.0* | 0.0 | *1.2* | 15.2 | *1.1* | 3.3 | *0.0* | 8.0 |
| **Astacidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.2 | *0.1* | 0.0 | *1.0* | 0.2 |
| **Baetidae** | *11.5* | 6.8 | *4.8* | 4.7 | *3.7* | 3.9 | *5.8* | 4.4 | *1.2* | 4.7 |
| **Brachycentridae** | *1.2* | 0.2 | *0.1* | 0.0 | *1.2* | 0.1 | *0.3* | 0.8 | *3.2* | 0.4 |
| **Caenidae** | *5.7* | 8.7 | *2.7* | 2.0 | *1.8* | 6.1 | *2.4* | 2.6 | *0.5* | 3.5 |
| **Chironomidae** | *7.6* | 12.0 | *5.1* | 5.3 | *1.6* | 8.7 | *8.0* | 4.8 | *2.5* | 4.1 |
| **Chrysomelidae** | *0.5* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.8 |
| **Coenagriidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.1 | *0.0* | 0.0 | *0.0* | 0.1 |
| **Corixidae** | *0.0* | 0.3 | *0.1* | 0.0 | *0.0* | 0.0 | *0.0* | 0.7 | *0.0* | 0.0 |
| **Dendrocoelidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Dixidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Dytiscidae** | *0.2* | 0.9 | *0.5* | 1.0 | *0.1* | 0.0 | *0.0* | 0.1 | *0.0* | 0.3 |
| **Elminthidae** | *1.4* | 1.2 | *2.9* | 3.1 | *2.2* | 0.4 | *2.5* | 1.3 | *0.6* | 1.5 |
| **Empididae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.0 | *0.1* | 0.0 | *0.0* | 0.0 |
| **Ephemerellidae** | *26.9* | 17.2 | *18.6* | 31.9 | *11.4* | 7.7 | *13.9* | 10.3 | *7.8* | 7.7 |
| **Ephemeridae** | *0.1* | 0.7 | *0.1* | 0.0 | *0.5* | 0.0 | *1.4* | 0.1 | *0.1* | 0.0 |
| **Erpobdellidae** | *0.8* | 0.7 | *0.3* | 0.3 | *0.4* | 0.3 | *0.5* | 0.5 | *0.1* | 0.2 |
| **Gammaridae** | *12.3* | 22.5 | *29.4* | 30.6 | *40.6* | 10.7 | *32.8* | 26.6 | *58.2* | 40.0 |
| **Glossiphoniidae** | *0.1* | 0.0 | *0.0* | 0.0 | *0.1* | 0.1 | *0.0* | 0.0 | *0.0* | 0.1 |
| **Goeridae** | *0.1* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Gyrinidae** | *0.1* | 1.4 | *0.1* | 0.2 | *0.0* | 0.1 | *0.0* | 0.1 | *0.0* | 0.4 |
| **Haliplidae** | *0.1* | 1.4 | *0.1* | 0.2 | *0.0* | 0.1 | *0.0* | 0.1 | *0.0* | 0.4 |
| **Helodidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.1 |
| **Heptageniidae** | *0.0* | 0.3 | *0.3* | 0.0 | *0.6* | 0.0 | *0.4* | 0.9 | *0.1* | 0.4 |
| **Hydrida** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Hydrobiidae** | *0.0* | 0.0 | *0.1* | 0.2 | *1.6* | 22.0 | *0.5* | 4.0 | *2.2* | 10.3 |
| **Hydroporini** | *0.2* | 0.3 | *0.0* | 0.2 | *0.0* | 0.0 | *0.0* | 0.1 | *0.0* | 0.0 |
| **Hydropsychidae** | *0.1* | 0.2 | *0.3* | 0.2 | *0.1* | 0.2 | *0.2* | 0.1 | *0.1* | 0.0 |
| **Hydroptilidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.1 | *0.4* | 0.0 | *0.0* | 0.0 |
| **Lepidostomatidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.0 | *0.0* | 0.1 | *0.5* | 0.5 |
| **Leptoceridae** | *0.2* | 0.0 | *0.0* | 0.0 | *0.1* | 0.0 | *0.9* | 1.2 | *1.0* | 0.5 |
| **Leptophlebiidae** | *0.1* | 0.0 | *0.2* | 0.2 | *0.1* | 0.0 | *0.5* | 0.5 | *0.3* | 0.0 |
| **Leuctridae** | *0.0* | 0.2 | *0.3* | 0.2 | *0.1* | 0.0 | *3.3* | 4.4 | *2.5* | 0.5 |
| **Limnephilidae** | *2.6* | 2.7 | *3.1* | 1.7 | *1.4* | 0.6 | *1.5* | 0.7 | *0.5* | 2.0 |
| **Lymnaeidae** | *2.4* | 1.1 | *0.2* | 0.2 | *0.4* | 0.3 | *0.3* | 1.3 | *0.1* | 0.5 |
| **Mesoveliidae** | *0.1* | 0.0 | *0.0* | 0.0 | *0.0* | 0.1 | *0.0* | 0.0 | *0.6* | 0.0 |
| **Molannidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Nepidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Neritidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.3* | 0.0 |
| **Notonectidae** | *0.1* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.1 |
| **Odontoceridae** | *0.1* | 0.0 | *0.5* | 0.8 | *0.0* | 0.1 | *0.0* | 0.5 | *0.4* | 0.0 |
| **Oligochaeta** | *7.2* | 1.6 | *2.0* | 2.0 | *2.2* | 2.7 | *3.7* | 2.1 | *2.7* | 3.2 |
| **Perlodidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.1 | *0.0* | 0.1 |
| **Physidae** | *2.4* | 4.4 | *0.0* | 0.0 | *0.2* | 0.0 | *1.1* | 5.8 | *0.0* | 0.3 |
| **Piscicolidae** | *1.0* | 0.2 | *0.2* | 0.2 | *0.1* | 0.1 | *0.0* | 0.1 | *0.0* | 0.1 |
| **Planariidae** | *0.8* | 2.1 | *0.1* | 1.4 | *0.0* | 7.0 | *1.7* | 8.6 | *0.0* | 0.7 |
| **Planorbidae** | *0.0* | 0.4 | *0.1* | 0.1 | *0.1* | 4.0 | *0.0* | 0.0 | *0.8* | 4.1 |
| **Polycentropodidae** | *0.0* | 0.0 | *0.0* | 0.0 | *2.2* | 0.3 | *3.8* | 1.4 | *6.0* | 1.2 |
| **Psychomyiidae** | *0.0* | 0.0 | *0.1* | 0.2 | *0.2* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Ptychopteridae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Rhyacophilidae** | *0.3* | 0.2 | *0.6* | 0.7 | *0.0* | 0.0 | *0.3* | 0.0 | *0.0* | 0.0 |
| **Sericostomatidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.7* | 0.0 | *0.1* | 1.2 | *0.0* | 0.1 |
| **Sialidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.7* | 0.0 | *0.1* | 1.2 | *0.0* | 0.1 |
| **Simuliidae** | *4.0* | 2.1 | *24.5* | 11.1 | *20.9* | 6.9 | *9.6* | 8.1 | *1.2* | 0.7 |
| **Sphaeriidae** | *1.7* | 0.4 | *0.2* | 0.4 | *0.1* | 0.0 | *0.2* | 0.1 | *0.0* | 0.1 |
| **Succinidae** | *0.1* | 0.0 | *0.0* | 0.0 | *0.0* | 0.2 | *1.1* | 0.7 | *0.0* | 0.0 |
| **Tabanidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.2 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Tipulidae** | *0.9* | 0.2 | *0.1* | 0.2 | *0.3* | 0.0 | *0.2* | 0.7 | *0.9* | 0.2 |
| **Valvatidae** | *0.1* | 0.0 | *0.0* | 0.0 | *0.1* | 0.1 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Zonitidae** | *0.1* | 0.0 | *0.0* | 0.0 | *0.1* | 0.1 | *0.0* | 0.0 | *0.0* | 0.0 |

**Table 18. Percentage composition by family from restored and unrestored reaches of the River Wylye.** *(Margin and midstream samples pooled)*

| Percentage composition | *Knook* | | *Stockton* | | *Yarnbury Court* | | *Langford Fisheries* | | *Hanging Langford* | | *Great Wishford* | | *Wilton* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Status** | *Unres* | **Res** | *Unres* | **Res** | *Unres* | **Res** | *Unres* | **Res** | *Unres* | **Res** | *Unres* | **Res** | *Unres* | **Res** |
| **Agriidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.1 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.1 |
| **Ancylidae** | *0.3* | 0.0 | *2.2* | 0.5 | *0.0* | 0.1 | *0.1* | 0.0 | *0.2* | 0.5 | *0.1* | 0.1 | *0.5* | 0.0 |
| **Asellidae** | *1.9* | 0.9 | *1.1* | 6.2 | *0.4* | 5.0 | *5.0* | 1.9 | *1.9* | 7.6 | *0.1* | 0.2 | *0.0* | 1.4 |
| **Astacidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.0 |
| **Baetidae** | *2.3* | 3.0 | *6.6* | 16.8 | *0.8* | 8.3 | *2.9* | 3.2 | *0.2* | 1.2 | *6.8* | 11.5 | *6.6* | 5.5 |
| **Brachycentridae** | *0.1* | 0.1 | *0.8* | 0.2 | *0.0* | 0.2 | *0.2* | 0.5 | *0.4* | 0.0 | *0.2* | 0.1 | *0.0* | 0.1 |
| **Caenidae** | *0.9* | 0.5 | *2.2* | 0.0 | *0.5* | 0.0 | *3.0* | 3.2 | *2.7* | 6.2 | *0.2* | 1.0 | *0.4* | 0.9 |
| **Chironomidae** | *1.2* | 2.3 | *8.0* | 10.7 | *0.5* | 3.8 | *10.7* | 4.3 | *1.5* | 4.4 | *9.3* | 9.9 | *4.6* | 3.3 |
| **Chrysomelidae** | *0.0* | 0.0 | *0.0* | 0.1 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Coenagriidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.1 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Corixidae** | *0.0* | 0.0 | *0.0* | 0.8 | *0.0* | 0.0 | *0.9* | 0.3 | *3.6* | 0.1 | *0.1* | 0.2 | *0.6* | 0.8 |
| **Dendrocoelidae** | *0.0* | 0.1 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Dixidae** | *0.0* | 0.1 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Dytiscidae** | *0.1* | 0.0 | *1.3* | 0.5 | *0.1* | 0.0 | *0.1* | 0.1 | *0.1* | 0.0 | *0.5* | 0.1 | *0.6* | 0.0 |
| **Elminthidae** | *1.0* | 3.0 | *7.5* | 2.2 | *0.4* | 0.8 | *5.0* | 7.9 | *2.7* | 3.3 | *0.5* | 0.6 | *4.2* | 1.0 |
| **Empididae** | *0.0* | 0.0 | *0.0* | 0.1 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.2 |
| **Ephemerellidae** | *24.1* | 13.0 | *36.1* | 11.0 | *4.7* | 13.3 | *19.2* | 27.4 | *20.9* | 29.1 | *14.2* | 14.8 | *4.9* | 3.4 |
| **Ephemeridae** | *0.3* | 2.7 | *0.0* | 0.0 | *0.0* | 0.3 | *0.4* | 0.2 | *0.0* | 0.0 | *0.0* | 0.1 | *0.3* | 0.2 |
| **Erpobdellidae** | *0.2* | 0.0 | *0.4* | 0.2 | *0.0* | 0.0 | *1.0* | 1.4 | *0.4* | 1.0 | *0.0* | 0.0 | *0.0* | 0.3 |
| **Gammaridae** | *45.4* | 28.5 | *9.6* | 13.0 | *0.5* | 48.5 | *8.6* | 14.7 | *33.3* | 28.2 | *16.2* | 9.8 | *43.2* | 22.7 |
| **Glossiphoniidae** | *0.1* | 0.1 | *1.0* | 0.2 | *0.0* | 0.2 | *1.9* | 2.9 | *0.9* | 3.0 | *0.2* | 0.6 | *0.3* | 0.5 |
| **Goeridae** | *0.4* | 0.0 | *0.0* | 0.2 | *0.0* | 0.0 | *0.0* | 0.2 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Gyrinidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.2 | *1.2* | 0.1 | *0.0* | 0.0 | *0.6* | 0.1 |
| **Haliplidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.2 | *1.2* | 0.1 | *0.0* | 0.0 | *0.6* | 0.1 |
| **Helodidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Heptageniidae** | *0.0* | 0.0 | *0.4* | 0.1 | *0.1* | 1.1 | *0.8* | 0.0 | *0.6* | 0.2 | *0.0* | 0.1 | *0.4* | 0.4 |
| **Hydrida** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Hydrobiidae** | *0.4* | 0.5 | *0.0* | 0.0 | *0.2* | 0.4 | *0.5* | 1.8 | *10.9* | 0.4 | *32.8* | 5.2 | *14.9* | 26.0 |
| **Hydroporini** | *0.0* | 0.0 | *0.1* | 0.2 | *0.0* | 0.0 | *0.2* | 0.1 | *0.0* | 0.9 | *0.0* | 0.2 | *0.0* | 0.0 |
| **Hydropsychidae** | *0.2* | 0.2 | *0.0* | 0.1 | *0.0* | 1.3 | *0.0* | 0.1 | *0.1* | 0.1 | *0.0* | 0.0 | *0.3* | 0.0 |
| **Hydroptilidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *1.8* | 0.4 |
| **Lepidostomatidae** | *1.2* | 1.2 | *1.1* | 0.6 | *0.0* | 0.0 | *3.5* | 2.0 | *0.7* | 1.0 | *0.1* | 0.0 | *0.4* | 0.2 |
| **Leptoceridae** | *0.6* | 0.6 | *0.2* | 0.3 | *0.2* | 1.1 | *1.1* | 1.1 | *0.8* | 0.5 | *0.1* | 0.1 | *0.3* | 0.5 |
| **Leptophlebiidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Leuctridae** | *0.0* | 0.0 | *0.0* | 0.3 | *0.1* | 1.2 | *0.6* | 0.6 | *0.2* | 0.3 | *0.1* | 0.2 | *0.4* | 0.1 |
| **Limnephilidae** | *0.6* | 1.2 | *0.3* | 0.4 | *0.1* | 0.5 | *0.2* | 0.3 | *0.7* | 0.6 | *0.3* | 0.3 | *0.2* | 0.5 |
| **Lymnaeidae** | *0.1* | 0.1 | *0.1* | 0.7 | *0.1* | 0.0 | *0.8* | 1.3 | *0.4* | 0.1 | *0.0* | 4.3 | *0.2* | 1.6 |
| **Mesoveliidae** | *0.0* | 0.0 | *0.2* | 0.1 | *0.0* | 0.1 | *0.2* | 0.1 | *0.1* | 0.0 | *0.0* | 0.0 | *0.1* | 0.1 |
| **Molannidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.3* | 0.1 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Nepidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Neritidae** | *0.1* | 0.1 | *1.0* | 0.0 | *0.0* | 0.2 | *1.2* | 3.8 | *0.1* | 0.0 | *0.0* | 0.2 | *2.2* | 0.0 |
| **Notonectidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Odontoceridae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Oligochaeta** | *1.1* | 3.5 | *3.5* | 28.1 | *0.2* | 1.1 | *6.8* | 5.4 | *4.6* | 4.3 | *1.4* | 1.9 | *2.0* | 2.4 |
| **Perlodidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Physidae** | *0.0* | 0.0 | *0.2* | 0.4 | *0.1* | 1.3 | *0.1* | 3.0 | *0.1* | 0.7 | *0.1* | 0.9 | *0.0* | 1.2 |
| **Piscicolidae** | *0.1* | 0.0 | *0.4* | 0.1 | *0.0* | 0.1 | *0.1* | 0.0 | *1.6* | 0.3 | *0.1* | 0.1 | *0.0* | 0.1 |
| **Planariidae** | *2.0* | 2.5 | *0.6* | 1.2 | *0.0* | 0.4 | *2.2* | 1.4 | *0.7* | 0.3 | *0.2* | 0.2 | *0.0* | 0.3 |
| **Planorbidae** | *0.1* | 0.3 | *0.6* | 0.3 | *0.5* | 1.1 | *1.4* | 2.8 | *1.2* | 1.2 | *0.1* | 0.4 | *0.3* | 0.1 |
| **Polycentropodidae** | *0.1* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.1 |
| **Psychomyiidae** | *0.0* | 0.1 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.2 | *0.0* | 0.3 | *0.0* | 0.1 | *0.4* | 0.1 |
| **Ptychopteridae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.0 |
| **Rhyacophilidae** | *0.1* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.2* | 0.0 | *0.2* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Sericostomatidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *2.4* | 0.0 | *0.0* | 0.5 | *0.0* | 1.1 | *0.0* | 0.9 |
| **Sialidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *2.4* | 0.0 | *0.0* | 0.5 | *0.0* | 1.1 | *0.0* | 0.9 |
| **Simuliidae** | *14.4* | 30.4 | *12.0* | 3.0 | *90.3* | 9.2 | *8.3* | 1.5 | *5.7* | 2.8 | *15.9* | 34.6 | *3.9* | 22.1 |
| **Sphaeriidae** | *0.3* | 4.2 | *2.1* | 0.4 | *0.0* | 0.4 | *5.9* | 3.9 | *0.4* | 0.5 | *0.2* | 0.5 | *0.1* | 0.5 |
| **Succinidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.9* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.7 |
| **Tabanidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Tipulidae** | *0.1* | 0.2 | *0.1* | 0.2 | *0.1* | 0.0 | *0.2* | 0.0 | *0.6* | 0.1 | *0.1* | 0.0 | *0.3* | 0.1 |
| **Valvatidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.0 | *0.0* | 0.0 | *0.0* | 0.2 | *0.1* | 0.2 |
| **Zonitidae** | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.0 | *0.0* | 0.0 | *0.0* | 0.2 | *0.1* | 0.2 |

**Table 19. Percentage composition by family from restored and unrestored reaches of the River Till**

| Percentage composition | *Till Uffington* | | *Till Stapleford* | |
|---|---|---|---|---|
| **Status** | *Unres* | **Res** | *Unres* | **Res** |
| **Agriidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Ancylidae** | *0.2* | 1.2 | *0.0* | 0.4 |
| **Asellidae** | *0.6* | 0.4 | *10.3* | 2.5 |
| **Astacidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Baetidae** | *4.6* | 10.2 | *9.8* | 9.3 |
| **Brachycentridae** | *0.0* | 0.0 | *0.0* | 0.1 |
| **Caenidae** | *0.1* | 0.0 | *0.2* | 0.1 |
| **Chironomidae** | *41.7* | 11.4 | *6.1* | 3.5 |
| **Chrysomelidae** | *0.0* | 0.0 | *0.1* | 0.0 |
| **Coenagriidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Corixidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Dendrocoelidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Dixidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Dytiscidae** | *0.1* | 0.1 | *0.3* | 0.1 |
| **Elminthidae** | *2.3* | 1.5 | *1.6* | 0.7 |
| **Empididae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Ephemerellidae** | *7.5* | 14.3 | *7.7* | 4.7 |
| **Ephemeridae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Erpobdellidae** | *0.5* | 0.3 | *0.9* | 0.3 |
| **Gammaridae** | *21.3* | 33.5 | *30.7* | 54.9 |
| **Glossiphoniidae** | *0.5* | 0.3 | *0.6* | 0.3 |
| **Goeridae** | *0.1* | 0.1 | *0.2* | 0.3 |
| **Gyrinidae** | *0.0* | 0.0 | *0.2* | 0.0 |
| **Haliplidae** | *0.0* | 0.0 | *0.2* | 0.0 |
| **Helodidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Heptageniidae** | *0.4* | 0.4 | *3.3* | 1.0 |
| **Hydrida** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Hydrobiidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Hydroporini** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Hydropsychidae** | *0.0* | 0.2 | *0.0* | 0.0 |
| **Hydroptilidae** | *0.1* | 0.1 | *0.2* | 0.0 |
| **Lepidostomatidae** | *0.6* | 0.3 | *0.0* | 0.0 |
| **Leptoceridae** | *0.7* | 0.3 | *0.1* | 0.2 |
| **Leptophlebiidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Leuctridae** | *0.7* | 0.4 | *0.0* | 0.1 |
| **Limnephilidae** | *0.7* | 0.3 | *2.1* | 0.6 |
| **Lymnaeidae** | *0.0* | 0.1 | *0.1* | 0.0 |
| **Mesoveliidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Molannidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Nepidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Neritidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Notonectidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Odontoceridae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Oligochaeta** | *1.0* | 0.9 | *6.8* | 3.9 |
| **Perlodidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Physidae** | *3.9* | 1.1 | *1.8* | 1.5 |
| **Piscicolidae** | *0.1* | 0.2 | *0.3* | 0.1 |
| **Planariidae** | *0.8* | 1.5 | *7.3* | 1.8 |
| **Planorbidae** | *0.4* | 0.0 | *0.4* | 0.0 |
| **Polycentropodidae** | *1.9* | 0.4 | *0.0* | 0.1 |
| **Psychomyiidae** | *0.3* | 0.2 | *0.2* | 0.1 |
| **Ptychopteridae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Rhyacophilidae** | *0.1* | 0.1 | *0.3* | 0.5 |
| **Sericostomatidae** | *0.2* | 0.0 | *0.1* | 0.0 |
| **Sialidae** | *0.2* | 0.0 | *0.1* | 0.0 |
| **Simuliidae** | *3.6* | 18.5 | *6.5* | 11.8 |
| **Sphaeriidae** | *3.6* | 0.1 | *0.1* | 0.1 |
| **Succinidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Tabanidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Tipulidae** | *0.1* | 0.0 | *0.8* | 0.3 |
| **Valvatidae** | *0.0* | 0.0 | *0.0* | 0.0 |
| **Zonitidae** | *0.0* | 0.0 | *0.0* | 0.0 |

## Table 20. Percentage compositions by family from restored and unrestored reaches of the Sherston and Malmesbury Avons

| | Pinkney | | Easton Grey (Gravel) | | | Cowage farm | | Hyams farm | | Kingsmead | | Great Somerford | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Status** | ***Unres*** | **Res** | ***Unres*** | ***Unres*** | ***Res*** | ***Unres*** | **Res** | ***Unres*** | **Res** | ***Unres*** | **Res** | ***Unres*** | **Res** |
| **Agriidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.2 |
| **Ancylidae** | *0.0* | 0.2 | *0.1* | *0.0* | 0.1 | *0.0* | 0.1 | *0.1* | 0.8 | *0.2* | 0.6 | *0.0* | 0.0 |
| **Asellidae** | *1.0* | 0.5 | *0.3* | *1.6* | 1.7 | *0.0* | 0.1 | *0.0* | 0.2 | *4.1* | 1.6 | *5.8* | 2.3 |
| **Astacidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Baetidae** | *4.9* | 0.6 | *2.3* | *5.5* | 12.1 | *2.7* | 3.2 | *0.5* | 4.4 | *3.8* | 4.2 | *20.7* | 32.9 |
| **Brachycentridae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Caenidae** | *2.9* | 0.1 | *3.6* | *6.6* | 12.0 | *0.9* | 0.1 | *1.5* | 0.1 | *9.1* | 3.3 | *6.4* | 5.6 |
| **Chironomidae** | *10.6* | 6.2 | *3.1* | *6.2* | 6.9 | *2.1* | 6.3 | *17.7* | 1.3 | *6.8* | 3.2 | *11.5* | 7.7 |
| **Chrysomelidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.1 | *0.1* | 0.1 | *0.0* | 0.0 |
| **Coenagriidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.0 | *0.1* | 0.0 |
| **Corixidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.1* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Dendrocoelidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.2* | 0.1 | *0.0* | 0.0 |
| **Dixidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.2* | 0.1 | *0.0* | 0.0 |
| **Dytiscidae** | *0.0* | 0.0 | *0.1* | *0.4* | 0.7 | *0.0* | 0.0 | *0.5* | 0.1 | *0.7* | 0.3 | *0.1* | 0.4 |
| **Elminthidae** | *0.1* | 0.1 | *0.3* | *0.2* | 1.9 | *0.0* | 0.0 | *2.3* | 0.6 | *0.5* | 0.5 | *2.7* | 0.2 |
| **Empididae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.1 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Ephemerellidae** | *11.2* | 1.1 | *6.9* | *13.9* | 15.1 | *3.7* | 4.7 | *5.6* | 4.7 | *32.2* | 14.5 | *10.3* | 22.5 |
| **Ephemeridae** | *0.3* | 0.1 | *1.1* | *1.7* | 2.2 | *0.3* | 0.1 | *0.3* | 0.1 | *1.2* | 0.5 | *0.0* | 0.0 |
| **Erpobdellidae** | *0.0* | 0.1 | *0.2* | *1.0* | 1.7 | *0.0* | 0.0 | *0.1* | 0.1 | *3.3* | 1.2 | *0.3* | 0.4 |
| **Gammaridae** | *8.4* | 0.5 | *5.0* | *30.9* | 25.7 | *4.6* | 1.8 | *6.1* | 15.8 | *2.1* | 10.9 | *8.0* | 12.3 |
| **Glossiphoniidae** | *0.3* | 0.1 | *0.2* | *0.8* | 0.9 | *0.1* | 0.1 | *0.1* | 0.1 | *0.5* | 0.3 | *0.1* | 0.4 |
| **Goeridae** | *0.2* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Gyrinidae** | *0.0* | 0.0 | *0.0* | *0.4* | 0.0 | *0.0* | 0.0 | *0.7* | 0.2 | *2.5* | 1.0 | *0.0* | 1.0 |
| **Haliplidae** | *0.0* | 0.0 | *0.0* | *0.4* | 0.0 | *0.0* | 0.0 | *0.7* | 0.2 | *2.5* | 1.0 | *0.0* | 1.0 |
| **Helodidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Heptageniidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.0 | *0.0* | 0.0 |
| **Hydrida** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Hydrobiidae** | *48.4* | 87.7 | *67.8* | *19.8* | 1.8 | *81.3* | 81.4 | *60.6* | 68.2 | *12.4* | 48.3 | *16.2* | 0.4 |
| **Hydroporini** | *0.0* | 0.0 | *0.0* | *0.4* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.0 | *0.0* | 0.0 |
| **Hydropsychidae** | *0.2* | 0.0 | *0.1* | *0.0* | 1.3 | *0.0* | 0.0 | *0.0* | 0.1 | *0.0* | 0.1 | *0.4* | 1.0 |
| **Hydroptilidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Lepidostomatidae** | *0.0* | 0.0 | *0.6* | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Leptoceridae** | *0.9* | 0.1 | *0.4* | *0.1* | 0.2 | *0.4* | 0.3 | *0.3* | 0.4 | *0.5* | 0.5 | *0.5* | 2.1 |
| **Leptophlebiidae** | *2.1* | 0.5 | *0.5* | *1.2* | 1.6 | *0.3* | 0.6 | *0.3* | 0.0 | *0.0* | 0.0 | *0.2* | 0.0 |
| **Leuctridae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.4 | *0.0* | 0.0 | *0.0* | 0.1 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Limnephilidae** | *0.0* | 0.2 | *0.5* | *3.4* | 2.8 | *0.2* | 0.2 | *0.6* | 0.3 | *0.0* | 0.2 | *0.3* | 0.0 |
| **Lymnaeidae** | *0.2* | 0.0 | *0.4* | *0.2* | 0.3 | *0.1* | 0.0 | *0.0* | 0.0 | *0.2* | 0.1 | *0.0* | 0.2 |
| **Mesoveliidae** | *0.0* | 0.0 | *0.0* | *0.1* | 0.2 | *0.0* | 0.0 | *0.1* | 0.0 | *0.1* | 0.0 | *0.0* | 0.0 |
| **Molannidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Nepidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.1 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Neritidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Notonectidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Odontoceridae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.1* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Oligochaeta** | *3.2* | 0.6 | *1.8* | *2.1* | 2.8 | *1.0* | 0.4 | *0.5* | 1.0 | *3.7* | 2.0 | *2.5* | 2.1 |
| **Perlodidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Physidae** | *0.0* | 0.0 | *0.0* | *0.8* | 0.9 | *0.1* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Piscicolidae** | *0.0* | 0.1 | *0.1* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.0 | *0.1* | 0.0 |
| **Planariidae** | *0.0* | 0.0 | *0.4* | *0.3* | 0.4 | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.0 | *0.2* | 0.0 |
| **Planorbidae** | *2.2* | 0.8 | *0.7* | *0.7* | 0.9 | *1.3* | 0.2 | *0.7* | 0.0 | *1.5* | 0.6 | *0.0* | 0.0 |
| **Polycentropodidae** | *0.0* | 0.0 | *0.1* | *0.0* | 0.9 | *0.0* | 0.1 | *0.1* | 0.0 | *7.4* | 2.6 | *4.8* | 1.7 |
| **Psychomyiidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.1 | *0.0* | 0.1 | *0.0* | 0.0 |
| **Ptychopteridae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Rhyacophilidae** | *0.0* | 0.0 | *1.4* | *0.8* | 1.6 | *0.0* | 0.0 | *0.0* | 0.2 | *0.0* | 0.1 | *0.0* | 0.0 |
| **Sericostomatidae** | *0.0* | 0.1 | *0.0* | *0.6* | 0.9 | *0.2* | 0.1 | *0.0* | 0.0 | *1.5* | 0.6 | *0.0* | 0.0 |
| **Sialidae** | *0.0* | 0.1 | *0.0* | *0.6* | 0.9 | *0.2* | 0.1 | *0.0* | 0.0 | *1.5* | 0.6 | *0.0* | 0.0 |
| **Simuliidae** | *0.6* | 0.0 | *0.9* | *0.0* | 1.9 | *0.1* | 0.0 | *0.0* | 0.2 | *0.1* | 0.1 | *5.3* | 5.2 |
| **Sphaeriidae** | *1.2* | 0.1 | *0.0* | *0.0* | 0.0 | *0.1* | 0.1 | *0.9* | 0.0 | *4.8* | 1.7 | *2.0* | 0.0 |
| **Succinidae** | *0.1* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Tabanidae** | *0.0* | 0.0 | *0.1* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.1 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Tipulidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.1* | 0.4 | *0.0* | 0.3 | *0.2* | 0.4 |
| **Valvatidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |
| **Zonitidae** | *0.0* | 0.0 | *0.0* | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 | *0.0* | 0.0 |

## Table 21. Mean /median diversity indices for all midstream and marginal samples

| Index | Midstream | Margin | P |
|---|---|---|---|
| **H’** | 1.997 | 2.132 | 0.067 |
| **D** | 4.9 | 6.10 | **0.03** |
| **J’** | 0.441 | 0.521 | ***<0.001*** |
| **No taxa** | 23.2 | 23.20 | 0.99 |
| **BMWP** | 131.4 | 117.80 | **0.024** |
| **ASPT** | 5.79 | 5.24 | ***<0.001*** |

**Bold** = significant, ***Bold Italics*** = highly significant

## Table 22. Relative abundance of families in marginal and midstream samples from all sites on three Wessex Rivers.

The significance of the differences in mean abundance is indicated by asterisks
Results of t-tests, NS=p>0.05, *, p<0.05, **, p<0.01, ***, p<0.001

| Midstream | Margin | No significant difference |
|---|---|---|
| Ancylidae*** | Asellidae*** | Agriidae |
| Brachycentridae* | Corixidae ** | Astacidae |
| Caenidae*** | Gyrinidae** | Baetidae |
| Elminthidae*** | Limnephilidae* | Chironomidae |
| Goeridae* | Lymnaeidae*** | Dytiscidae |
| Heptageniidae*** | Planorbidae*** | Ephemerellidae |
| Hydropsychidae*** | Sialidae* | Erpobdellidae |
| Leuctridae** | Succinidae* | Gammaridae |
| Rhyacophilidae*** | | Glossiphoniidae |
| Simuliidae*** | | Haliplidae |
| Tipulidae* | | Hydrobiidae |
| | | Lepidostomatidae |
| | | Leptoceridae |
| | | Leptophlebiidae |
| | | Notonectidae |
| | | Neritidae |
| | | Odontoceridae |
| | | Oligochaeta |
| | | Piscicolidae |
| | | Planariidae |
| | | Polycentropidae |
| | | Psychomyidae |
| | | Sericostomatidae |
| | | Sphaeriidae |

**Table 23. Results of paired t-tests on diversity indices from invertebrate data.**

Pooled margin and midstream samples

| | Mean/Median | | |
|---|---|---|---|
| **Index** | **Unrestored** | **Restored** | **p(sig)** |
| H' | 2.06 | 2.15 | 0.49(NS) |
| D | 5.37 | 5.93 | 0.86(NS) |
| No.Taxa | 23 | 23 | 0.87(NS) |
| Equit (J') | 0.498 | 0.518 | 0.50(NS) |
| BMWP | 170.5 | 169.9 | 0.91(NS) |
| ASPT | 5.66 | 5.61 | 0.50(NS) |

**Table 24. Results of paired t-test on diversity indices based on invertebrate family composition of midstream and marginal samples from three Wessex rivers. Summer 2000.**

| **Midstream Samples** | | | | |
|---|---|---|---|---|
| **Index** | **Value** | **Unrestored** | **Restored** | **p (sig)** |
| **H’** | Mean | 1.86 | 1.94 | |
| | *(1 SD)* | *0.59* | *0.4* | 0.45(NS) |
| **D** | Mean | 4.9 | 4.9 | |
| | *(1 SD)* | *2.7* | *1.83* | 0.95(NS) |
| **No Taxa** | Mean | 22.6 | 2.38 | |
| | *(1 SD)* | *4.7* | *4.8* | 0.33(NS) |
| **J’** | Mean | 0.41 | 0.43 | |
| | *(1 SD)* | *0.13* | *0.09* | 0.45(NS) |
| **BMWP** | Mean | 129 | 133.8 | |
| | *(1 SD)* | *29.2* | *27.7* | 0.5(NS) |
| **ASPT** | Mean | 5.84 | 5.74 | |
| | *(1 SD)* | *0.37* | *0.34* | 0.29(NS) |
| **Marginal Samples** | | | | |
| **Index** | **Value** | **Unrestored** | **Restored** | **p (sig)** |
| **H’** | Median | 2.13 | 1.82 | |
| | *Quartiles* | *1.8-2.4* | *1.9-2.3* | 0.94(NS) |
| **D** | Mean | 6 | 6.11 | |
| | *(1 SD)* | *2.7* | *2.8* | 0.24(NS) |
| **No Taxa** | Mean | 23.6 | 22.7 | |
| | *(1 SD)* | *4.7* | *4.7* | 0.24(NS) |
| **J’** | Median | 0.52 | 0.52 | |
| | *Quartiles* | *0.5-0.6* | *0.5-0.6* | 0.94(NS) |
| **BMWP** | Mean | 122.7 | 112.8 | |
| | *(1 SD)* | *28.7* | *297.8* | 0.1(NS) |
| **ASPT** | Mean | 5.33 | 5.2 | |
| | *(1 SD)* | *0.4* | *0.6* | 0.21(NS) |

**Table 25. Number of invertebrates species common and specific to restored and unrestored reaches, Wessex rivers, Summer 2000**

| River | Common | Unrestored | Restored |
|---|---|---|---|
| **Piddle/Devils Brook** | 52 | 2 | 4 |
| **Wylye/Till** | 51 | 2 | 3 |
| **Avon Reaches** | 45 | 6 | 1 |

**Table 26 Comparison of restoration methods on selected variable in three Wessex rivers**

| Variable | Type A (Sediment redistributions) | Type B (Sediment Augmentation) | p | Significance |
|---|---|---|---|---|
| **Substrate Diversity** | 1.47 | 1.63 | 0.15 | NS |
| **Max Depth** | 50.6 | 37.7 | 0.16 | NS |
| **Invertebrate Number** | 2.24 | 1.55 | 0.34 | NS |
| **Number of Taxa** | 32.2 | 29.2 | 0.23 | NS |
| **Equitability** | .55 | 0.37 | 0.13 | NS |
| **BMWP Score** | 172.6 | 160.8 | 0.42 | NS |
| **ASPT Score** | 5.62 | 5.63 | 0.13 | NS |

**Table 27. Values of p for the two-way ANOVA on invertebrate data from Wessex rivers and restored and unrestored reaches (see Figure 21)**

| PARAMETER | BETWEEN RIVERS | BETWEEN TREATMENTS | INTER-ACTION | SIGNIFICANT DIFFERENCES* |
|---|---|---|---|---|
| **H’** | 0.028 | 0.872 | 0.61 | Piddle>Avons |
| **J’** | 0.002 | 0.903 | 0.586 | Piddle.Avons |
| **No.Taxa** | 0.002 | 0.920 | 0.786 | Piddle.Avons<br>Piddle>Devil’s |
| **BMWP Score** | <0.001 | 0.903 | 0.618 | Piddle.Avons<br>Piddle>Devil’s |
| **ASPT** | 0.044 | 0.782 | 0.216 | None |

** Tukey-test or Student-Neuman Keuls test as appropriate. Significant=p<0.05*
*For all the Anova results all values over 0.05 indicate not-significant*

## Table 28. Summarised physical and biological data for all sites surveyed in three Wessex rivers. Summer 2000

| Site | U or R | SD depth (cm) | Max depth (cm) | Mean Width (m) | Substrate Diversity (H') | Substrate Diversity (D) | Substrate Categories (N) | Substrate Equitability (J') | Canopy Category (Code) | Weed *Ranunculus* (%cover) | Flora Number of Aquatics | Flora Number of Bankside | Invertebrates (Family level identification) Diversity (H') | Invertebrates Simpsons D | Invertebrates (Taxa) N' | Invertebrates Equitability (J') | BMWP Score | ASPT Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Devil's Brook** | **U** | 0.6 | 53 | 3 | 1.333 | 3.08 | 6 | 0.481 | 0 | 80 | 12 | 9 | 2.41 | 6.134 | 27 | 0.531 | 142 | 5.68 |
| **Devil's Brook** | **R** | 0.35 | 51 | 4 | 1.220 | 3.05 | 4 | 0.440 | 1 | 80 | 9 | 4 | 2.58 | 9.825 | 27 | 0.569 | 143 | 5.50 |
| **Devil's Brook** | **U** | 0.6 | 44 | 3 | 1.294 | 3.47 | 4 | 0.467 | 0 | 80 | 12 | 15 | 2.21 | 6.135 | 24 | 0.488 | 119 | 5.17 |
| **Devil's Brook** | **R** | 0.35 | 79 | 4 | 1.453 | 4.09 | 5 | 0.524 | 1 | 80 | 9 | 7 | 2.49 | 7.704 | 30 | 0.550 | 148 | 5.48 |
| **Devil's Brook** | **U** | 0.5 | 53 | 3 | 1.333 | 3.08 | 6 | 0.481 | 0 | 90 | 12 | 9 | 2.31 | 7.193 | 27 | 0.510 | 155 | 5.74 |
| **Devil's Brook** | **R** | 0.35 | 51 | 4 | 1.220 | 3.05 | 4 | 0.440 | 1 | 80 | 13 | 4 | 2.08 | 5.385 | 29 | 0.459 | 167 | 5.96 |
| **Devil's Brook** | **U** | 0.5 | 44 | 3 | 1.294 | 3.47 | 4 | 0.467 | 0 | 90 | 12 | 15 | 1.58 | 2.967 | 30 | 0.349 | 143 | 5.50 |
| **Devil's Brook** | **R** | 0.35 | 79 | 4 | 1.453 | 4.09 | 5 | 0.524 | 1 | 80 | 13 | 7 | 2.53 | 8.259 | 29 | 0.558 | 147 | 5.44 |
| **Burleston** | **U** | 0.5 | 49 | 7 | 1.519 | 3.96 | 7 | 0.548 | 2 | 30 | 10 | 11 | 2.57 | 8.251 | 38 | 0.634 | 200 | 5.71 |
| **Burleston** | **R** | 0.4 | 94 | 4 | 1.403 | 3.77 | 5 | 0.506 | 0 | 60 | 13 | 7 | 2.48 | 8.306 | 29 | 0.610 | 156 | 5.57 |
| **Park Farm** | **U** | 0.46 | 47 | 5 | 1.403 | 3.77 | 5 | 0.506 | 2 | 60 | 5 | 23 | 2.07 | 5.296 | 32 | 0.509 | 192 | 6.00 |
| **Park Farm** | **R** | 0.7 | 72 | 5 | 1.403 | 3.77 | 5 | 0.506 | 0 | 70 | 9 | 15 | 2.00 | 4.658 | 29 | 0.493 | 157 | 5.61 |
| **Southover** | **U** | 0.35 | 66 | 4 | 1.629 | 4.84 | 6 | 0.587 | 2 | 30 | 9 | 15 | 2.10 | 4.436 | 38 | 0.518 | 208 | 5.78 |
| **Southover** | **R** | 0.45 | 91 | 8 | 1.576 | 4.45 | 6 | 0.568 | 1 | 20 | 11 | 10 | 2.45 | 8.804 | 32 | 0.602 | 157 | 5.23 |
| **Briantspuddle** | **U** | 0.5 | 69 | 5 | 1.875 | 6.03 | 8 | 0.676 | 4 | 10 | 6 | 18 | 2.47 | 6.626 | 35 | 0.608 | 201 | 6.09 |
| **Briantspuddle** | **R** | 0.55 | 92 | 6 | 1.625 | 4.59 | 6 | 0.586 | 2 | 30 | 7 | 17 | 2.72 | 9.114 | 39 | 0.671 | 221 | 6.14 |
| **Throop** | **U** | 0.35 | 83 | 6 | 1.804 | 5.25 | 9 | 0.651 | 4 | 5 | 8 | 22 | 1.86 | 2.834 | 31 | 0.458 | 194 | 6.47 |
| **Throop** | **R** | 0.62 | 115 | -- | 1.726 | 5.04 | 7 | 0.623 | 1 | 40 | 13 | 14 | 2.33 | 5.217 | 38 | 0.573 | 213 | 5.61 |
| **Knook** | **U** | 0.45 | 100 | 8 | 1.414 | 3.86 | 5 | 0.510 | 1 | 90 | 12 | 18 | 1.73 | 3.489 | 31 | 0.429 | 178 | 5.74 |
| **Knook** | **R** | 0.4 | 78 | 10 | 1.483 | 4.01 | 6 | 0.535 | 2 | 80 | 13 | 17 | 2.08 | 5.076 | 30 | 0.517 | 160 | 5.52 |
| **Stockton** | **U** | 0.4 | 110 | 10 | 1.625 | 4.20 | 7 | 0.586 | 2 | 90 | 8 | 15 | 2.30 | 5.789 | 29 | 0.571 | 151 | 5.39 |
| **Stockton** | **R** | 0.5 | 110 | 8 | 1.684 | 4.84 | 7 | 0.607 | 1 | 50 | 9 | 15 | 2.25 | 6.523 | 35 | 0.559 | 183 | 5.72 |
| **Yarnbury Court** | **U** | 0.3 | 140 | 12 | 1.592 | 3.94 | 7 | 0.574 | 3 | 20 | 8 | 12 | 0.52 | 1.223 | 26 | 0.129 | 144 | 5.54 |
| **Yarnbury Court** | **R** | 0.62 | 91 | 9 | 1.168 | 2.74 | 5 | 0.421 | 1 | 50 | 9 | 7 | 1.89 | 3.668 | 25 | 0.470 | 139 | 5.56 |
| **Till, Stapleford** | **U** | 0.4 | 83 | 7 | 1.523 | 3.82 | 7 | 0.549 | 3 | 10 | 11 | 16 | 2.06 | 4.310 | 34 | 0.552 | 192 | 6.00 |
| **Till, Stapleford** | **R** | 0.68 | 102 | 7 | 1.479 | 3.68 | 6 | 0.533 | 1 | 70 | 9 | 13 | 2.04 | 5.226 | 32 | 0.546 | 181 | 5.84 |
| **Till, Uffington House** | **U** | 0.6 | 92 | 9 | 1.294 | 3.05 | 6 | 0.467 | 2 | 40 | 12 | 19 | 2.46 | 7.975 | 33 | 0.659 | 174 | 5.44 |
| **Till, Uffington House** | **R** | 0.95 | 76 | 8 | 1.082 | 2.26 | 6 | 0.390 | 3 | 10 | 12 | 19 | 1.75 | 3.026 | 28 | 0.468 | 169 | 6.04 |
| **Langford Fisheries** | **U** | 0.4 | 115 | 10 | 1.917 | 5.21 | 11 | 0.691 | 0 | 60 | 14 | 17 | 2.89 | 12.307 | 41 | 0.718 | 222 | 5.69 |
| **Langford Fisheries** | **R** | 0.4 | 102 | 11 | 1.583 | 3.57 | 8 | 0.571 | 3 | 20 | 14 | 24 | 2.69 | 8.541 | 38 | 0.669 | 211 | 5.86 |
| **Hanging Langford** | **U** | 0.28 | 125 | 9 | 1.515 | 3.02 | 9 | 0.547 | 2 | 30 | 17 | 20 | 2.31 | 5.703 | 39 | 0.575 | 219 | 5.62 |
| **Hanging Langford** | **R** | 0.48 | 95 | 8 | 1.791 | 4.95 | 8 | 0.646 | 3 | 40 | 13 | 17 | 2.24 | 5.544 | 32 | 0.556 | 165 | 5.32 |
| **Great Wishford** | **U** | 0.2 | 135 | 21 | 1.392 | 3.54 | 6 | 0.502 | 0 | 50 | 10 | 25 | 1.91 | 5.187 | 34 | 0.474 | 169 | 5.45 |
| **Great Wishford** | **R** | 0.3 | 150 | 18 | 1.562 | 4.73 | 6 | 0.563 | 0 | 50 | 14 | 17 | 2.15 | 5.568 | 37 | 0.535 | 196 | 5.60 |
| **Wilton** | **U** | 0.56 | 52 | 14 | 0.997 | 2.01 | 8 | 0.360 | 1 | 40 | 7 | 26 | 2.15 | 4.456 | 35 | 0.533 | 191 | 5.79 |
| **Wilton** | **R** | 0.3 | 101 | 10 | 1.460 | 4.08 | 6 | 0.526 | 0 | 80 | 18 | 21 | 2.23 | 5.714 | 41 | 0.553 | 209 | 5.65 |
| **Pinkney** | **U** | 0.2 | 33 | 7 | 1.412 | 3.22 | 6 | 0.509 | 0 | 10 | 13 | 24 | 1.88 | 3.698 | 26 | 0.415 | 132 | 5.50 |
| **Pinkney** | **R** | 0.6 | 46 | 8 | 1.627 | 5.09 | 6 | 0.587 | 2 | 0 | 13 | 19 | 0.62 | 1.292 | 25 | 0.136 | 135 | 5.40 |
| **Easton Grey** | **U** | 0.2 | 90 | 10 | 1.956 | 5.45 | 11 | 0.705 | 4 | 5 | 13 | 20 | 1.47 | 2.128 | 29 | 0.323 | 154 | 5.70 |
| **Easton Grey** | **R** | 0.5 | 90 | 13 | 2.079 | 7.37 | 10 | 0.750 | 1 | 80 | 15 | 17 | 2.51 | 7.889 | 30 | 0.554 | 160 | 5.52 |
| **Cowage farm** | **U** | 0.4 | 105 | 7 | 1.557 | 4.36 | 7 | 0.562 | 1 | 5 | 15 | 14 | 0.90 | 1.501 | 24 | 0.199 | 144 | 6.00 |
| **Cowage farm** | **R** | 0.5 | 78 | 6 | 1.743 | 4.89 | 8 | 0.629 | 1 | 0 | 7 | 16 | 0.83 | 1.494 | 27 | 0.184 | 153 | 5.67 |
| **Hyams Farm** | **U** | 0.2 | 67 | 7 | 1.765 | 5.11 | 8 | 0.637 | 3 | 0 | 10 | 12 | 1.43 | 2.462 | 27 | 0.315 | 152 | 5.63 |
| **Hyams Farm** | **R** | 0.45 | 27 | 7 | 1.580 | 4.45 | 7 | 0.570 | 3 | 5 | 12 | 11 | 1.20 | 2.021 | 30 | 0.265 | 167 | 5.76 |
| **Kingsmead** | **U** | 0.25 | 52 | 10 | 1.624 | 3.82 | 9 | 0.586 | 1 | 0 | 11 | 32 | 2.42 | 6.818 | 31 | 0.533 | 155 | 5.17 |
| **Kingsmead** | **R** | 0.95 | 50 | 10 | 1.634 | 3.34 | 10 | 0.589 | 1 | 5 | 9 | 20 | 1.95 | 3.677 | 40 | 0.430 | 215 | 5.66 |
| **Great Somerford** | **U** | 0.54 | 88 | 9 | 1.509 | 3.70 | 7 | 0.544 | 1 | 30 | 7 | 10 | 2.42 | 8.842 | 24 | 0.534 | 126 | 5.25 |
| **Great Somerford** | **R** | 0.7 | 105 | 12 | 1.214 | 2.80 | 7 | 0.438 | 0 | 5 | 8 | 18 | 2.08 | 5.371 | 21 | 0.458 | 107 | 5.10 |

**Table 29. Results of paired t-tests comparing physical data from all restored and unrestored reaches of three Wessex rivers. Summer 2000**

| Variable | Treatment | Mean | SD | p |
|---|---|---|---|---|
| **Maximum depth** | ***Unrestored*** | 78.96 | 31.25 | |
| **(cm)** | ***Restored*** | 84.38 | 26.49 | 0.33 |
| **Average width** | ***Unrestored*** | 7.54 | 4.12 | |
| **(m)** | ***Restored*** | 7.70 | 3.33 | 0.70 |
| **Maximum current** | ***Unrestored*** | 0.41 | 0.14 | |
| **velocity ($ms^{-1}$)** | ***Restored*** | 0.52 | 0.18 | **0.03*** |
| **H' (substrates)** | ***Unrestored*** | 1.52 | 0.23 | |
| | ***Restored*** | 1.51 | 0.23 | 0.76 |
| **Simpsons D (substrates)** | ***Unrestored*** | 3.97 | 0.94 | |
| | ***Restored*** | 4.11 | 1.06 | 0.42 |
| **Number of substrate types** | ***Unrestored*** | 7.04 | 1.85 | |
| | ***Restored*** | 6.38 | 1.58 | **0.02*** |
| **Equitability (J') (substrates)** | ***Unrestored*** | 0.55 | 0.08 | |
| | ***Restored*** | 0.55 | 0.08 | 0.76 |
| **Canopy (categories 0-4)** | ***Unrestored*** | 1.58 | 1.38 | |
| | ***Restored*** | 1.25 | 0.99 | 0.32 |
| **% instream weed cover** | ***Unrestored*** | 39.80 | 32.60 | |
| | ***Restored*** | 45.20 | 30.70 | 0.37 |

## Table 30 Percentage changes between unrestored and restored reaches of three Wessex Rivers. Summer 2000

| SITES | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unrestored** | **Restored** | **Treatment** | **Depth** | **Width** | **Velocity** | **H'Subs** | **Simsubs** | **Catsubs** | **Equsubs** | **Canopy** | **% Cover** |
| **Devil's Brook** | **Devil's Brook** | ***EX*** | -3.77 | 35.48 | -41.67 | -8.51 | -0.99 | -33.33 | -8.51 | 100.00 | 0.00 |
| **Devil's Brook** | **Devil's Brook** | ***EX*** | 79.55 | 35.48 | -41.67 | 12.30 | 17.91 | 25.00 | 12.31 | 100.00 | 0.00 |
| **Devil's Brook** | **Devil's Brook** | ***EX*** | -3.77 | 35.48 | -30.00 | -8.51 | -0.99 | -33.33 | -8.51 | 100.00 | -11.11 |
| **Devil's Brook** | **Devil's Brook** | ***EX*** | 79.55 | 35.48 | -30.00 | 12.30 | 17.91 | 25.00 | 12.31 | 100.00 | -11.11 |
| **Burleston** | **Burleston** | ***AUG*** | 91.84 | -61.17 | -20.00 | -7.65 | -4.90 | -28.57 | -7.65 | -100.00 | 100.00 |
| **Park Farm** | **Park farm** | ***AUG*** | 53.19 | 0.00 | 52.17 | 0.00 | 0.00 | 0.00 | 0.00 | -100.00 | 16.67 |
| **Southover** | **Southover** | ***EX*** | 37.88 | 48.89 | 28.57 | -3.24 | -7.90 | 0.00 | -3.23 | -50.00 | -33.33 |
| **Briantspuddle** | **Briantspuddle** | ***EX*** | 33.33 | 18.03 | 10.00 | -13.33 | -23.91 | -25.00 | -13.33 | -50.00 | 200.00 |
| **Throop** | **Throop** | ***EX*** | 38.55 | 14.29 | 77.14 | -4.31 | -4.00 | -22.22 | -4.30 | -75.00 | 700.00 |
| **Knook** | **Knook** | ***EX*** | -22.00 | 15.79 | -11.11 | 4.88 | 4.00 | 20.00 | 4.88 | 100.00 | -11.11 |
| **Stockton** | **Stockton** | ***EX*** | 0.00 | -18.75 | 25.00 | 3.60 | 15.23 | 0.00 | 3.60 | -50.00 | -44.44 |
| **Yarnbury Court** | **Yarnbury court** | ***EX*** | -35.00 | -35.29 | 106.67 | -26.65 | -30.59 | -28.57 | -26.65 | -67.00 | 150.00 |
| **Till, Uffington** | **Till, Uffington** | ***AUG*** | 22.89 | 0.00 | 70.00 | -2.88 | -3.55 | -14.29 | -2.88 | -67.00 | 600.00 |
| **Till, Stapleford** | **Till, Stapleford** | ***AUG*** | -17.39 | -13.33 | 58.33 | -16.40 | -25.83 | 0.00 | -16.40 | 67.00 | -75.00 |
| **Langford Fishery** | **Langford Fishery** | ***AUG*** | -11.30 | 9.52 | 0.00 | -17.41 | -31.50 | -27.27 | -17.41 | 100.00 | -66.67 |
| **Hanging Langford** | **Hanging Langford** | ***AUG*** | -24.00 | -13.33 | 71.43 | 18.17 | 64.03 | -11.11 | 18.17 | 67.00 | 33.33 |
| **Little Wishford** | **Little Wishford** | ***AUG*** | 11.11 | -20.00 | 50.00 | 12.22 | 33.52 | 0.00 | 12.22 | 0.00 | 0.00 |
| **Wilton** | **Wilton** | ***AUG*** | 94.23 | -42.11 | -46.43 | 46.34 | 103.04 | -25.00 | 46.35 | -100.00 | 100.00 |
| **Pinkney** | **Pinkney** | ***AUG*** | 39.39 | 13.33 | 200.00 | 15.26 | 57.95 | 0.00 | 15.26 | 100.00 | -100.00 |
| **Easton Grey** | **Easton Grey** | ***AUG*** | 0.00 | 23.08 | 150.00 | 6.31 | 35.13 | -9.09 | 6.31 | -75.00 | 1500.00 |
| **Cowage Farm** | **Cowage Farm** | ***AUG*** | -25.71 | -18.18 | 25.00 | 11.96 | 12.22 | 14.29 | 11.96 | 0.00 | -100.00 |
| **Hyams Farm** | **Hyams Farm** | ***AUG*** | -59.70 | -2.57 | 125.00 | -10.49 | -12.95 | -12.50 | -10.49 | 0.00 | 0.00 |
| **Kingsmead** | **Kingsmead** | ***EX*** | -3.85 | 5.00 | 280.00 | 0.60 | -12.65 | 11.11 | 0.61 | 0.00 | 0.00 |
| **Great Somerford** | **Great Somerford** | ***EX*** | 19.32 | 26.53 | 29.63 | -19.56 | -24.43 | 0.00 | -19.56 | -100.00 | -83.33 |

*Ex =excavation treatment, AUG= gravel augmentation*

**Table 31. Values of p for the 2-way ANOVA on physical variables measured in three Wessex streams. Summer 2000**

| Variable | Between Rivers | Between Treatments | Interaction |
|---|---|---|---|
| **Maximum depth** | ***<0.001*** | 0.34 | 0.27 |
| **Average width** | ***<0.001*** | 0.79 | 0.68 |
| **Maximum velocity** | **0.015** | **0.004** | ***<0.001*** |
| **H' (substrates)** | **0.011** | 0.64 | 0.9 |
| **J' (substrates)** | **0.011** | 0.64 | 0.9 |
| **D (substrates)** | **0.03** | 0.89 | 0.73 |
| **No. substrate types** | ***<0.001*** | 0.17 | 0.88 |
| **Canopy (categorical)** | **0.07** | 0.33 | 0.06 |
| **% weed cover** | **0.001** | **0.036** | 0.8 |

**bold** = significant***, bold-italics*** = highly significant,

**Table 32. Correlation matrix for structural and biological variables in three Wessex rivers. (bold = negative correlation)**

| | **Biological variables** | | | | | |
|---|---|---|---|---|---|---|
| **Structural variables** | ***% Cover*** | ***H'*** | ***J'*** | ***No.Taxa*** | ***BMWP*** | ***ASPT*** |
| **Max. current velocity** | | | | | | |
| **Max. depth** | | | | | | |
| **Average width** | | | | | | |
| **Physical diversity (H')** | | | | <0.05 | 0.039 | |
| **No. Physical features (N)** | | | | 0.02 | 0.014 | |
| **Physical evenness (J')** | | | | <0.05 | 0.039 | |
| **Canopy (density categories)** | **<0.001** | | | | | |
| **% cover Ranunculus spp.** | | 0.004 | 0.004 | | | |
| **No. of weed species(aquatic)** | | | | | | |
| **No. of weed species (bankside)** | | | | | | |

NB. Only significant correlations are shown

**Table 33. Target variables for estimating a Conservation Standard for a 50m reach of the River Wylye in the middle reaches (hypothetical example)**

| Organisms | Index (variable) | Target Value | Target Species |
|---|---|---|---|
| **Invertebrates** | BMWP | 200 | Vertigo sp. |
| | ASPT | 6 | A. pallipes |
| | No. taxa | 24 | |
| **Plants** | Instream spp | 6 | R. peltatus |
| | Bankside spp. | 27 | O. crocata |
| | % *Ranunculus* cover | 50 | |
| **Fish** | No Species | 9 | S. salar |
| | Total abundance | 10 | C. gobio |
| | Diversity (H') | 1.9 | L. planeri |
| | Equitability | 0.5 | |
| **Basic model (inverts)** | Rank log abundance | Truncated log normal | |

Points may be given for each variable and target species if a single index is required. Restoration or management actions may be specified to attain each component of the model.

An alternative name could be "Biodiversity Standards or Index for Rivers".

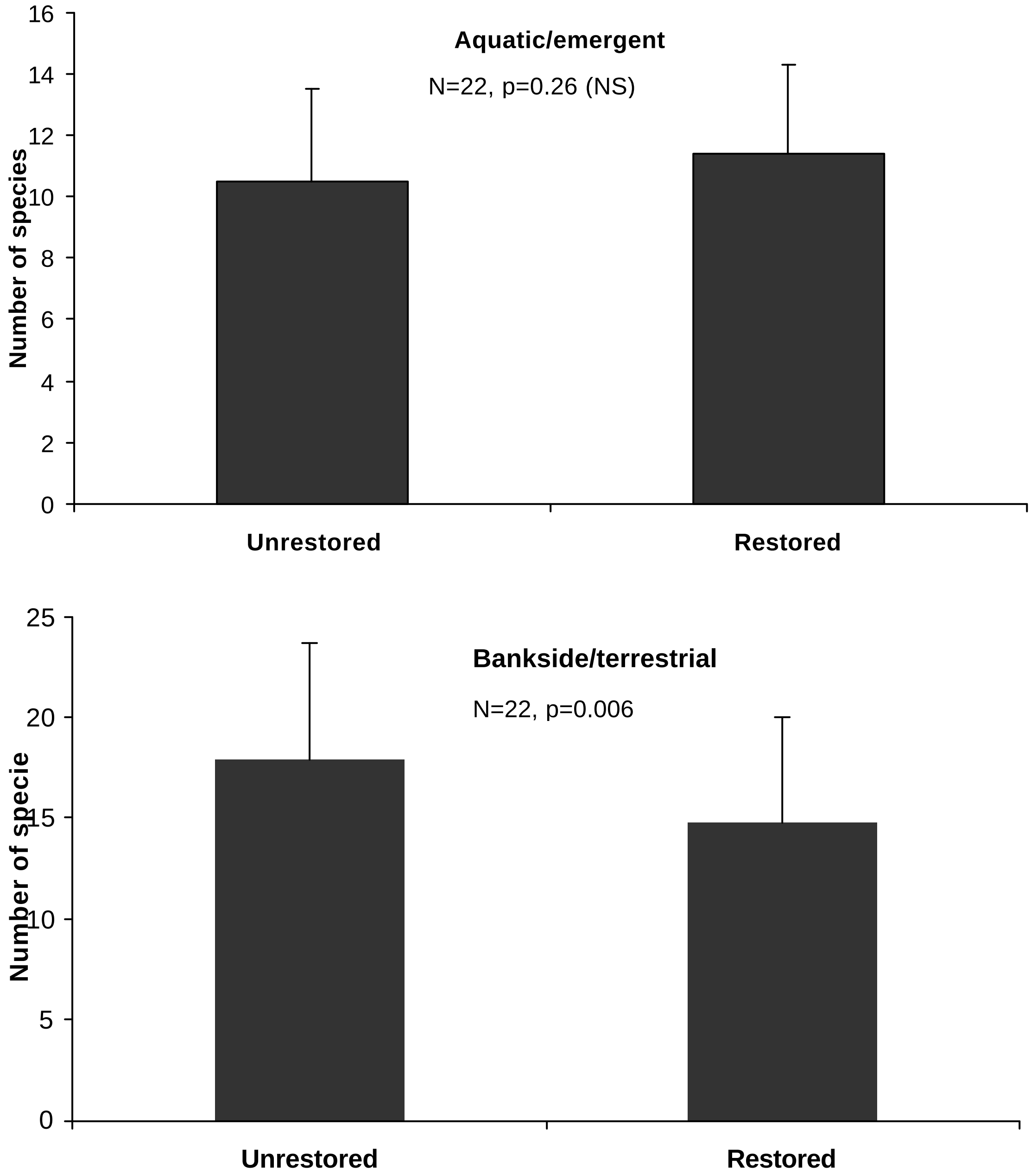



**Fig. 6** **Mean species richness of plants in all restored and unrestored reaches of three Wessex rivers. Summer2000**

***Results from paired-t-tests, ** = highly significant,***
***NS= not significant, p=>0.05***

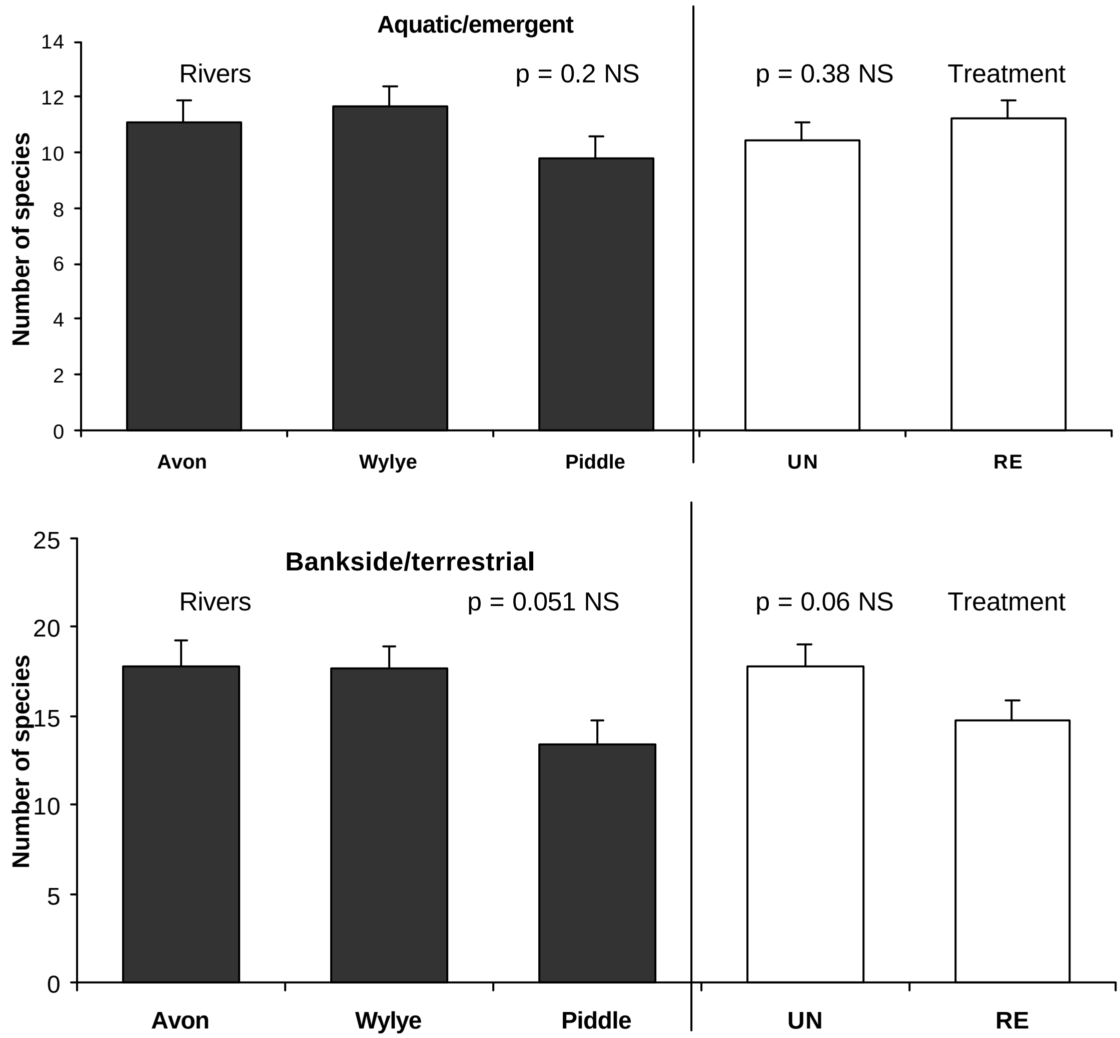



**Fig. 7 Results of two-way ANOVAS on plant species richness from restored and unrestored reaches of three Wessex rivers**

***NS= not significant (p>0.05)***

***No interactions, p=0.53 and 0.57 respectively***

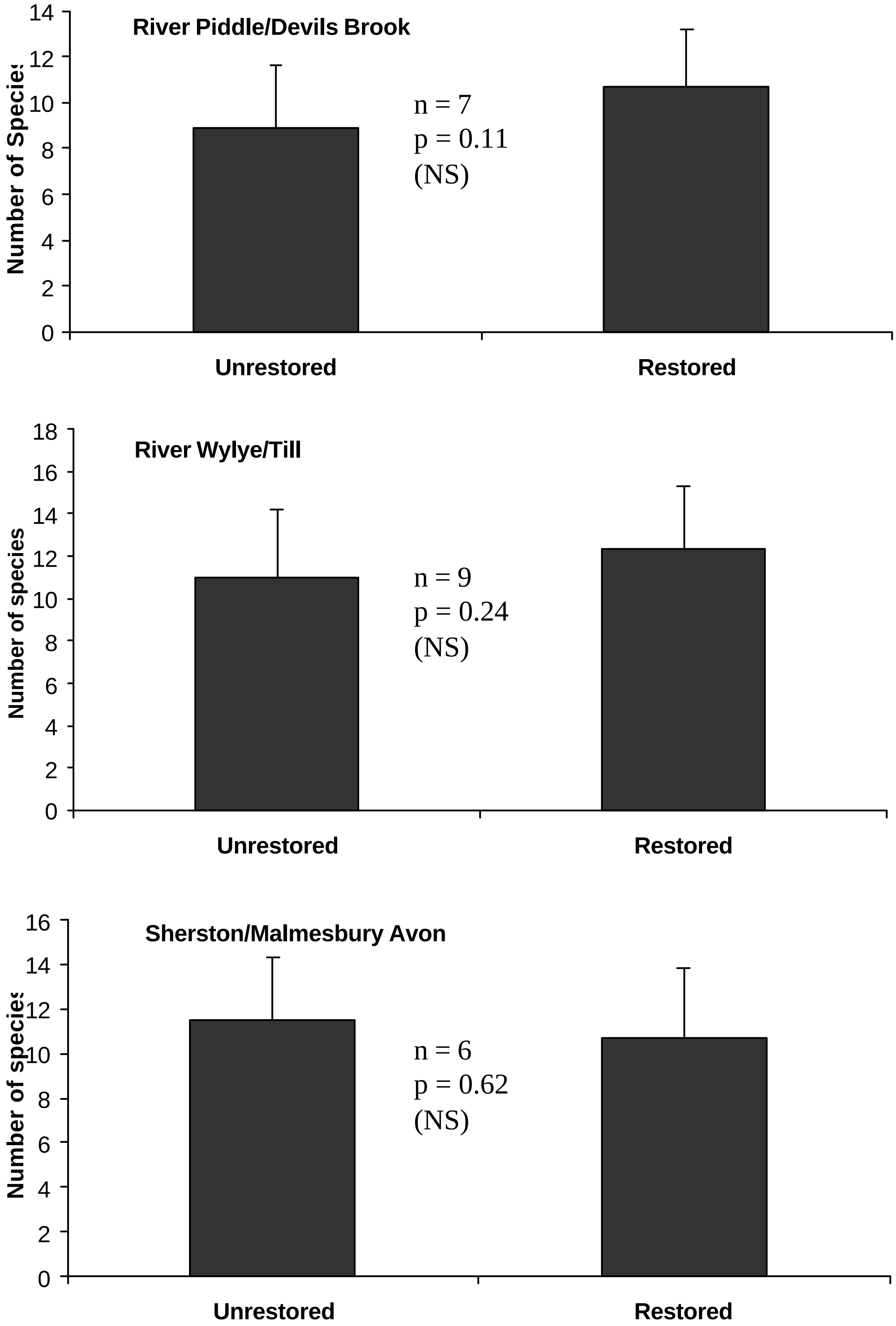



**Fig 8.** **Mean species-richness of aquatic plants in restored and unrestored reaches of three Wessex Rivers. Summer 2000.**
***error bars = 1 standard deviation***
***n= number pf samples, NS = not significant (p>0.05)***

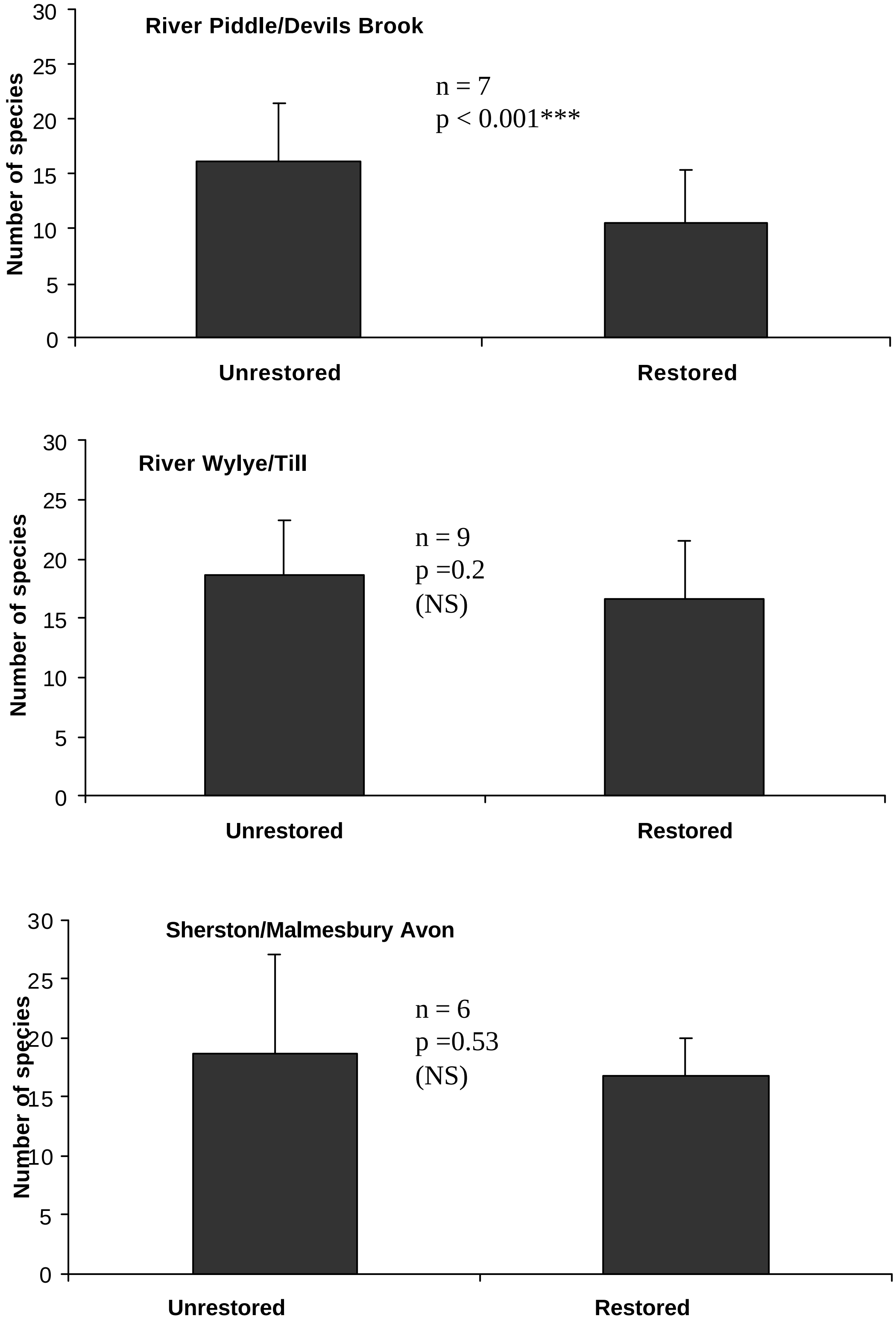



**Fig 9. Mean species richness of bankside plants and unrestored reaches of three Wessex rivers. Summer 2000**
***error bars = 1 standard deviation***
***n= number pf samples, NS = not significant (p>0.05)***

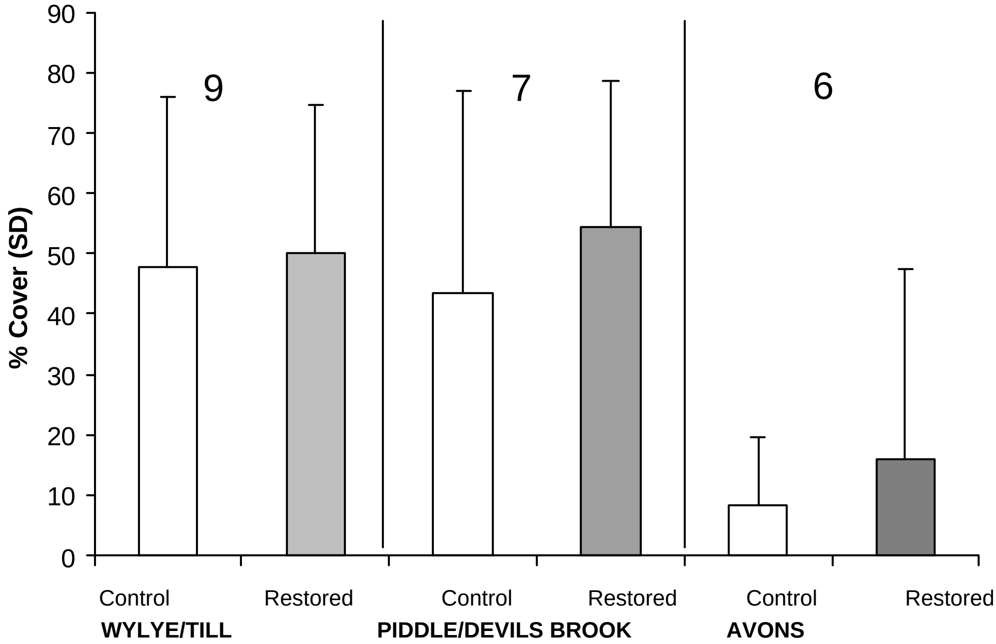



**Fig 10. Mean and standard deviations of percentage cover estimates for *Ranunculus* spp. at various sites in three river systems. (Cover estimates over 50 m reaches) (Number of replicates shown on figure).**

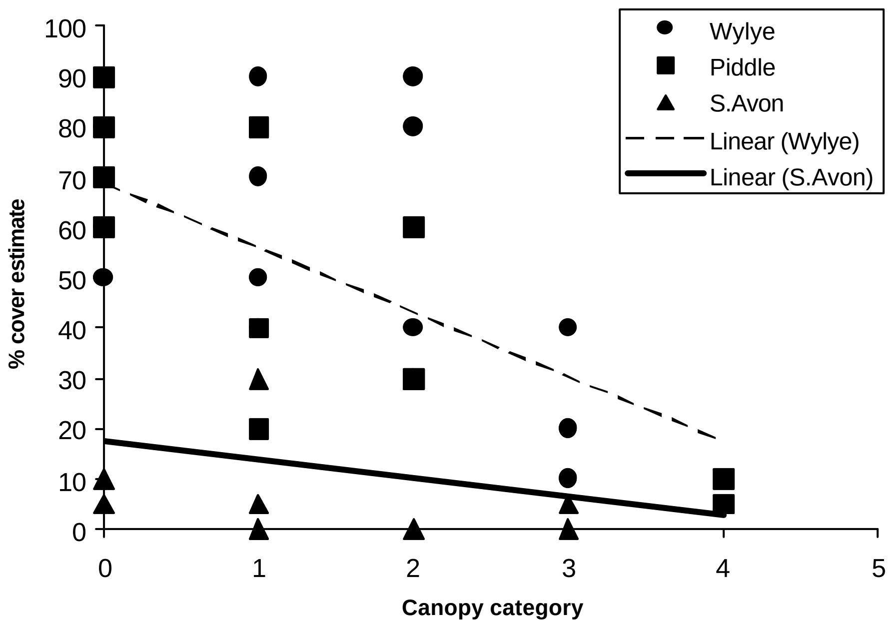



**Fig 11 Percentage of *Ranunculus* spp. in relation to categories of shade (estimated from tree density and occurrence) along three Wessex rivers.**

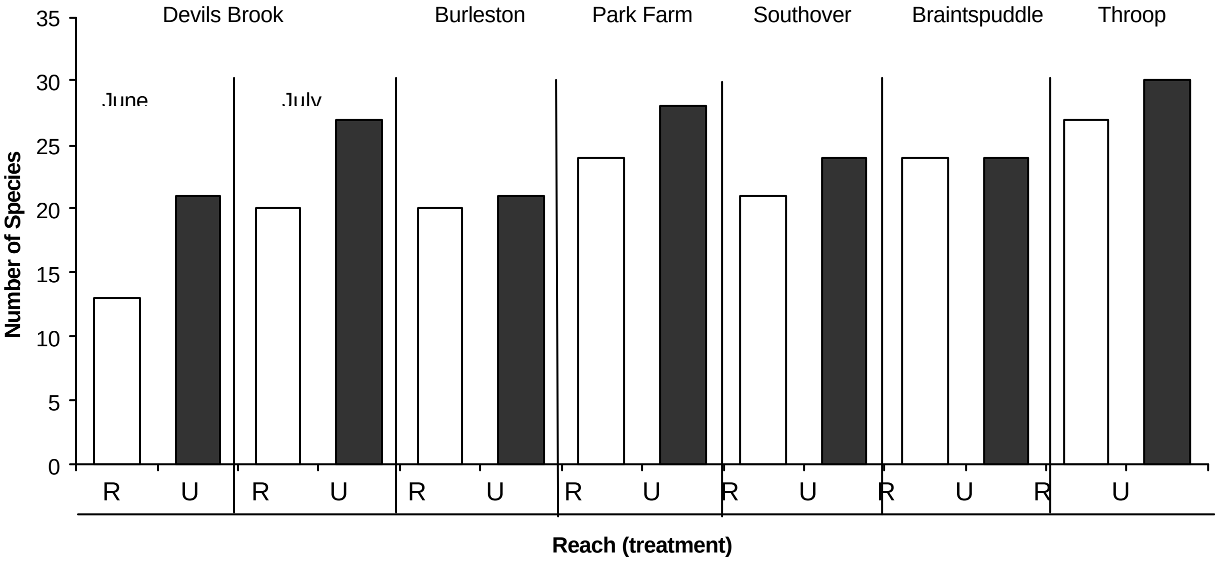



**Fig. 12 Numbers of plants species recorded at sites along the Devils Brook and River Piddle.**

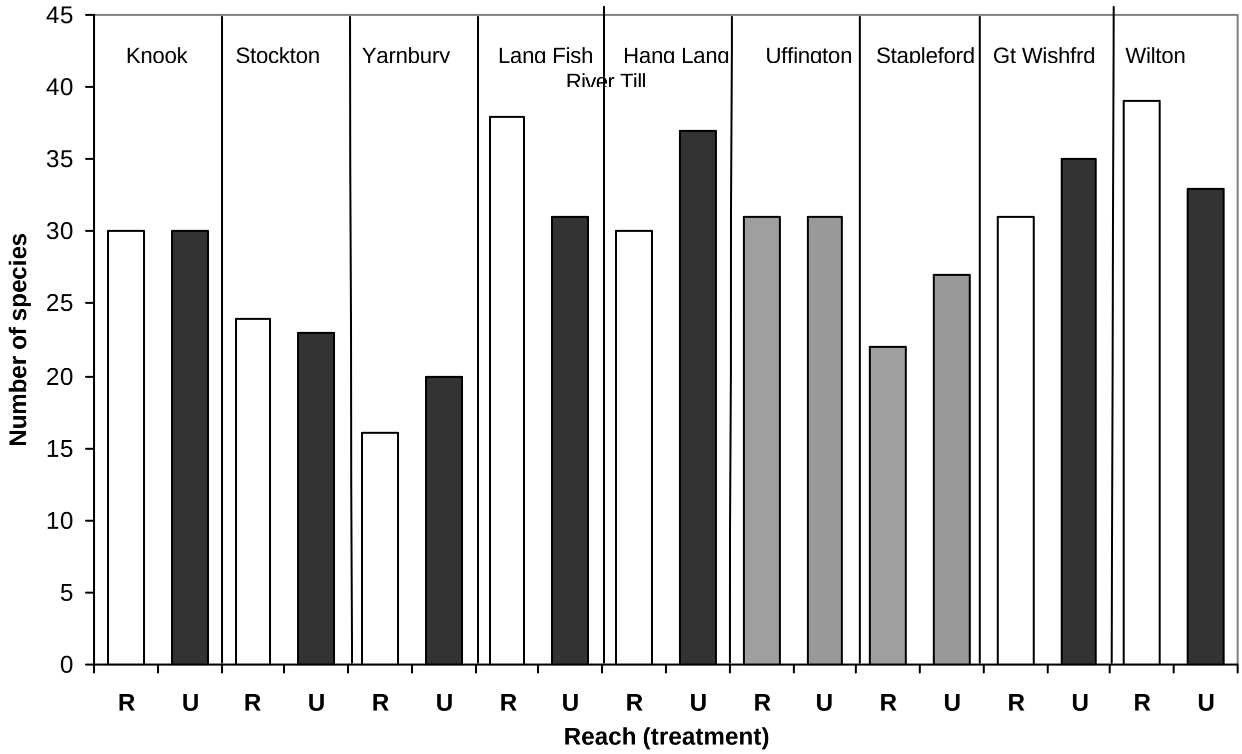



**Fig 13. Numbers of plant species recorded at sites along the River Wylye and River Till.**
**R = restored, U = unrestored. All species, aquatics plus terrestrial.**

**Fig 14 A comparison of the number of plant species recorded on restored (unfilled) and unrestored (filled) sites along the Devils Brook and the R. Piddle.**

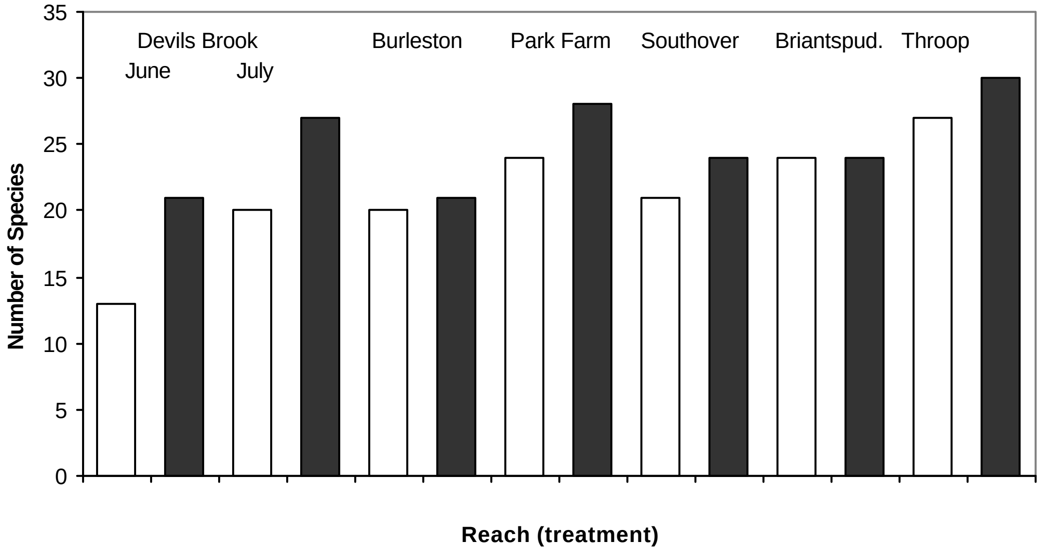


**Fig 15 b Species accumulation curves for bankside and terrestrial plants in three Wessex rivers. Summer 2000**

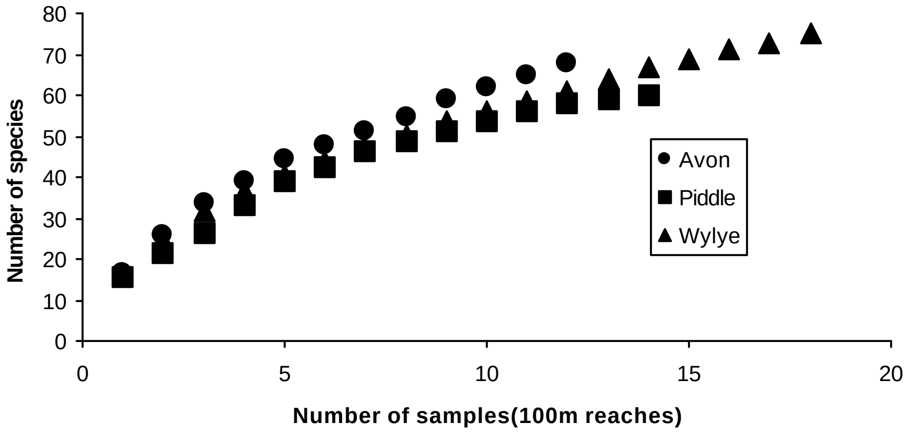
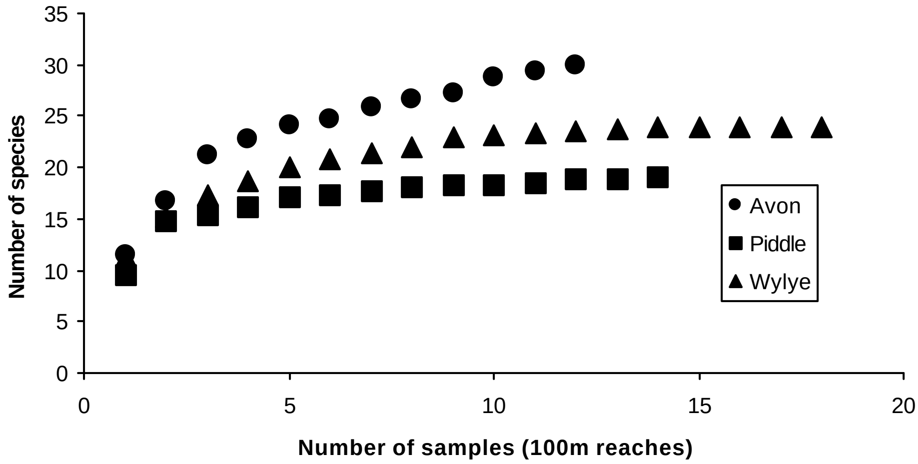



**Fig 15a Species accumulation curves for Aquatic and emergent plants in three Wessex rivers. Summer 2000**



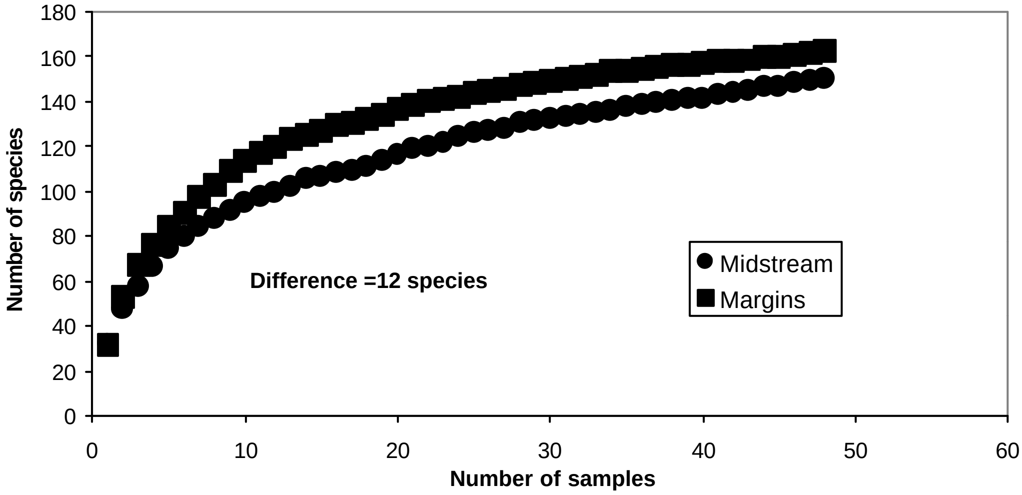



**Fig 16 Species accumulation curves for invertebrates in midstream and marginal habitat samples in three Wessex rivers. Summer 2000. (10 random iterations)**

**Figure 17. Diagrammatic representation of reaches for which data were summed to make comparisons compared in Figure 18. (Pairs of samples for cumulative comparisons) a, b, c see Figure 18, U-unrestored, R=restored**

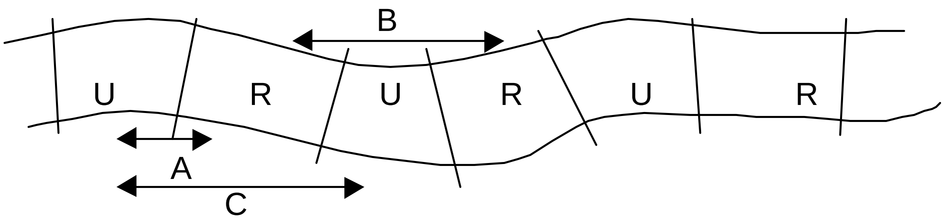
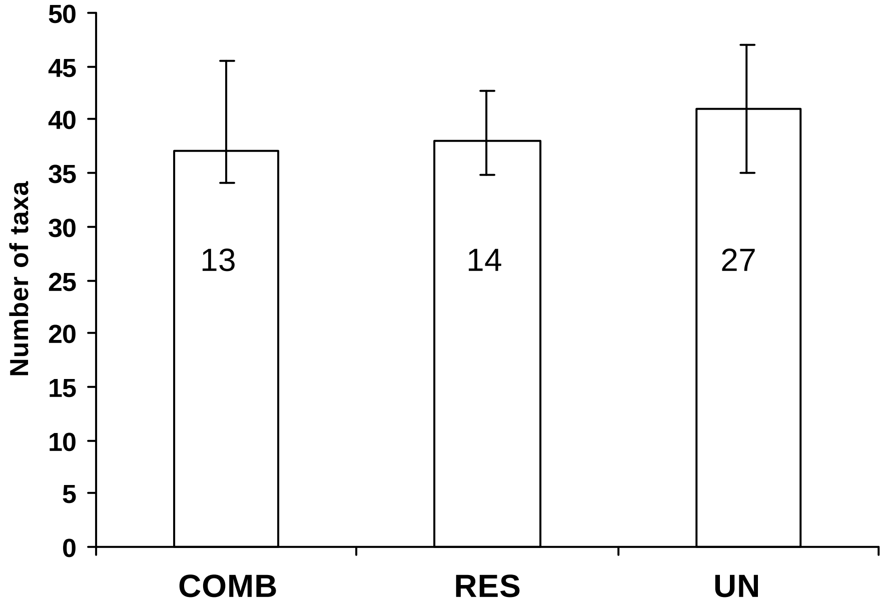


**Fig 18 Median and quartile numbers of BMWP families after accumulation of pairs of reaches (see Fig 17)**




**COMB= data accumulated from restored and unrestored reach at one site.**
**RES=data combined from adjacent restored reaches.**
**UNRES= data combined from adjacent unrestored reaches.**
**Number of samples shown in column**

**Fig 19 Species accumulation curves for midstream and marginal invertebrate samples from restored and unrestored reaches of three Wessex rivers**

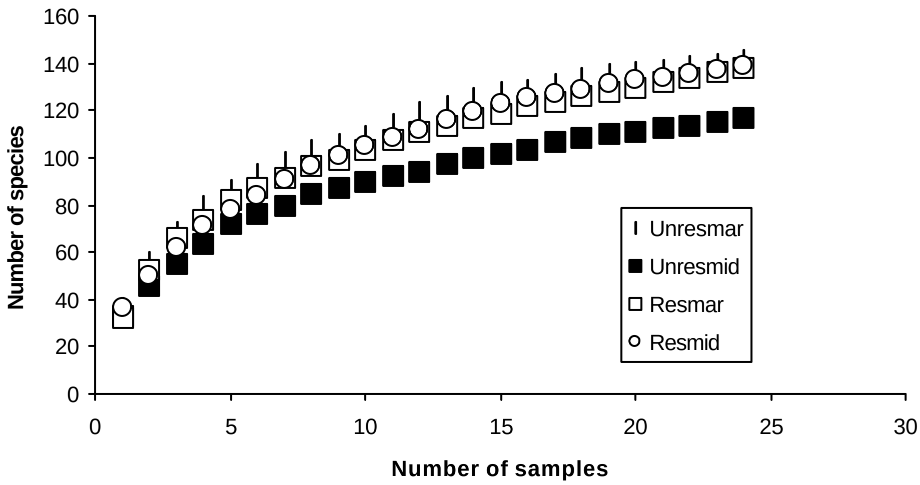


**Fig 20 Species accumulation curves for all samples from restored (Allrest) and unrestored (Allunrest) reaches in three Wessex rivers.**

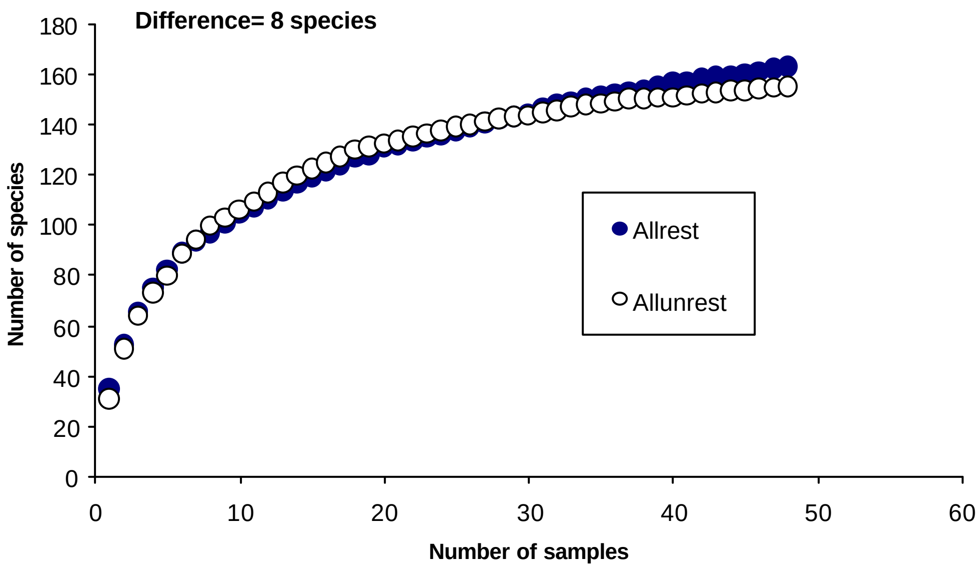


**Fig 21 Mean values for diversity and quality indices for invertebrates.**

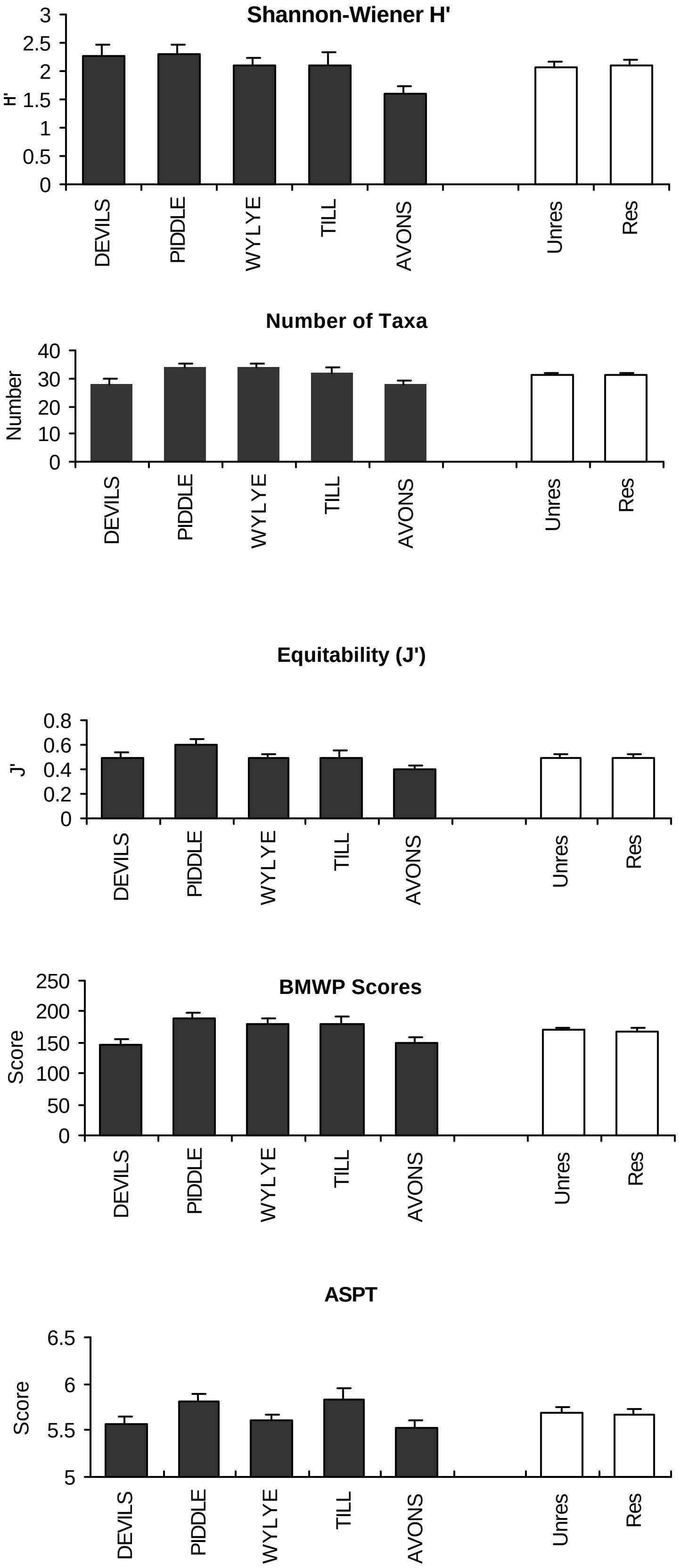


**Fig 22 Results of diversity ordering (Renyi index) for invertebrate data for all samples from reaches of five streams in the Wessex river systems.**

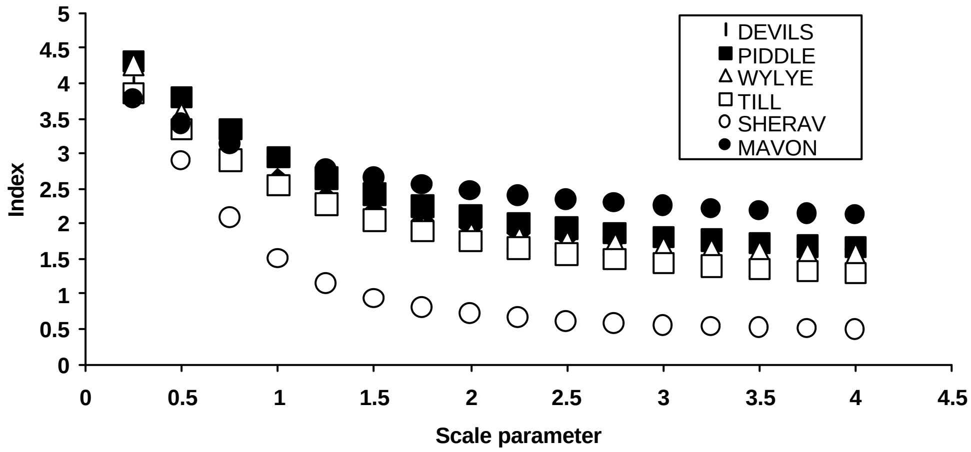



**Fig 23 BMWP Scores from the Devil's Brook and River Piddle compared with Environment Agency data. White= EA data, black = unrestored reaches hatched=restored reaches.**

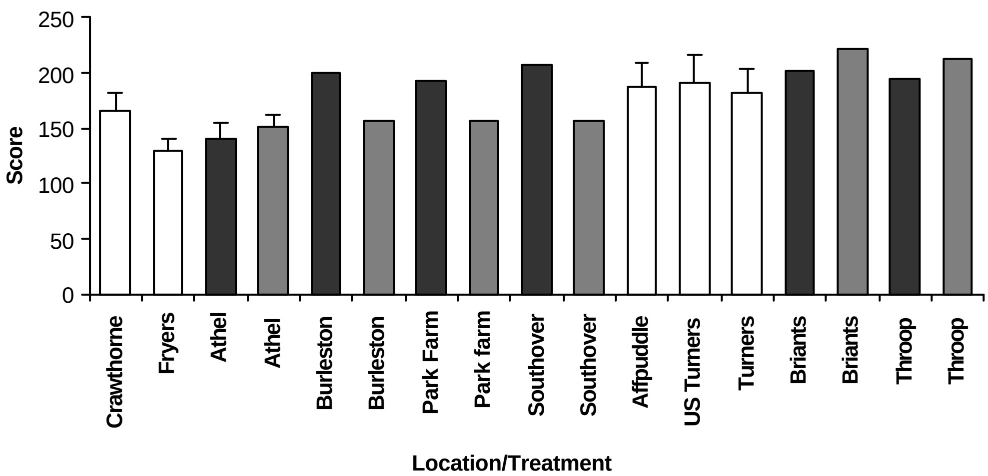


**Fig 24 BMWP Scores from Environment Agency surveys (clear) and restoration surveys (black). (EA data are means from various years, all W prefixes are from restoration survey, U=unrestored. R = restored. Sites are listed in Table 1.**

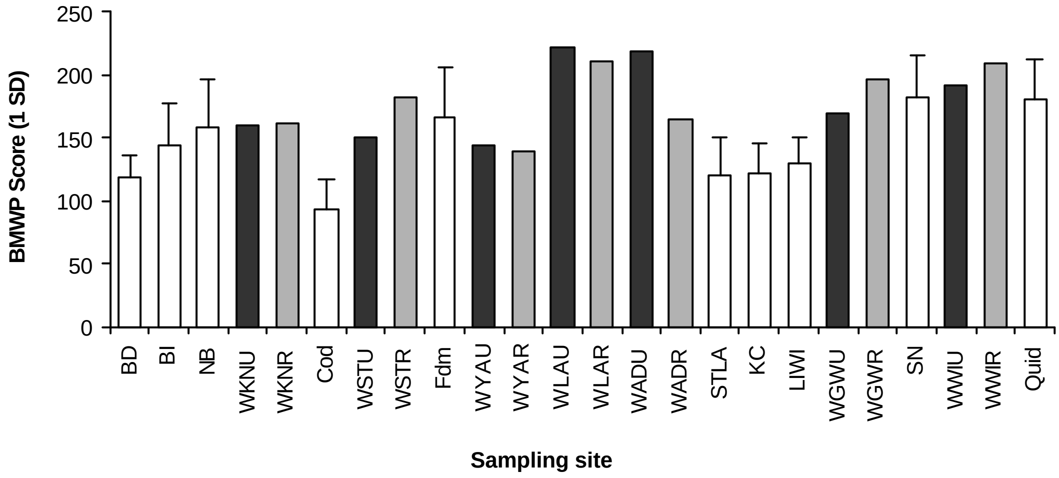



**Fig 25 BMWP scores from the Sherston and Malmesbury Avons compared with data from Environment Agency surveys. (white= EA data, black=unrestored hatched=restored reaches).**

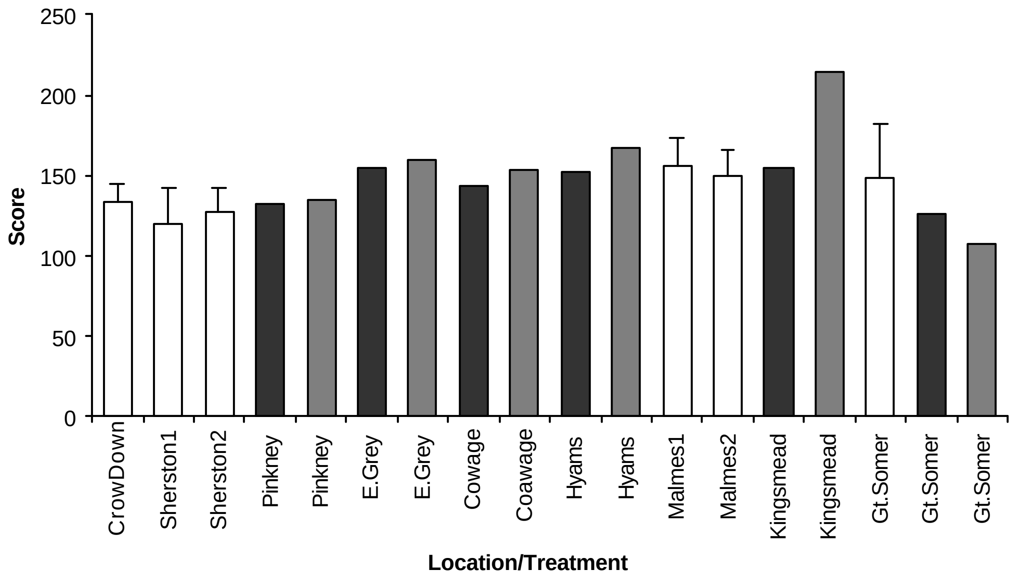


**Fig 26 Comparison of the density of native crayfish in fenced and unfenced reaches of the River Piddle, Dorset .**

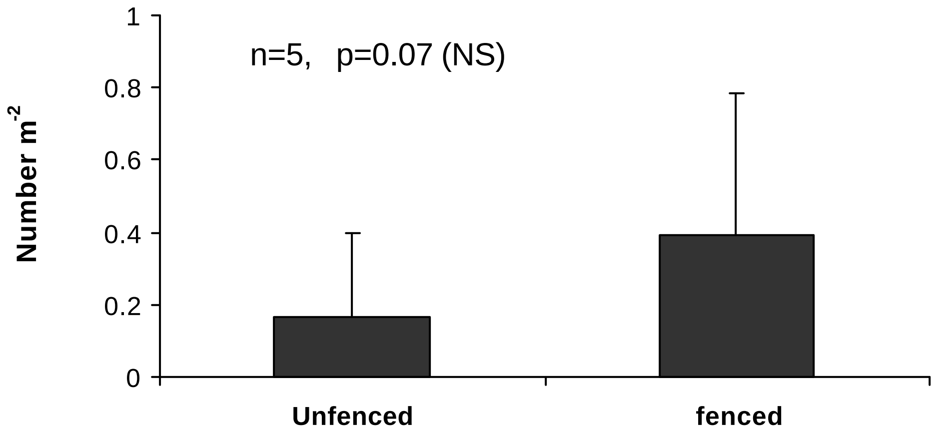


**Fig 28 Results of paired t-tests on fish densities in restored and unrestored reaches of the River Piddle and Devils Brook, Dorset.**
**0+ Trout**

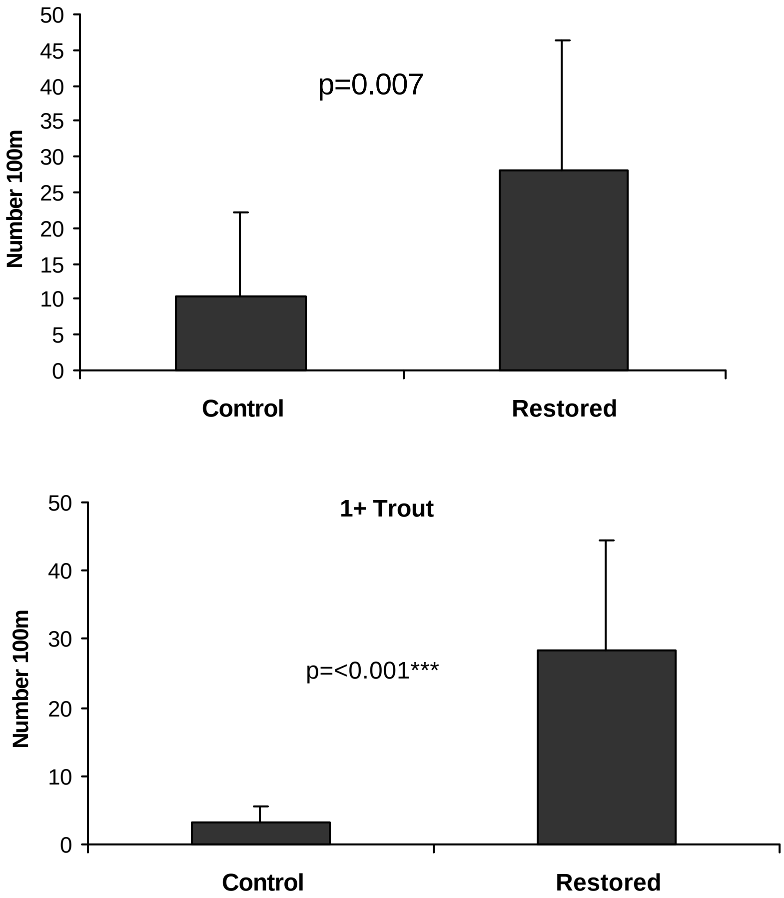



**Fig 29 Comparisons of the densities of trout in unfenced and fenced reaches of the Devils Brook. Dorset. (paired t-tests)**

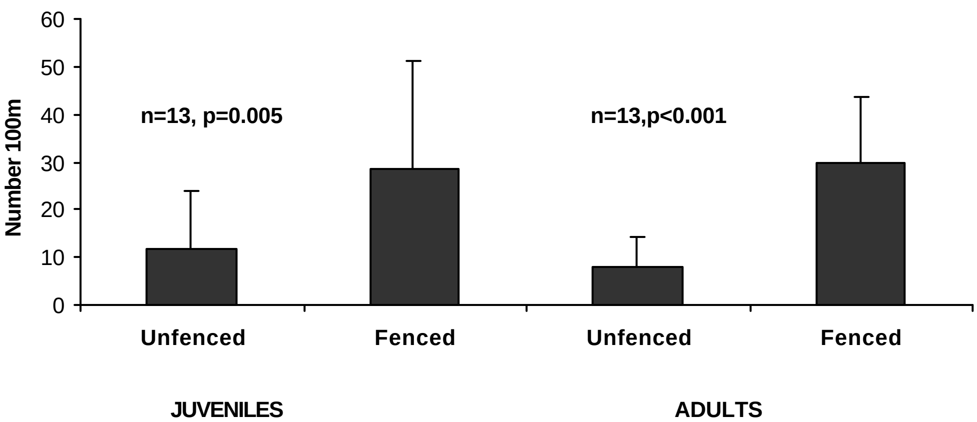


**Fig 30 Results of paired t-tests on fish densities in restored and unrestored reaches of the River Avon, Wiltshire, UK**

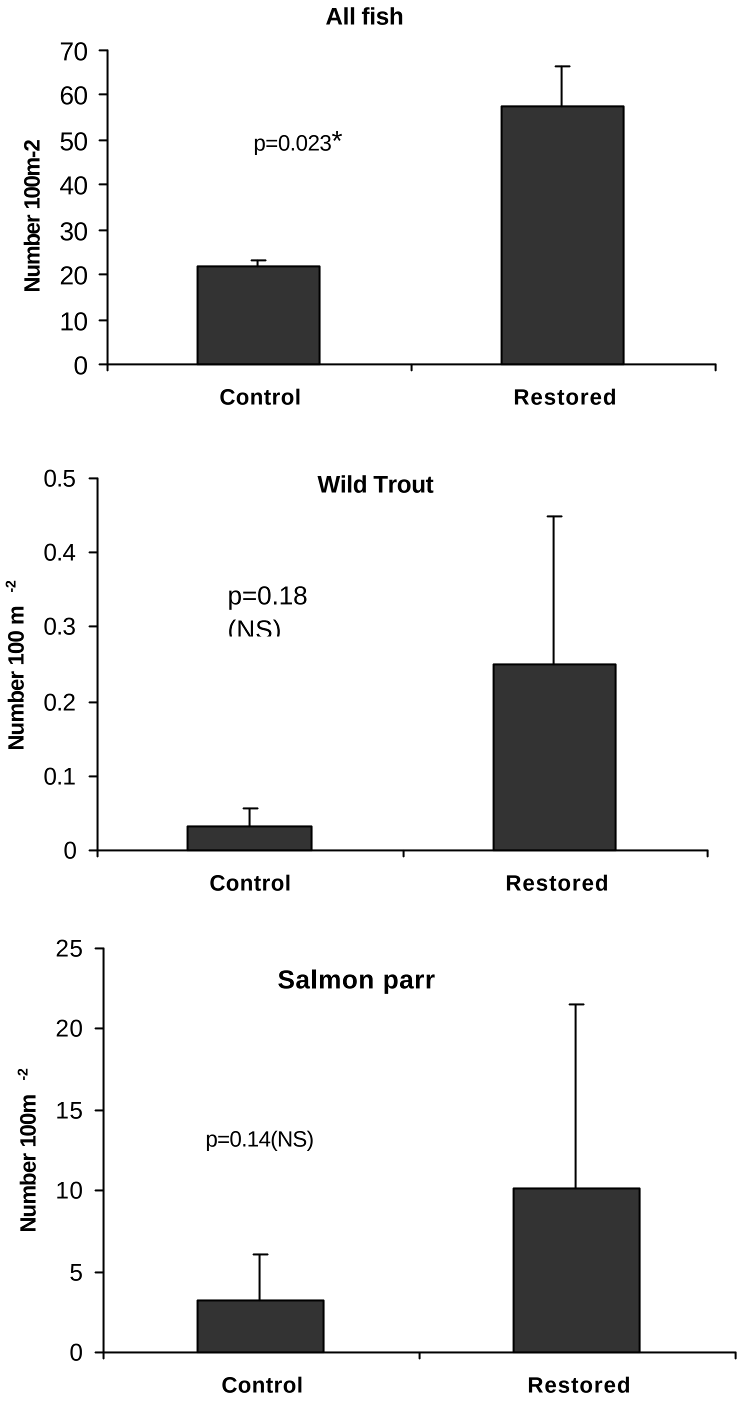


**Fig 31 Results of paired t-tests on fish densities in restored and unrestored reaches of the River Avon, Wiltshire.**

**Chub**

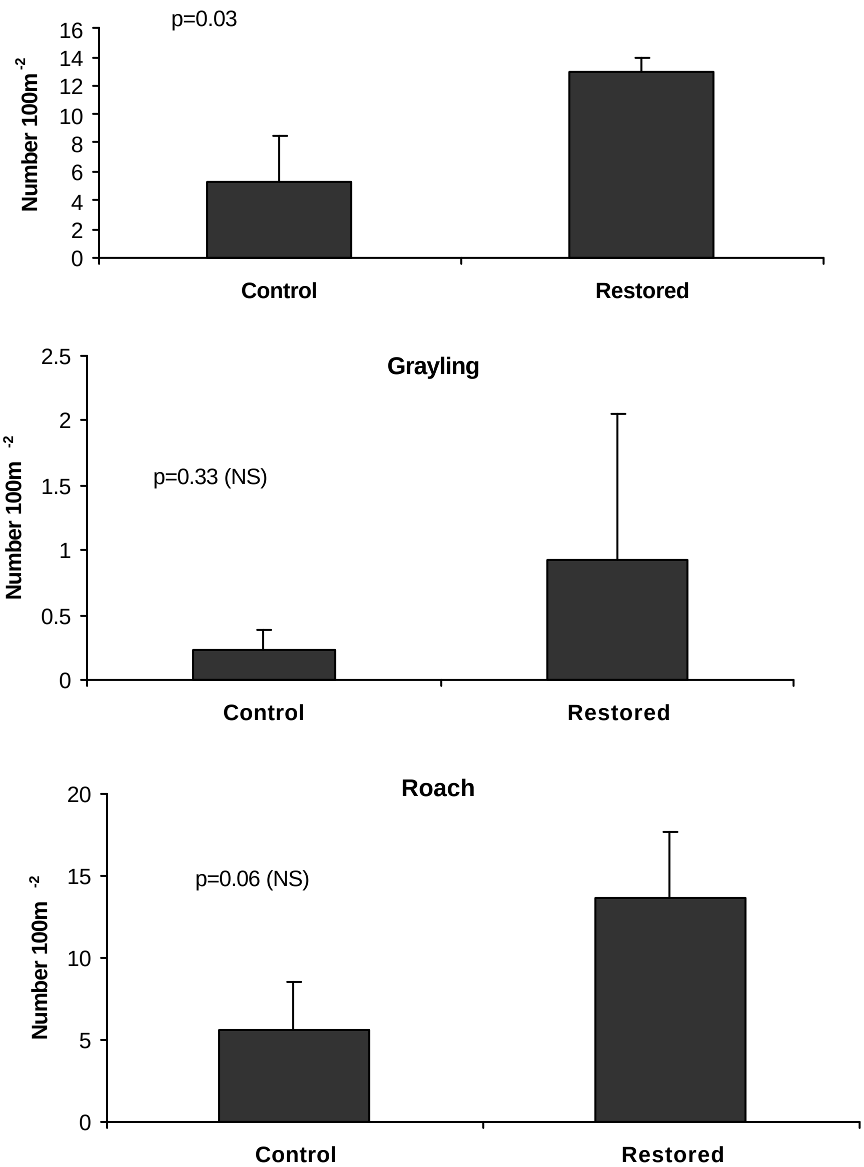


**Fig 32 Results of paired t-tests on fish densities in restored and unrestored reaches of the River Avon, Wiltshire.**

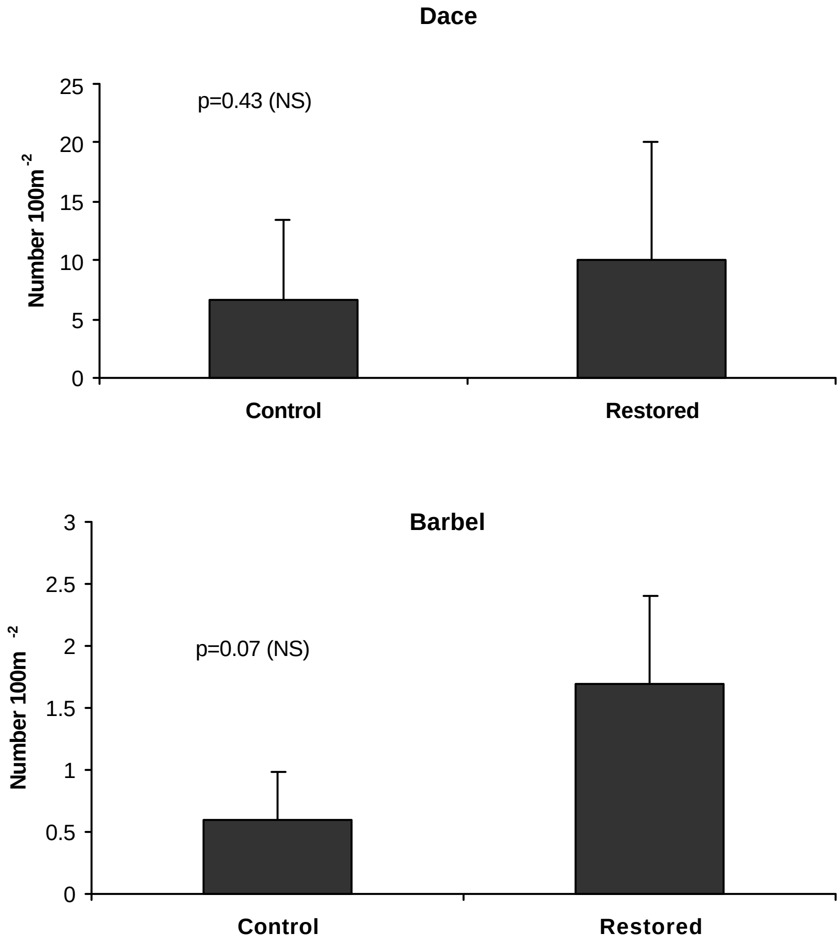
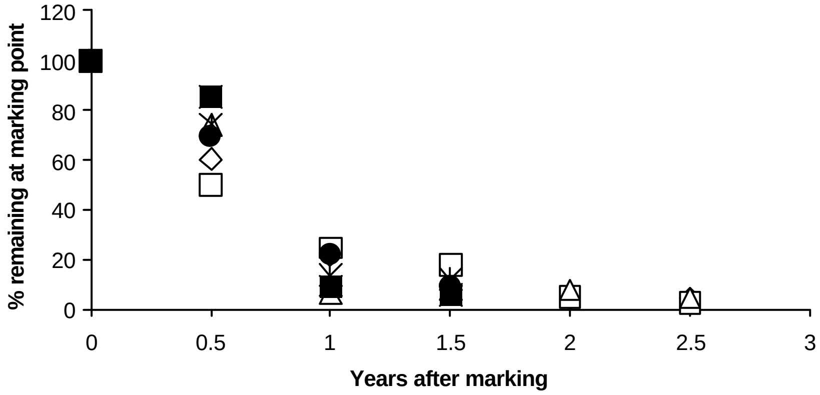


**Fig 33 Results of experiments to assess trout mobility in the River Piddle, 1994-96. After Summers et al, 1997**

**(a) marked 0+ trout**




**(b) % unmarked fish in reach**

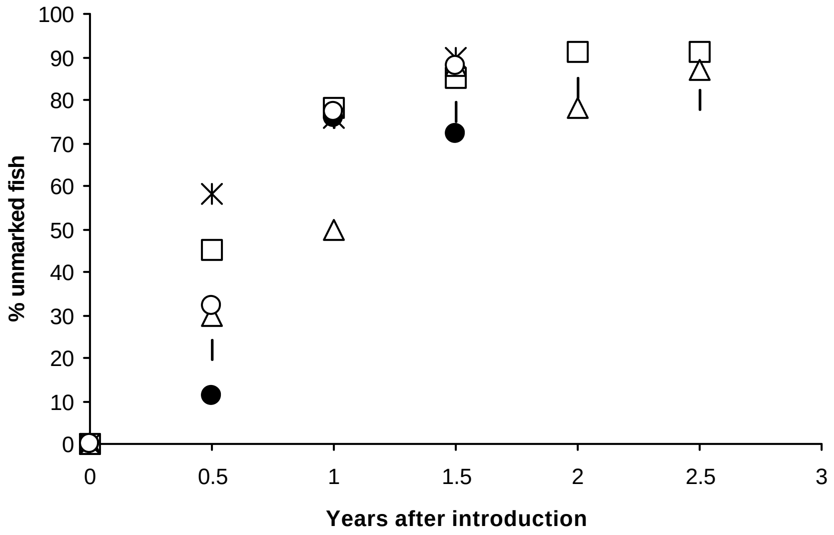
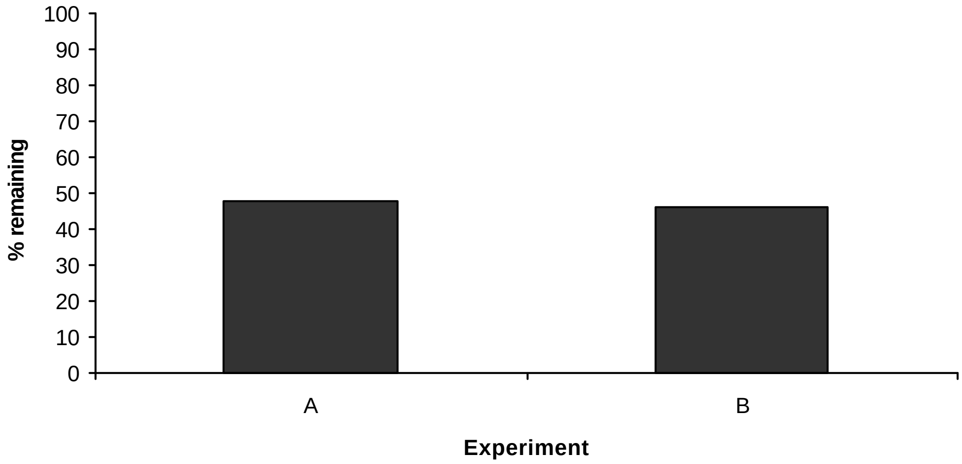


**Fig 34 Results of experiments to assess mobility of 2+ trout in the River Piddle 1994-96 (After Summers et al, 1997)**

**(a) Marked 2+trout remaining in orginal reach after 6 months.**




**b) Percentage of unmarked 2+ trout in two reaches of the River Piddle up to 1 year after marking.**

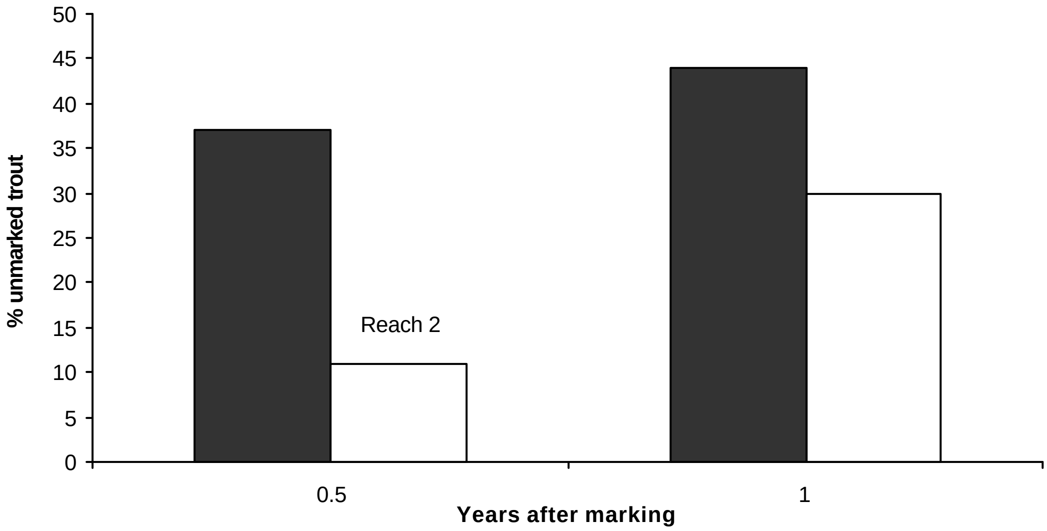


**Fig 35 Mean and Std. Dev. of physical variables from study rivers and restored and unrestored sites.**

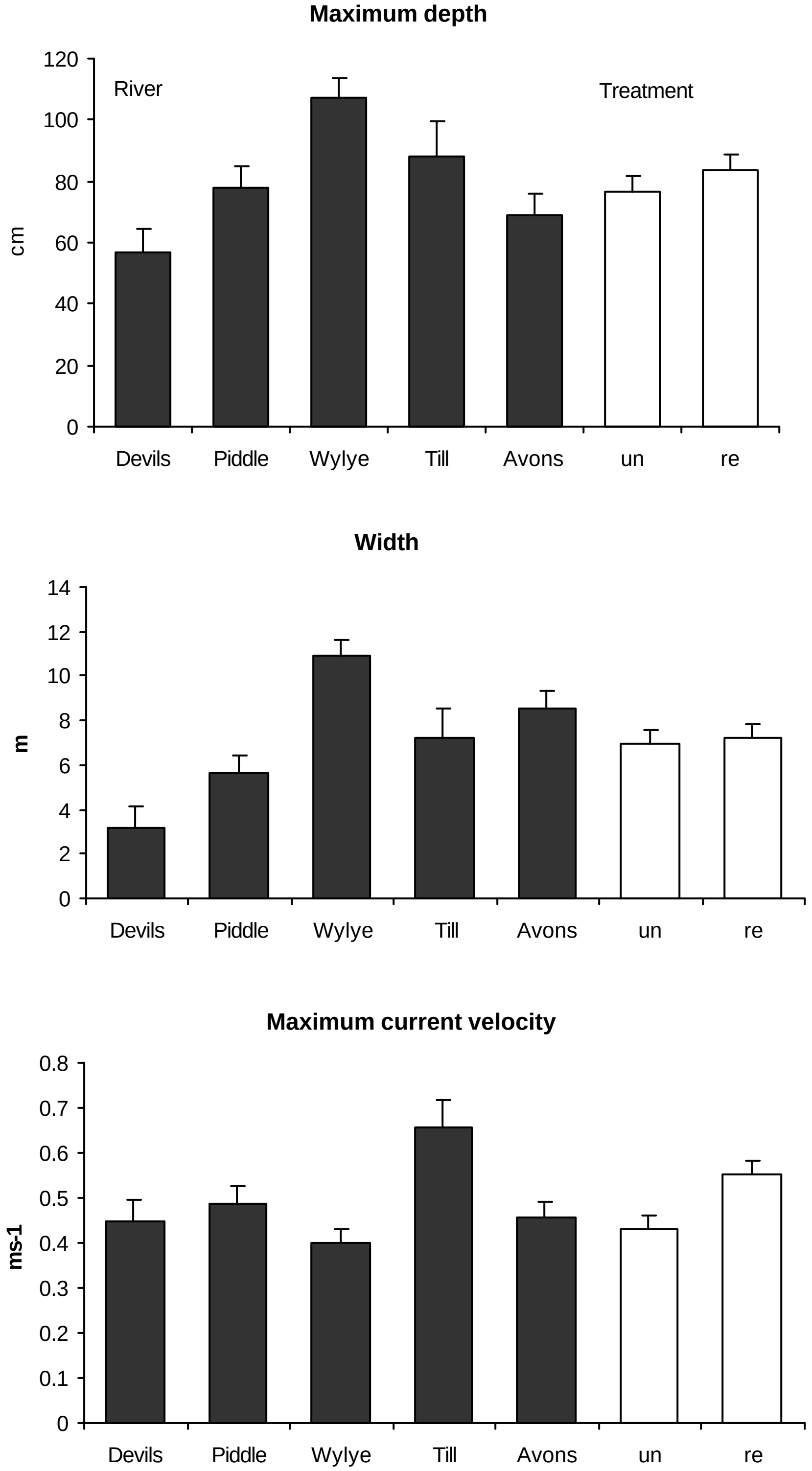


**Fig 36 Mean and Std. Dev. of diversity indices based on substrate composition (as % occurrence in point - contact surveys), from restored and unrestored reaches of three Wessex rivers.**

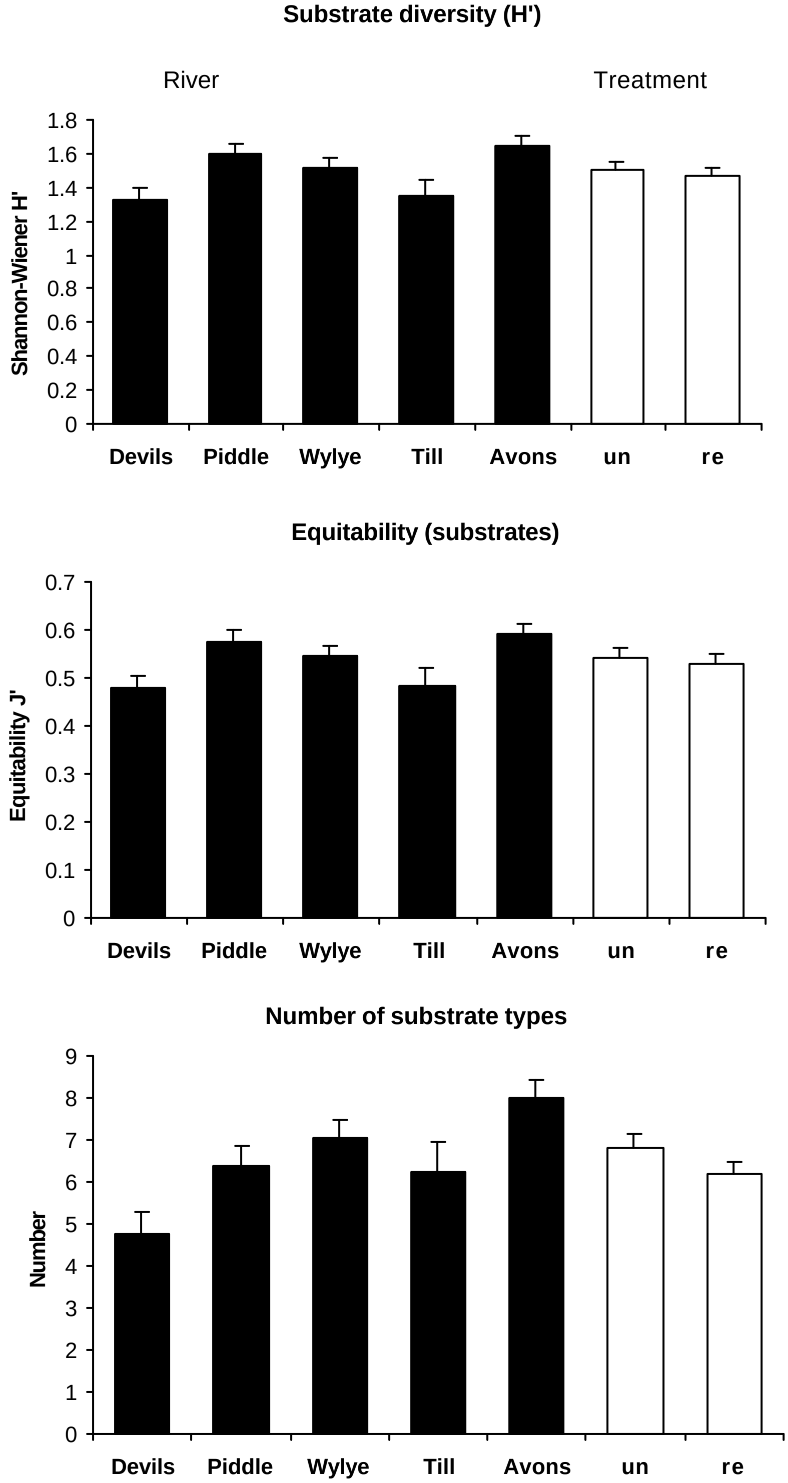


**Plate 1. Devils Brook, showing the unrestored reach. Grazed and trampled by cattle.**

**Plate 2. River Wylye. Unrestored reach showing uniformity of channel and lack of pool-riffle sequences.**

**Plate 3. Typical bank profile of a reach in the Malmesbury Avon.**

**Plate 4. Sherston Avon, downstream of Easton Grey, showing natural substrate of limestone plates.**

**Plate 5. Restoration method on the Malmesbury Avon, using large Sarsen stones to create current deflectors and gravel to create a riffle.**