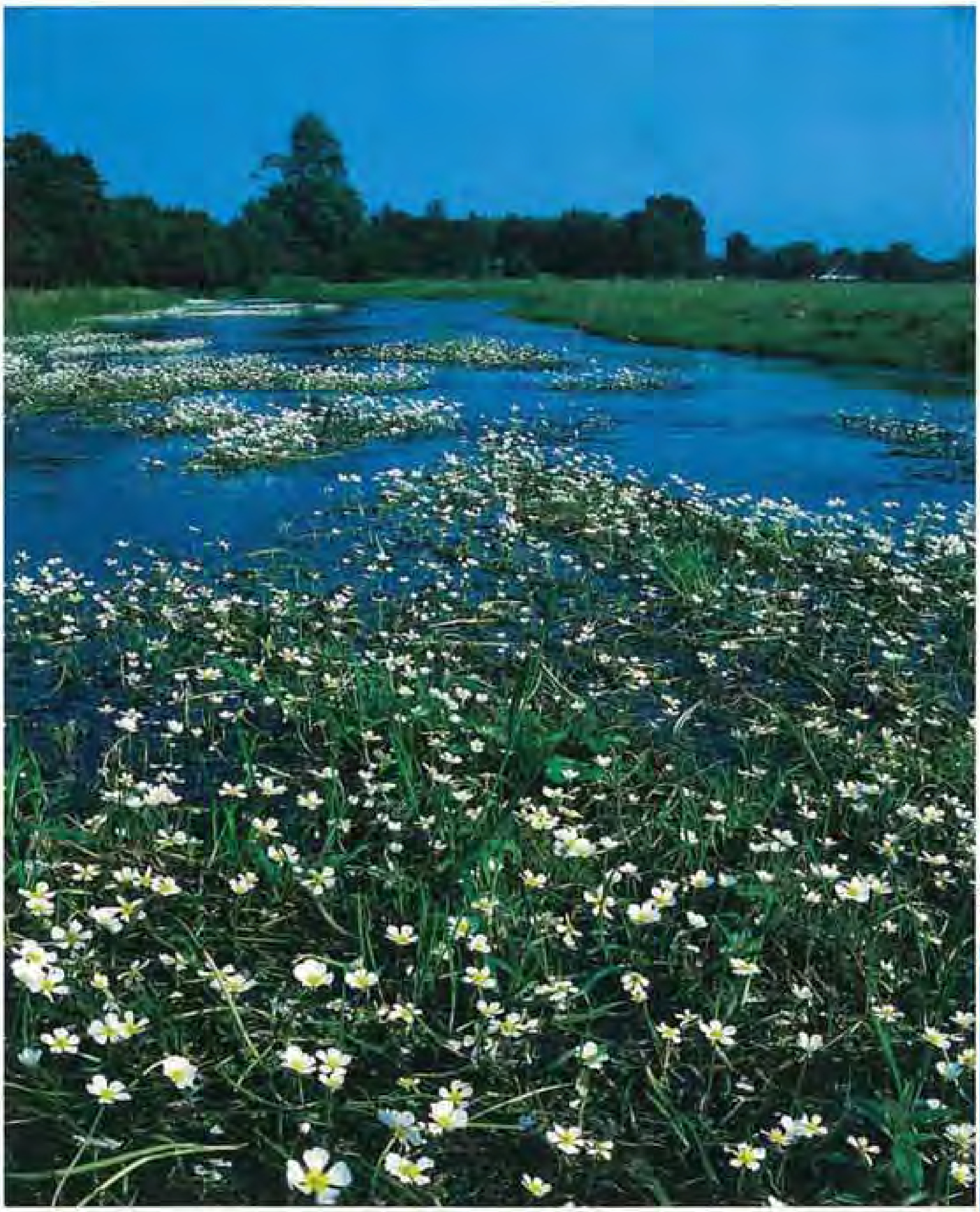
Chalk rivers

nature conservation and management



ENGLISH NATURE

ENVIRONMENT AGENCY

Conserving WATER for life

Chalk rivers
nature conservation and management

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Water Research Centre

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Chalk rivers - nature conservation and management

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Background

This handbook was commissioned by English Nature and the Environment Agency, primarily to provide an objective basis for formulating conservation strategies for relevant Sites of Special Scientific Interest (SSSIs) and Special Areas of Conservation (SACs) and as a source of advice on river management. It was also seen as being applicable to chalk rivers more generally and has increasingly been regarded as important to the work of the Biodiversity Action Plan Steering Group on chalk rivers, which is led by the Environment Agency.

The Project Steering Group consisted of representatives of English Nature and the Environment Agency under the chairmanship of the Project Leader, David Withrington (English Nature). Group members were:

David Withrington (Chairman)	English Nature, Head Office
Tim Holzer	Environment Agency, Southern Region
Mary Gibson	English Nature, Head Office
Doug Kite	English Nature, Dorset Team
Cath Beaver	Environment Agency, Head Office

Following the production of a full draft, the document was sent for comment to contacts within the following organisations:

Environment Agency (selected regions)
English Nature (selected regions)
Farming and Rural Conservation Agency (FRCA)
RSPB
Hampshire Wildlife Trust
Southern Water Services
National Farmers Union
Institute of Freshwater Ecology
Atlantic Salmon Trust
Salmon and Trout Association
Game Conservancy
British Trout Association

Responses were received from the majority of consultees, whilst comments were also provided by the Test and Itchen Association, the Wiltshire Fishery Association and the Institute of Hydrology. This final version was prepared following detailed consideration of all comments received.

Chris Mainstone
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February 1999

1. Introduction

This handbook has been produced to assist those involved in developing, implementing and reviewing management plans for chalk rivers, including conservation strategies for priority sites (see below). It contains information on characteristic wildlife communities, their habitat requirements and the ecological impact of activities that are relevant to the chalk river environment. It provides guidance on setting management objectives, options for mitigating impacts, and measures for the maintaining and enhancing the river channel, riparian and floodplain areas associated with chalk rivers.

The term 'chalk river' is used in this document to describe watercourses dominated by groundwater discharge from chalk geology, including those that flow over a range of non-chalk surface geologies at various points along their length, particularly in the lower reaches. The chalk influence gives rise to a distinctive hydrochemistry and flow regime, creating characteristic assemblages of plants and animals. There are no ecologically meaningful criteria to determine when a watercourse contains too much influence from other geologies to be termed a chalk river, and this has led to extensive debate over which rivers in England should qualify in the strictest sense.

England contains numerous examples of this river type, located in and downstream of areas of outcropping chalk in the south, East Anglia and up into Lincolnshire and Yorkshire. Indeed, England has the major part of the chalk river resource of Europe (UK Biodiversity Steering Group 1995). Owing to their international importance, chalk rivers have been identified by the UK Biodiversity Steering Group (BSG) as a key habitat, and a separate steering group has been established to oversee the execution of a published action plan (UK BSG 1995). Figure 1.1 shows those watercourses included in a preliminary list of chalk rivers drawn up under the auspices of the steering group.

Chalk rivers – like most lowland rivers in England - are generally highly physically modified systems. Their current ecological significance and their value to society (in terms of visual amenity and specific water and catchment uses) are intricately linked to certain aspects of historical modification. Some of the most important modifications from an ecological perspective have become commercially obsolete and require alternative impetus for their maintenance or restoration (inundated meadowland is a particular case in point). More recent structural modifications, largely for flood defence, land drainage and subsequent agricultural improvement, have had severe detrimental impacts on the conservation value of chalk rivers and their associated habitats.

A number of chalk rivers have been designated as Sites of Special Scientific Interest (SSSIs). This interest focuses on the river channel, and English Nature and the Environment Agency are currently drawing up joint conservation strategies for their protection and enhancement. The designated rivers are:

- Test
- Itchen
- Hampshire Avon
- Frome
- Kennet
- Lambourn
- upper Nar
- Wensum (upper reaches)
- Hull headwaters
- Moors (upper reaches)

There are also other sections of chalk rivers that are included in SSSIs, such as the Bere Stream (a tributary of the River Piddle).
Under the EU 'Habitats' Directive (92/43/EEC), Special Areas for Conservation (SACs) are being designated to protect listed species and habitats. Based on the SSSI network, the candidate list of cSACs includes two chalk river systems:

- **Itchen**, designated for *Ranunculus* beds and the southern damselfly (*Coenagrion mercuriale*);

- **Hampshire Avon**, designated for *Ranunculus* beds, Atlantic salmon (*Salmo salar*), bullhead (*Cottus gobio*), sea and brook lampreys (*Petromyzon marinus* and *Lampetra planeri*), and Desmoulin's whorl snail (*Vertigo moulinsiana).*

A further candidate SAC of relevance has been nominated in the Kennet catchment, restricted to floodplain wetlands supporting Desmoulin's whorl snail.

The human pressure on chalk rivers is intense: there is great demand for abstracting the high quality water for a variety of purposes; the river serves the typical function of receiving effluent discharges of various types; flood defence operations and intensified agriculture add further widespread ecological stress, whilst fisheries management modifies habitats and fish communities to suit the needs and preferences of game anglers. Nature conservation objectives have to recognise the reality of modern catchment land use, water use and public expectation, whilst at the same time guiding human activities towards approaches more sympathetic to the characteristic ecology of chalk rivers. It is hoped that this document will help to achieve this balance.

This document should not be used in a prescriptive way. The management objectives appropriate for a particular river reach should be set using a detailed knowledge of existing and historical conditions in terms of physical, chemical and biological status, and the best understanding possible of the nature of the changes brought about by human activity. A range of management options is available for any given river or river reach to alleviate specific impacts or to encourage different aspects of the biological community. This document is intended to provide basic information on these different management options, so that an appropriate strategy can be decided in the light of local circumstances. It does not provide extensive practical information on best management practices, although references are often cited where such information is available. In the case of specific impacts, it is important to recognise that the mechanisms responsible are often unclear; in such cases mitigation measures are outlined that are likely to succeed, but cannot be guaranteed to resolve the problem if they are not implemented within a wider framework of river restoration.

Figure 1.1 The UK distribution of watercourses with a strong chalk influence

2. Environmental characteristics of chalk rivers

2.1 Characteristic hydrology

Chalk is a soft and highly porous rock, distinct from the harder and heavily fissured limestones, which occur in areas such as the north Pennines. The principal hydrological pathway to the river network is through slow percolation into the underlying aquifer and subsequent discharge via springs, which may occur at various points along the length of the river in addition to the perennial head and winterbourne sections. Overland flow is therefore generally a minor component of natural stream flow, with around 80% of the annual stream discharge typically originating from the aquifer in pure chalk-based systems (Mann *et al.* 1989).

The slow release of water from the aquifer greatly attenuates the sporadic nature of rainfall, providing a relatively stable hydrological regime with a characteristic annual cycle. Ratios of maximum to minimum daily mean flows are generally less than 10:1 and often of the order of 3:1 on pure chalk geologies (Ladle and Westlake 1976), contrasting with clay catchments where ratios are greater than 100:1. Importantly, whilst peak flows are relatively small compared to 'flashier' river types, they are sustained for longer periods by the high baseflow component. Spring-fed channels have been found to equal or exceed bank-full flows for around 30% of the time compared to 5% in run-off dominated rivers (Whiting and Stam 1995). This produces sustained waterlogging in riparian soils, a characteristic of chalk river floodplains in their pristine state.

This is not to say that chalk rivers are necessarily incapable of producing rapid responses to rainfall. Whilst the majority of run-off is derived from sub-surface flows and shallow aquifers, rainfall events can produce a moderately flashy 'freshet' when catchment aquifers are full and soil moisture deficits around the catchment are low. In addition, many watercourses that are categorised as chalk rivers have some (perhaps much) influence from impermeable drift deposits (mainly clay), such that a rapid response to rainfall can be expected to occur naturally in some parts of the catchment.

An example of the annual hydrograph of a medium-sized chalk river is given in Figure 2.1, with year-to-year variations reflecting the strong dependence of flows on annual recharge of the aquifer through rainfall. Depending upon the onset of autumn/winter rains, stream discharge tends to increase in December, associated with a rainfall-induced rise in shallower sections of the aquifer, and continues to increase until March or April. Through this time springflow at the perennial head increases in strength, whilst springs along the ephemeral 'winterbourne' section reactivate after lying dormant through the summer months. Flows then decline steadily through the summer and autumn until the shallow aquifer is again bolstered in the winter by percolating autumnal rainfall. Inevitably, where chalk rivers flow over mixed geology, the hydrograph will be naturally distorted by run-off from impermeable soils or flows from aquifers with faster response times. Artificial distortions will be created by a variety of human activities, including urban development, land drainage and abstraction (see Section 5).

2.2 Structural development and definition of reference conditions for conservation management

Chalk rivers have changed greatly in their physical appearance over the centuries, shaped by human activities for a range of purposes. The highly permeable nature of chalk means that catchments have a characteristically low drainage density, with very little branching of watercourses except in areas affected by drift deposits of impermeable soils. Headwaters are located some way down the catchment where the winter water table reaches ground level and the first ephemeral springs occur. Smaller chalk streams probably originally flowed in ill-defined channels through alder (*Alnus glutinosa*) and willow (*Salix* spp.) carr (Ladle and Westlake 1976). Inputs of woody debris would have been substantial, with frequent debris dams forming and creating diversions to flow. Larger river sections would have formed better-defined channels, probably creating multiple channel systems with hydrologically stable cross-links (i.e. anastomosed channels).

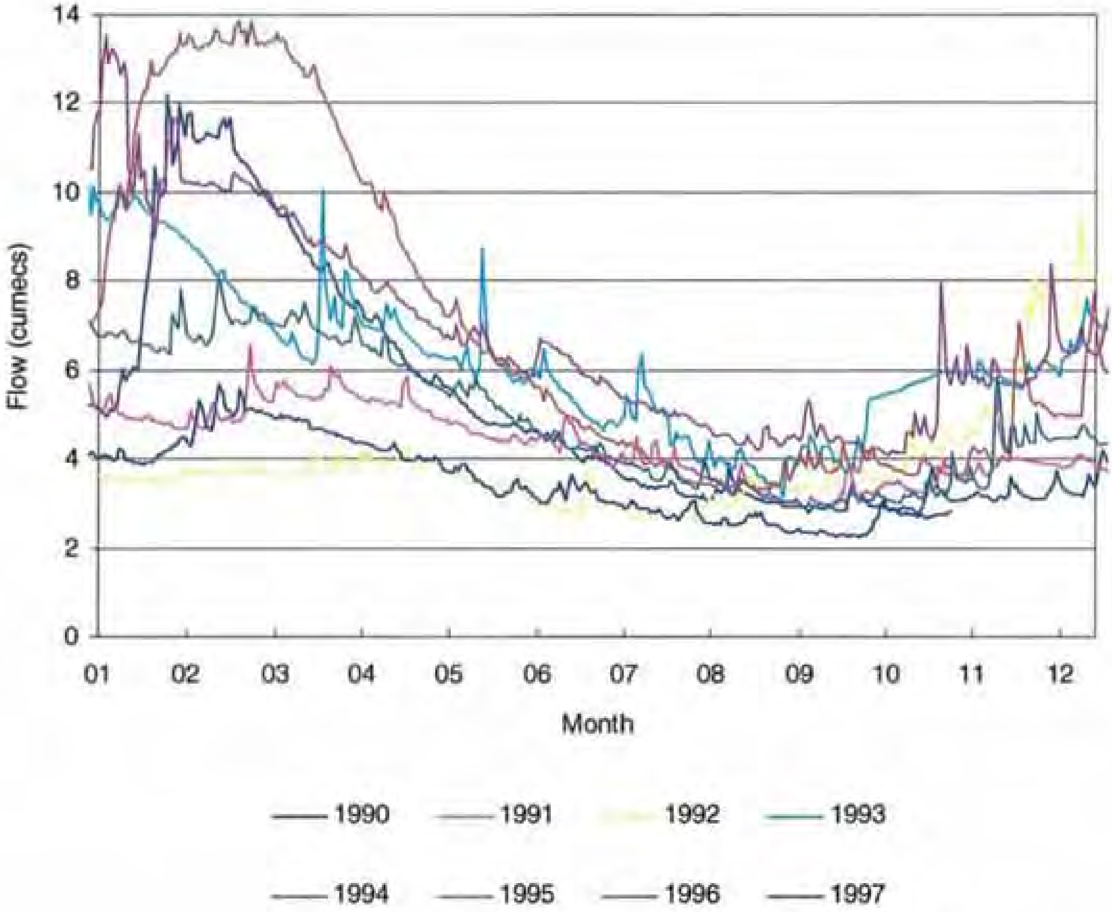


Figure 2.1 Example of the shape and variability of the annual hydrograph in chalk rivers - the Test at Chilbolton

Existing examples of how small chalk streams might have appeared some centuries ago are few and far between: a 500 m stretch of the Bere Stream SSSI (tributary of the Piddle, see Plates 1 and 2) which flows through alder and willow carr, and a much smaller similar fragment on the upper Wylye (tributary of the Avon) are amongst the best known. The upper Nar also supports similar habitat, albeit with a more distinct channel morphology owing to its relatively high hydraulic energy. The communities supported by this original habitat would have been very different from those supported by most chalk streams today, with the now characteristic and highly valued *Ranunculus* beds probably only occurring where gaps in the tree canopy allowed higher light intensities. Fen and swamp plant species tolerant of shade would have dominated the banks. There are no British examples of larger chalk rivers with natural channel geomorphology, as they have all been heavily modified over the years.

Following limited meadow-formation in Roman and Saxon times, most remaining carr vegetation was cleared and drained between the 17th and 19th centuries to provide additional land for agriculture. Fewer and larger channels were established, often just single channels in the case of smaller watercourses, and water meadows were developed alongside. The degree of geomorphological diversity up to and after this time is currently unclear. Channel morphology is a function of hydrological regime, sediment delivery and the drift geology through which the river flows. Chalk rivers generally have low hydraulic energy, too low to mobilise gravel, and are, therefore, less able to shape channel morphology than other river types. This said, it is possible that physically diverse channels were formed in the post-glacial period (when hydraulic energies were much higher due to the melting of the retreating ice sheet) and survived as relict features. In recent centuries, the nature of bed sediments has been determined by the transport of silts and sands, with very low solids inputs to the channel (see next section) leaving extensive gravel beds and long 'glides' of mixed but finer substrates.

The channels of chalk rivers today are typified by the following features (drawn from Sear *et al.* in press), but it is uncertain to what extent they are the result of natural or artificial processes:

- low longitudinal frequency of riffles and pools;
- infrequent gravel shoals and exposed riverine substrates;
- shallow cross section (average width to depth ratios of 33);
- sinuous channel form.

This latter feature is perhaps surprising considering the lack of sinuosity in some of the best examples of chalk river (such as the Itchen). It is likely that historical channel geomorphology would have varied substantially between different chalk rivers depending upon local circumstances and position in the river network. Thus, the probability of a strong riffle-pool sequence is higher on steep perennial sections where hydraulic energy is high. Sections of the upper Nar in Norfolk have steep gradients and exhibit a moderately distinct riffle-pool structure that may well have been present on other chalk streams with reasonable energy. The probability of strong meander sequences occurring naturally inevitably increases from the upper reaches to the lower reaches, as the river moves onto alluvial substrates on the floodplain proper.

Adjacent to the river channel, water meadows were created in wide-ranging situations in chalk river valleys, from the lower floodplain right up into the headwaters. Some were even created along winterbourne sections to make use of winter flows, although it is fair to say that a good number turned out to be ineffective. By controlled flooding, these meadows provided a flush of new grass early in the season for sheep. Water meadow development and the construction of numerous water mills led to the creation and stabilisation of the well developed multiple channels that are evident on larger chalk rivers today (such as the Test and the Itchen). The loss of trees, through the conversion of woodland to meadow, provided increased light to the channels, giving rise to the luxuriant plant growth which now characterises chalk rivers.

All water meadows associated with chalk rivers were of the 'floated' type, typical of low-gradient riparian areas where careful 'setting' of ground levels was required for the system to function properly. In their day, water meadows were used intensively, typically grazed by sheep at stocking rates of 30 per acre through the spring (but up to 500 per acre for a single day), followed by a hay cut and aftermath grazing by cattle (Moon and Green 1940). The feeder river was dammed by a weir and water was led off through hatches or sluices into the main carrier. It was then fed into secondary carriers situated along the ridges of a ridge-and-furrow field system. From here, water overtopped the carriers and flowed down the slopes into ditches or 'drawns' situated in the furrows, and thence back to the river further downstream. The idea was to keep the water moving so as not to produce stagnant conditions in the soil that would impair grass growth.

The 'floated' water meadow system was labour-intensive and required a highly skilled workforce, factors, which led to its decline in the late 19th century. In terms of plant and invertebrate communities, it is likely that water meadows were not of such high ecological value as the lightly grazed flood pastures and associated ditch systems that developed from many of them following their abandonment. Equally, their intensive use in springtime meant that they were little used by breeding wetland birds. However, they were particularly important for overwintering waders and wildfowl, providing an important source of shallow, ice-free water for feeding.

In terms of defining suitable reference conditions for chalk rivers against which objectives may be set, it is neither socio-economically feasible nor publicly desirable to aim for large scale reversion to the original woodland carr habitat. In nature conservation terms, much of the flora and fauna for which chalk river valleys are now valued would be severely affected by such action. In general, therefore, the 'characteristic' flora and fauna of high quality chalk rivers is taken to be that of low-intensity meadow-dominated catchments with a high water table and frequent winter inundation of riparian and floodplain areas, before widespread post-war intensification of agriculture but after the majority of woodland clearance. In this context, the original woodland carr is treated as a highly valuable but spatially limited habitat.

Plate 1 The Bere Stream, illustrating the original riparian vegetation associated with chalk streams.

Plate 2 The Bere Stream, showing a gap in the tree canopy where *Ranunculus* would have thrived as a minor component of the original plant community.

Generalisations concerning channel morphology are difficult, but a sinuous channel might reasonably be expected although a distinct riffle-pool structure may be absent (depending upon natural hydraulic energy and the surface geology over which the river flows). Gravels can be expected to feature strongly in bed sediments, with relatively low levels of fine particulates under unimpacted conditions. Gravel shoals and exposed sediments would probably occur infrequently, but individual features would be all the more valuable to the ecology of the river for their scarcity.

2.3 Characteristic water properties

As with flow, the chemical and physical properties of the river water are relatively stable in the unimpacted state. The slow percolation of water through the chalk imparts a characteristically high alkalinity and conductivity to the river water, due mainly to calcium bicarbonate, with pH values typically lying in the range 7.4 to 8.0. Long residence times in the chalk aquifer stabilise water temperature against the extremes of the seasons. In southern England, water enters the river from springs at about 11 °C, ensuring that temperatures remain relatively warm in the winter but relatively cool in the summer. Inevitably, the temperature at any one point in the river will depend upon factors such as the season (air temperature), the distance from the spring line and the size of the river, but the characteristic annual temperature range of a sizeable southern chalk stream is around 5 - 17 °C.

Owing to the physical filtration of most of the streamflow by percolation through chalk, and the relatively low hydraulic energy of chalk rivers (generating minimal natural bankside erosion), inputs of solid material are naturally low in chalk rivers. The characteristic state is therefore one of clear waters with very low levels of suspended solids and low bed loads of fine sediment. As discussed in the previous section, this has important implications for the nature of riverine substrates in the unimpacted state. In the lower sections of chalk rivers, the influence of alluvial soils and the flushing of substrates in upstream reaches will naturally lead to higher solids levels, focused on the autumn period when rainfall, run-off and river flows increase. However, under the reference conditions outlined in the previous section, the increase would not be expected to be that great, with loads reduced by the action of overbank flooding and the use of water-meadows to trap silts.

Nutrient levels are heavily influenced by human activity, and so values characteristic of relatively unimpacted conditions have to be inferred. Phosphorus and nitrogen levels are artificially elevated in many chalk rivers. The chalk and overlying soil (albeit typically thin) buffers against contamination of the aquifer by phosphorus as it is not easily leached, so that groundwater or springwater concentrations can potentially give a reasonably good indication of natural phosphorus levels (but see Section 5.6). Figure 2.2 shows groundwater data for the upper catchment of the Hampshire Avon. Although the geological picture of the upper catchment is confused by the occurrence of greensand, the data suggest that Soluble Reactive Phosphorus (SRP, broadly approximating to bioavailable phosphorus) concentrations are characteristically less than 0.02 mg l^{-1} (some contamination can be seen at a number of, probably shallow, boreholes - see Section 5.6). Unfortunately, the analytical limit of detection used is not good, and so it is not possible to judge how far below this figure ambient concentrations lie using these data; however, more accurate observations made by commercial cress farmers suggest that concentrations are typically around 0.01 mg l^{-1}.

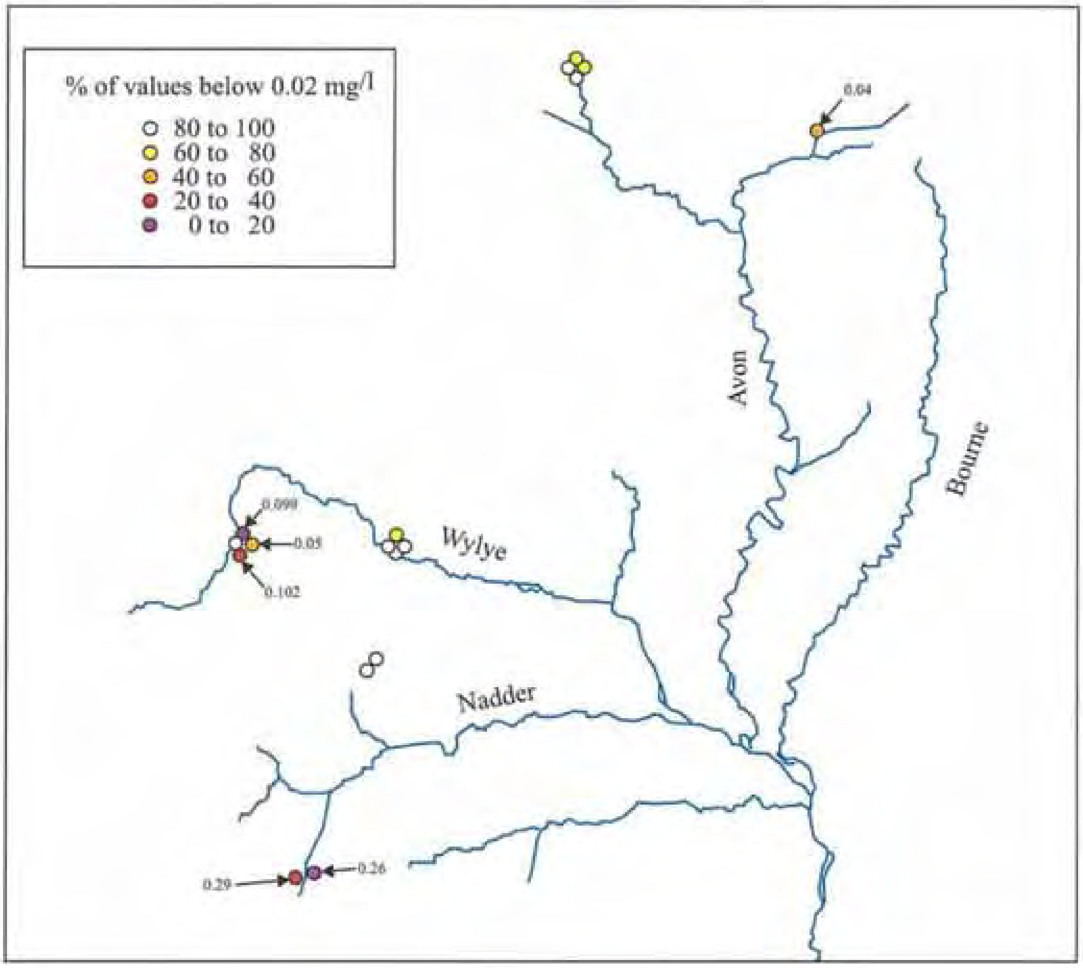
'Nutrient spiralling' will occur down the length of the river and there will be inputs from surface run-off (particularly where impermeable drift deposits overly the chalk), such that some natural elevation in phosphorus levels would be expected from source to mouth in chalk river systems. However, this is unlikely to generate concentrations exceeding 0.03 mg l^{-1} SRP unless there are substantial areas of clay soil within the catchment (see Mainstone *et al.* 1998 for more information). Importantly, phosphorus concentrations are determined almost entirely by baseflow during the growing season, with little or no release to the water column from internal sources (i.e. sediment and vegetation), such that concentrations of SRP of 0.01 mg l^{-1} or less can be expected in the unimpacted state (Mainstone *et al.* 1998). These theoretical considerations are supported by observations of near-pristine chalk streams in France, where SRP concentrations range between 0.01 and 0.03 SRP mg l^{-1} (Robach *et al.* 1996).

Indicative values of key water quality parameters that might be expected in chalk rivers in near-pristine conditions are given in Table 2.1, drawing heavily on observations by Robach *et al.* (1996) in French examples but also including subjective judgement of historical UK conditions. These should be used as a broad guide only, and are not intended for use in evaluations of specific rivers or river reaches without more detailed assessment of local circumstances. Significant differences might be expected between rivers on the basis of the nature of drift deposits and the influence of other geologies. Values for upper, middle and lower reaches take some account of nutrient spiralling and the tendency to encounter non-chalk geologies further down the catchment, and also admit some low-level anthropogenic impact from extensive agriculture and low population levels.

Table 2.1 Indicative values (annual means) of key water quality parameters in chalk rivers under near-pristine conditions.

Parameter	Upper reaches	Middle reaches	Lower reaches
Suspended solids (mg l^{-1})	<2	4	6
SRP (mg P mg l^{-1})	<0.01	0.02	0.03
Total Phosphorus (mg P l^{-1})	0.02	0.04	0.06
Nitrate (mg NO_3-N l^{-1})	0.2	0.5	1.0
Total Ammonia (mg NH_3-N l^{-1})	0.01	0.03	0.05
pH	7.8-8.0	7.8	7.4

Figure 2.2 **Groundwater levels of SRP in the upper catchment of the Hampshire Avon (1992-96 inclusive). Mean concentrations are indicated where more than 40% of samples lie above limit of detection.**



3. Characteristic wildlife communities of chalk rivers

3.1 Introduction

Like many highly valued habitats, chalk rivers are special because of the diverse and characteristic biological communities that they support. They play host to rare and/or endangered species, some of which have a strong preference for chalk river systems, but this is only one facet of their conservation value. Bearing this in mind, species have been listed in Table 3.1 that have been designated as high priority by legislation, international agreement or national review and that inhabit (but not necessarily exclusively) chalk river systems. This section places these species in the wider context of chalk river communities and emphasises the value of the river type as a functioning ecosystem.

Before embarking on an account of the biological communities characteristically supported by chalk rivers, it should be noted that this broad category of river encompasses a wide range of physico-chemical conditions, from ephemeral winterbourne sections to large chalk rivers, which frequently have a range of geological influences. Biological communities reflect these longitudinal changes, although some components are more affected than others. For instance, the species composition of fish communities in chalk rivers is heavily influenced by river size and a range of associated habitat variables, whilst bird and mammal communities are more affected by the nature of riparian and floodplain habitats.

For the purposes of this document, this range of environments has to be categorised so that communities can be described in a way that relates to the broad type of habitat provided. However, it is recognised that any division of river systems in this way imposes artificial boundaries on the largely continuous nature of ecological change. Moreover, such simplistic categorisation ignores the complex combination of factors that dictate the suitability of a river reach to any given species. Bearing this in mind, the categories used in this document should only be thought of as a rough guide to the environments offered by chalk rivers, with the reader always conscious of the dynamic ecological interactions occurring between (as well as within) different sections of a river. Four **categories** of watercourse, defined below, have been used in the following community descriptions (see also Plates 3 to 6).

Category:

1. **Winterbournes**	those that have a naturally dry period each year (except in unusual circumstances).
2. **Perennial headwaters**	first order streams, below the perennial head that dry out only in exceptional circumstances.
3. **Classic chalk streams**	stream order 1 to 3, not normally exceeding 10 metres in width and ever drying out.
4. **Large chalk rivers**	generally wider than 10 metres.

For the purposes of describing plant communities, which are heavily influenced by catchment geology, the last category has been divided into 2 major sub-groups.

Category:

4a. **Classic chalk rivers**	where chalk constitutes more than 80% of the underlying geology.
4b. **Mixed geology chalk rivers**	which sustain strong summer flows due to high base flows but are influenced heavily by the presence of other solid geology or quaternary deposits.

Table 3.1 Designated priority species supported by chalk river SSSIs, their calcareous tributaries and riparian wetlands

Group/species	BAP (S/M)[1]	Hab.Dir	Bern	Bonn	W&CAct	Nat. status	Test	Itchen	Avon	Frome	Hull	Nar	Kennet	Lambourn	Upper Wensum	Upper Moors
1. Plants																
Ranunculion fluitantis[2]	-	IV	-	-	-		*	*	*	*	*	*	*	*	*	*
a) *R. peltatus*	-	"	-	-	-	-	*	*	*	*			*	*	?	*
b) *R. penicillatus subsp pseudofluitans*	-	"	-	-	-	-	*	*	*	*	*	*	*	*	*	*
c) *R. fluitans*	-	"	-	-	-	-	?	?	?	*			*	?	?	*
Oenanthe fluviatilis	-	-	-	-	-	Scarce[3]	*	*	*	*	*		*		*	*
2. Invertebrates[4]																
Austropotamobius pallipes (Crayfish)	S	IIa	-	-	5		*	*	*	*		*	*	*	*	
Oulimnius troglodytes (Beetle)	-	-	-	-	-	Notable	*	*								
Riolus cupreus (Beetle)	-	-	-	-	-	Notable	*	*								
Riolus subviolaceus (Beetle)	-	-	-	-	-	Notable	*	*								
Agabus biguttatus (Beetle)	-	-	-	-	-	Notable				*						
Metalype fragilis (Caddis)	-	-	-	-	-	Notable	*	*						*		
Ylodes conspersus (Caddis)	-	-	-	-	-	Notable	*	*					*	*		
Baetis atrebatinus (Mayfly)	-	-	-	-	-	Scarce	*	*	*							
Paraleptophleba wernerii (Mayfly)	-	-	-	-	-	PRDB3				*						*
Coenagrion mercuriale (Dragonfly)	S	IIa	II	-	-	RDB3	*[5]	*	*[5]							
Valvata macrostoma (Snail)	-	-	-	-	-	RDB2	*	*	*							
Vertigo moulinsiana (Snail)	S	IIa	-	-	-	RDB3	*		*				*		*	
Pisidium tenuilineatum (Mussel)	S	-	-	-	-	RDB3	*	*	*							
3. Fish																
Atlantic salmon (*Salmo salar*)	-	IIa/Va	III	-	-		*	*	*	*	-	-	*[6]		-	
Bullhead (*Cottus gobio*)	-	IIa	-	-	-		*	*	*	*	P	*	P	P	P	*
Brook lamprey (*Lampetra planeri*)	-	IIa	III	-	-		*	*	*	*	P	P	P	P	P	*
River lamprey (*Lampetra fluviatilis*)	-	IIa/V	III	-	-		?	?	*	*	?	?	?	?	?	
Sea lamprey (*Petromyzon marinus*)		IIa	III				?	?	*	*	?	?	?	?	?	
Spined loach (*Cobitis taenia*)		IIa					-	-	-	-	-	*	-	-	-	
Grayling (*Thymallus thymallus*)		Va	III				*	*	*	*	?	?	?	?	?	

Group/species	BAP (S/M)[1]	Hab.Dir	Bern	Bonn	W&CAct	Nat. status	Test	Itchen	Avon	Frome	Hull	Nar	Kennet	Lambourn	Upper Wensum	Upper Moors
4. Birds																
Kingfisher *(Alcedo atthis)*	-	-	II	-	I	Amber	*	*	*	*	*	*	*	*	*	*
Cetti's warbler *(Cettia cetti)*	-	-	-	-	I	Amber	*	*	*	*	?	?	?	?	?	
Bewick's swan *(Cygnus columbianis)*	-	-	-	-	I	Amber	-	-	*	*	-	-	-	-	?	
Green sandpiper *(Tringa ochropus)*	-	-	II	II	I	-	*	*	?	?	?	?	?	*	?	
Reed bunting *(Emberiza schoeniclus)*	M	-	-	-	-	Red	*	*	*	*	*	*	*	*	?	*
Water rail *(Rallus aquaticus)*						Amber	*	?	?	?	?	?	?	*	?	
Lapwing *(Vanellus vanellus)*						Amber	*	*	*	*	*	*	*	*	?	
Snipe *(Gallinago gallinago)*						Amber	*	*	*	*	*	*	*	*	?	*
Redshank *(Tringa totanus)*						Amber	*	*	*	*	*	*	*	*	?	
5. Mammals																
Otter *(Lutra lutra)*	S	IIa/IVa	II	-	5,6	*	O	*	O	*	?	P	P	P	?	O
Water vole *(Arvicola terrestris)*	S	-	-	-	5?	*	*	*	*	*	P	P	P	P	P	*
Water shrew *(Neomys fodiens)*	-	-	III	-	6	*	*	*	*	*	P	P	P	P	P	*
Daubenton's bat *(Myotis daubentonii)*	-	-	-	-	5	*	*	*	P	P	P	P	P	P	P	

BAP = UK Biodiversity Action Plan; Hab. Dir = EU Habitats Directive; Bern = Bern Convention; Bonn = Bonn Convention; W&C Act = Wildlife and Countryside Act 1981 and subsequent 5-yearly amendments. Nat. Status = National designations from Red Data Books (RDBs), Birds of Conservation Concern and other sources.

[1] Short or middle lists of the UK Biodiversity Action Plan.
[2] Floating beds of *Ranunculus* vegetation.
[3] Until recently considered scarce but now known to be present in more than 100 10 km squares in Britain.
[4] This list of invertebrate species is not comprehensive, and is largely restricted to those inhabiting the river channel or associated drains and ditches. Lack of occurrence may be due to a lack of recording effort.
[5] Present in the catchment but not occurring in habitats associated with chalk rivers.
[6] Currently being re-established by stocking following extinction.
P Probably present
O Occasional but no known breeding population at present

Plate 3 Example of a winterbourne section - the Till at Winterbourne Stoke.

Plate 4 Example of a perennial headwater section - the Piddle.

Plate 5 Example of a classic chalk stream - the middle reaches of the Itchen.

Plate 6 Example of a large chalk river - the lower reaches of the Hampshire Avon.

3.2 Plants

3.2.1 Background

The plant communities of chalk rivers can be characterised primarily using two major studies undertaken in the past twenty years. One is the 'NCC' national classification of British rivers based upon plant communities recorded from over 1500 UK river sites (Holmes 1989, updated by Holmes, Boon and Rowell 1999); the other is a winterbourne/headwater survey undertaken this decade at more than 125 sites over a minimum period of three years (Holmes 1996). These studies under-pin the overview provided here, supported by information in Haslam (1978, 1987) and work undertaken at the River Laboratory of the now Institute of Freshwater Ecology (e.g. Ham *et al.* 1981, 1982).

Table 3.2 shows the plants most associated with chalk rivers and streams, with differences in communities highlighted between the five categories of chalk watercourses. Note that the priority habitat '*Ranunculus* beds' scheduled under the EU Habitats Directive essentially comprises two species in chalk rivers, *R. peltatus* and *R. penicillatus* subsp. *pseudofluitans.* In addition, *R. fluitans* occurs in the lower reaches of some chalk rivers that are influenced by clay, but is not considered characteristic.

3.2.2 Plant communities of winterbournes

Winterbournes have very characteristic plant communities, which reflect the seasonal cycle of wetting and drying. The vegetation varies both between winterbournes and within winterbournes between years, depending largely upon the period of inundation each year. Three typical extremes can be recognised:

a) winterbournes that typically have flow for >8 months most years;
b) intermittent bournes that are dry for at least six months per year;
c) winterbournes with perched water-tables.

Inevitably, individual sites vary between category (a) and (b) from year to year depending upon the extent of aquifer recharge, and sections that are usually category (a) can be perennial for a number of years following repeated good recharge. In addition, category (a) and (b) sections will often be contiguous with one another on the same river, with (b) lying immediately upstream of (a) and the relative lengths of each section varying from year to year.

Within the channel of **category (a)** winterbournes, fast-growing aquatic annuals dominate. Water speedwells (*Veronica anagallis-aquatica/catenata* plus hybrid), pond water-crowfoot (*Ranunculus peltatus,* Plate 7) and water-cress (*Rorippa nasturtium-aquaticum,* Plate 8) are classic examples of this, but all three are rarely common together in the same short reaches of a winterbourne at any one time. Fool's water-cress (*Apium nodiflorum)* is consistently present, and grows as a perennial or annual at sites depending on the length of time sites are dry. Marsh foxtail (*Alopecurus geniculatus*) and sweet-grasses (including *Glyceria notata/fluitans* and hybrid) are common marginal plants. Crowfoot dominates the channel community in spring, giving way to water-cress and fool's water-cress in early summer. Only the latter species remains once flows fail in late summer. As the channel is rewetted in autumn or early winter, huge numbers of seedlings of all three species appear on the bed. Long stretches of the Lambourn, the Kennet above Marlborough, and the middle reaches of the Till are good examples of this classic category of winterbourne.

Category (b) winterbournes typically have an overwhelming dominance of non-aquatic grasses and herbs, with few or no wetland or aquatic higher plants present except during the spring period of flow. At this time fool's water-cress, water-cress, water-mint (*Mentha aquatica*), water forget-me-not (*Myosotis scorpioides*) and sweet-grass may be present alongside marsh foxtail and non-aquatic herbs and grasses. By summer only the non-aquatic species and the foxtail remain as the system becomes dry. Only in exceptional periods of recharge, when flow is retained up to June or July, will the non-aquatic grasses and herbs on the bed be killed by inundation. Typical sites are found in the headwaters of the Moors, Bourne, Gade, Misbourne, Pang, Kennet, Chitterne and Till.

Table 3.2 Characteristic plant species of different categories of chalk river.

Species\Watercourse category		R1	R2	R3	R4a	R4b
Alopecurus geniculatus	Marsh foxtail	3	1			
Ranunculus peltatus	Pond water-crowfoot	3	2	1		
Carex paniculata	Greater tussock-sedge		1	3	5	
Groenlandia densa	Opposite-leaved pondweed		1	2	4	
Hildenbrandia rivularis	A red alga		2	2	3	
Apium nodiflorum	Fool's water cress	5	5	5	5	5
Rorippa nasturtium-aquaticum	Water cress	4	5	5	5	5
*Glyceria fluitans/plicata/*hybrid	Sweet grass	4	4	4	2	3
Amblystegium riparium	A moss	1	3	3	2	2
Verrucaria (sp(p))	Aquatic lichens	1	3	4	3	1
Amblystegium fluviatile	A moss	1	2	2	3	1
Juncus acutiflorus	Sharp-flowered rush	1	2	2	4	2
Rhynchostegium riparioides	A moss	1	3	3	4	2
Cinclidotus fontinaloides	A moss	1	2	3	2	1
Filamentous green algae		1	1	1	1	4
Phalaris arundinacea	Reed canary-grass	1	5	5	5	5
Mentha aquatica	Water mint	5	5	5	5	5
Agrostis stolonifera	Creeping bent	5	5	5	5	5
Solanum dulcamara	Bittersweet	2	4	5	5	5
Epilobium hirsutum	Great willowherb	1	5	5	5	5
Myosotis scorpioides	Water forget-me-not	5	5	5	5	5
Vaucheria agg.	A filamentous alga	2	5	5	5	4
Eupatorium cannabinum	Hemp agrimony	1	2	4	5	4
Veronica beccabunga	Brooklime	4	5	5	5	5
Scrophularia auriculata	Water figwort	3	4	5	4	5
Trees		2	3	5	4	5
Salix species	Willows	1	3	5	5	5
Cladophora glomerata	A filamentous alga	2	4	4	5	5
Symphytum officinale	Comfrey	2	4	4	5	5
Lycopus europaeus	Gipsywort	1	3	4	5	5
Veronica anagallis-aquatica	Blue water speedwell	3	5	5	5	4
Juncus inflexus	Hard rush	2	4	5	5	4
Fontinalis antipyretica	A moss	2	4	5	5	4
Filipendula ulmaria	Meadowsweet	1	4	5	5	4
Stachys palustris	Marsh woundwort	2	2	2	5	4
Callitriche stagnalis	Common starwort	1	3	4	4	5
Lythrum salicaria	Purple loosestrife	1	2	4	5	4
Sparganium erectum	Branched bur-reed		3	5	5	5
Catabrosa aquatica	Whorl-grass		1	2	2	1
Callitriche platycarpa	Various-leaved water-starwort		2	3	5	3
Oenanthe crocata	Hemlock water-dropwort		4	3	4	4
Carex riparia	Greater pond sedge		1	4	4	5
Glyceria maxima	Reed sweet-grass		2	5	5	5
Ranunculus pen. subsp. *pseudofluitans*	Brook water-crowfoot		3	5	5	5
Iris pseudacorus	Water flag		4	4	5	5
Phragmites australis	Common reed		2	3	5	4
*Elodea canadensis**	Canadian waterweed		1	3	5	4
*Elodea nuttallii**	St John Nuttall's waterweed		1	3	4	4

Species\Watercourse category		R1	R2	R3	R4a	R4b
Callitriche obtusangula	Blunt-fruited water-starwort		2	5	5	3
Berula erecta	Lesser water parsnip		3	4	5	3
Carex acutiformis	Lesser pond sedge		3	5	5	4
Zannichellia palustris	Horned pondweed		1	3	5	3
*Impatiens capensis**	Orange balsam		1	1	5	4
Juncus effusus	Soft rush		3	4	1	3
Pellia endiviifolia	A liverwort		3	3	3	1
Hippurus vulgaris	Mare's-tail			2	4	1
Rumex hydrolopathum	Water dock			3	5	4
Scirpus (Schoenoplectus) lacustris	Bulrush			3	4	5
Myriophyllum spicatum	Spiked water-milfoil			3	3	4
Potamogeton pectinatus	Fennel-leaved pondweed			2		5
Sparganium emersum	Unbranched bur-reed			3	3	5
Lemna minor	Common duckweed			3	5	5
Oenanthe fluviatilis	River water-dropwort			2	3	3
Ranunculus circinatus	Fan-leaved water-crowfoot					1
Potamogeton perfoliatus	Perfoliate pondweed					4
Enteromorpha	A green alga					4
Butomus umbellatus	Flowering rush					4
Nuphar lutea	Yellow water-lily					5
Sagittaria sagittifolia	Arrowhead					5

R1 = Winterbournes; R2 = Perennial headwaters; R3 = Classic chalkstreams; R4a = Classic chalk rivers; R4b = Large, mixed geology;
5 = Expected (>75%); 4 = V. Likely (50-75%); 3 = Typical (25-50%); 2 = Occasional (10-25%); 1 = Rare (<10%).
* Introduced but now an established component of the flora.

Plate 7 Pond water-crowfoot, *Ranunculus peltatus*, the characteristic crowfoot of winterbournes.

Plate 8 Water-cress, *Rorippa nasturtium-aquaticum*, characteristically dominating the chalk stream flora in summer.

Category (c) reaches have water tables that are not in contact with the underlying groundwater table, therefore often retaining flow for longer periods than winterbourne stretches upstream and/or downstream. Such reaches usually have distinct communities, with *Glyceria* species often common and aquatic herbs being retained for longer through the year. Reed canary-grass *(Phalaris arundinacea)* and in-channel emergents such as water-cress and fool's water-cress are often present, but, unlike winterbournes with only intermittent flow, marsh foxtail is usually absent because water is present through most of the summer. The Bourne, a tributary of the Hampshire Avon, and the North and South Winterbourne in Dorset, are good examples of this category of winterbourne.

3.2.3 Plant communities of perennial headwaters

In contrast to winterbourne sections, marsh foxtail and non-aquatic grasses and herbs are absent from the stream bed of perennial chalk headwaters. Brook water-crowfoot (*Ranunculus penicillatus* subsp. *pseudofluitans*, Plate 9) and whorl-grass (*Catabrosa aquatica*, Plate 10) commonly occur in perennial headwaters but not in winterbournes, the former dominating the community in springtime. Other aquatic higher plants are typical, such as starworts (*Callitriche* spp.), water-speedwells, fool's water-cress, water-cress, water-mint, water forget-me-not, the aquatic small sweet-grass species (and hybrid), and also lesser water-parsnip (*Berula erecta*) where strong spring flows occur (such as in parts of the Mimram, Winterbourne, Lambourn and Hull). These are typically confined to the margins until the crowfoot declines in association with summer and autumn reductions in river flow. Also often present on pebble-cobble substrates are the aquatic lichen *Verrucaria* and the red alga *Hildenbrandia*, both of which are unable to withstand the dry phase of the winterbourne cycle.

Emergent and marginal reeds are much more commonly associated with perennial reaches than winterbournes. Reeds such as reed canary-grass, reed sweet-grass *(Glyceria maxima)*, common reed *(Phragmites australis)* and branched bur-reed *(Sparganium erectum)*, as well as lesser pond sedge *(Carex acutiformis)*, are much more typical downstream of reaches with an intermittent flow.

3.2.4 Plant communities of classic chalk streams

Examples of this category have a wide geographical distribution, being present in Yorkshire (Hull system), East Anglia (Nar, Wissey, Babingly and Wensum, Bure, Lark), the Thames catchment (Colne, Mimram, Lambourn, Kennet, Loddon, Whitewater) and southern England (Upper Hampshire Avon catchment, Piddle, Bere Stream, Frome, Moors). Higher plant assemblages are frequently more species-rich than those of perennial headwater reaches.

Brook water-crowfoot, water-cress, the starwort *Callitriche platycarpa* and blue water-speedwell *(Veronica anagallis-aquatica)* are typical instream species of the category (along with large chalk rivers reaches), with lesser pond sedge almost always found as a bankside plant. Species such as lesser water-parsnip, brooklime *(Veronica beccabunga)*, common water-starwort (*Callitriche stagnalis)* and the sweet-grass *Glyceria fluitans* are also common marginal species, with some of these occupying submerged channel positions as well. Three less common species are particularly associated with this category and also large chalk rivers (Section 3.2.5), these being mare's-tail *(Hippurus vulgaris)*, opposite-leaved pondweed *(Groenlandia densa)* and river water-dropwort *(Oenanthe fluviatilis)*. Only *O. fluviatilis* (Plate 11), which is endemic to northwest Europe and is thought to be declining across much of its range (including Britain - Preston and Croft 1997), is expected to be found in catchments not totally dominated by chalk.

As in other perennial sections, brook water-crowfoot is extremely dominant in spring and early summer, followed by recession when water-cress develops rapidly from seed and may completely smother the crowfoot by autumn. Water-speedwell tends to grow throughout the year, exploiting bare niches. Most of the water-cress growth dies back to the root in winter or is washed away, whilst the crowfoot is retained and even grows. Lesser water-parsnip declines little in winter in submerged locations, but dies back to the root on the margins. Examples of the spring dominance of crowfoot and summer dominance of water-cress are given in Plates 12, 13 and 14.

3.2.5 Plant communities of large chalk rivers

This category has been subdivided into what have been termed 'classic chalk rivers' and rivers on mixed geologies. This has been done to separate out the larger sections of the Test and Itchen, which have an extremely high proportion of chalk in their catchments (over 80%), from large rivers running down from chalk over a range of geological influences.

a) Classic chalk rivers

The larger sections of the Test and Itchen have plant communities that are somewhat different from other UK chalk rivers, having a higher species-richness than any other lowland river community in the UK (at more than 50 species per kilometre). The dominant species are essentially the same as those found in the smaller classic chalk streams (Section 3.2.4), with brook water-crowfoot typically dominating the stream bed in spring, to be succeeded by species such as water-cress and lesser water-parsnip in the summer. However, there are various higher plant species more likely to be found in classic chalk rivers than any other type of watercourse with chalk influence. These include blunt-fruited water-starwort *(Callitriche obtusangula)*, lesser water-parsnip, great water-dock *(Rumex hydrolapathum)*, horned pondweed *(Zannichellia palustris)*, greater tussock-sedge *(Carex paniculata)*, yellow loosestrife *(Lysimachia vulgaris)*, brook water-crowfoot and purple loosestrife (*Lythrum salicaria*). The moss *Fontinalis antipyretica* is common in many reaches of this category and the submerged ivy-leaved duckweed (*Lemna trisulca*) is also more typically found in the Test and Itchen than elsewhere on chalk.

b) Chalk rivers on mixed geologies

Most rivers falling into this category have many species in common with categories 3 and 4a (see section 3.1), but also commonly have other species that are indicative of clay, other rich substrates, or different hydrology. Such rivers are typically located in south-east England and East Anglia, and include the Hampshire Avon, Colne, lower Wissey, Lark, Nar, Wensum and Bure. Higher plants totally dominate the communities, with *Cladophora* and *Vaucheria* being the only non-flowering plants commonly present in such rivers. Of the more commonly occurring aquatic species, greater pond-sedge *(Carex riparia)*, unbranched bur-reed *(Sparganium emersum)*, fennel-leaved pondweed (*Potamogeton pectinatus*) and arrowhead *(Sagittaria sagittifolia)* are much more likely to be found in catchments of mixed geology than in systems with >80% chalk. Like the assemblages of the Test and Itchen, most communities of good quality rivers typically have very species-rich assemblages.

3.2.6 Floodplain plant communities

A range of important plant communities is characteristically supported by the floodplains of chalk rivers, although these have suffered greatly from post-war agricultural intensification. They range from lightly grazed wet meadow (Plate 15) and associated ditch systems, to tall herb fen (Plate 16), swamp communities and wet woodland (Plate 1). These communities often rely heavily on the structural and hydrological management of the river, which greatly influences local groundwater levels and dictates the extent of overbank flooding.

Swamp communities are typically dominated by sweet-grass, common reed and lesser pond sedge, but vegetation dominated by greater tussock-sedge (*Carex paniculata*) can also develop (typed as S3 by the National Vegetation Classification, NVC). Flood pastures/meadows support now uncommon grassland communities, meadow foxtail - great burnet (*Alopecurus pratensis - Sanguisorba officinalis*, NVC MG4) and crested dog's-tail - marsh marigold (*Cynosaurus cristatus - Caltha palustris*, NVC MG8). Species supported by such pastures include marsh lousewort (*Pedicularis palustris*), marsh valerian (*Valeriana dioica*), common meadow rue (*Thalictrum flavum*) and southern marsh orchid (*Dactylorhiza praetermissa*).

Plate 9 Brook water-crowfoot, *Ranunculus penicillatus* subsp. *pseudofluitans*, the characteristic crowfoot of perennial headwaters and classic chalk streams.

Plate 10 Whorl-grass, *Catabrosa aquatica*, typical of silty marginal sediments in chalk streams.

Plate 11 River water-dropwort, *Oenanthe fluviatilis*, a highly characteristic and threatened plant of chalk rivers.

Plate 12 Typical spring pattern of vegetation on the Till, with *Ranunculus* dominating.

Plate 13 Typical early summer pattern of vegetation on the Till, with Ranunculus flowering and marginal species beginning to invade the channel.

Plate 14 Typical late summer pattern of vegetation on the Till, with encroaching marginal plants leaving only a narrow low-flow channel of open water.

Tall herb fens typically support species such as meadowsweet (*Ulmaria filipendula*), common valerian (*Valeriana officinalis*), common meadow-rue and hemp agrimony (*Eupatorium cannabinum*). The S25 fen community (*Phragmites australis - Eupatorium cannabinum*) is particularly associated with riparian areas of chalk rivers, such as the Kennet, Avon, Test and Itchen.

3.3 Algae

Whilst the larger algal species have been considered briefly in the previous section in the context of higher plants, there is a need to consider characteristic algal communities in the wider context, including all forms of micro-algae. Since most chalk rivers do not have retention times sufficient to allow a true phytoplankton population to develop, this section concentrates on the various forms of algae in chalk rivers that are either attached to substrates or are associated with them, such that they avoid wash-out. These are a highly important source of plant productivity for chalk rivers, with a range of animal species depending upon them directly or indirectly as a food source. Consumers of this algal community include grazers (such as gastropod molluscs and mayfly nymphs) and filter feeders that strip out algal cells from the water column after they have been dislodged from their substrate. Algal species can be described by a combination of the associated substrate and their mode of life, as outlined in Table 3.3.

Table 3.3 Categories of non-planktonic algae in chalk rivers

<table>
<tr><td rowspan="5">Periphyton

A loose term used variously for attached micro-organisms</td><td></td><td>Epiphytic</td><td>Algae attached to plant stems, leaves and thalli.</td></tr>
<tr><td rowspan="4">Benthic forms</td><td>Episammic</td><td>Algae attached to sand particles and photsynthesising in the top 1 cm of the sediment. Some can detach themselves and re-attach in more favourable positions (since sand is an unstable environment).</td></tr>
<tr><td>Epipelic</td><td>Free-living algae that move about in the surface layers of sand and other (particularly finer) sediments. These become more important as sediments become finer.</td></tr>
<tr><td>Epilithic</td><td>Algae attached to stones and other large inorganic substrates.</td></tr>
<tr><td>Epibenthic</td><td>Algae living on the surface of bed sediments.</td></tr>
</table>

As might be imagined, algal communities in chalk rivers have been little studied compared to other biological groups, and so there is only a small information base upon which to draw. Importantly, most historical data (pre-1960) has been derived from algae colonising glass slides exposed for a short period of time, providing a biased selection of the species present.

Early information on the dominant species colonising glass slides in various sections of chalk river are given in Table 3.4 (drawing on studies by Butcher 1946), along with more recent information from the River Colne and Bere Stream. It should be noted that this information is drawn from a very small number of sites and from different times of the year, so should be treated with some caution. Limeencrusting species typical of chalk rivers are not represented in the table (probably largely as a result of the use of glass slides at most sites), including the blue-green species *Lyngbya kutzingii, Chamaesiphon polymorphus, Phormidium incrustatum* and *C. polonicus*. *Hildenbrandia*, a characteristic red alga of chalk stream gravels that forms a red stain on stones, is also absent from the species list. However, the species-richness in different algal groups does reflect the typical dominance of diatoms found in more recent studies of chalk rivers, with blue-green algae being next abundant and green algae generally being a relatively small component of the community.

Seasonal patterns in algal densities are characterised by a spring peak, followed by a depression in biomass in the summer and often a further smaller peak in autumn. Accumulation of biomass over the winter months is typically low. These patterns are associated with changes in the relative abundance of species and algal groups. For instance, on brook water-crowfoot in the Itchen (Shamsudin and Sleigh 1995), blue-green algae (particularly the genus *Phormidium*) were found to reach their peak abundances in autumn, when they accounted for around 25% of algal cells.

Reduced densities in summer are probably more related to the action of algal grazers than changes in productivity (as a result of physical and chemical factors), resulting in consumption rates of up to 55%. Studies where grazers have been removed have shown significant increases in algal densities (e.g. Marker *et al.* 1984, Creed 1994). Where grazing intensity is sufficiently low and/or growth rates are sufficiently high, algal films increase in thickness until the basal cells are deprived of light, carbon dioxide and nutrients and consequently die off, destabilising the film and causing it to be sloughed from the host plant. On the Bere Stream, Marker (1976b) observed net productivities of epilithic algae of around 30 g m^{-2} during the period March to July, initially accompanied by increases in biomass of 12 g m^{-2} but later producing no biomass increase, suggesting increasing effects of grazing and destabilisation of algal films.

Submerged plants, particularly *Ranunculus* spp., provide an excellent illuminated substrate in chalk rivers, creating zones of slow-moving water near the surface where attached and entangling algae (epiphytes) can grow. These algae restrict both light and nutrients reaching the plant's shoots and may also alter the pH and dissolved oxygen conditions locally in a way that restricts the plant's photosynthesis more than algal photosynthesis (Simpson and Eaton, 1986). Even *Cladophora*, a common filamentous epiphyte of *Ranunculus* and an epilithic alga in its own right, has its own unicellular epiphytes. In fact, work in experimental channels in the absence of higher plants (Marker and Casey 1982) recorded *Cladophora* and its epiphytes reaching biomass levels of 15 mg dry weight m^{-2} in March, before the *Cladophora* was smothered by epiphytic growths and subsequently declined to negligible levels after May.

Algal assemblages vary greatly between different habitats, as indicated by studies on the River Wylye (Table 3.5, Moore 1977) and more recent work on the Itchen (Table 3.6, Shamsudin and Sleigh 1995). Work on the Wylye separated abundant species into a number of habitat categories, whilst studies on the Itchen involved the recording of relative abundances of key genera on stones, brook water-crowfoot, *Cladophora* and in the water column. The two studies reflected the dominance by diatoms across a range of habitats, with lesser contributions from blue-green and green algae. On the Itchen, whilst many genera were common to two or more substrates, large differences were apparent in the relative importance of genera between habitats.

Table 3.4 Principal benthic algae found in chalk rivers in a range of studies (drawn from Butcher 1946, Westlake 1955, 1956, Westlake *et al.* 1972 and Marker 1976a, pers. comm. D. Westlake).

Site	Itchen @ Alresford	Test @ Longstock	Avon @ Breamore	Colne@ Springwell Lane	Bere Stream @ Bere Heath
Substrate	Glass slide	Glass slide	Glass slide	Glass slide	Gravel
Year	1936	1935	1936-38	1954/55	1969/70
Chalk river category	R2	R3	R4b	R3	R2
Diatoms (Bacillariophytes)					
Achnanthes lanceolata	*	**	**		
A. minutissimum	**	***	***		
Achnanthes spp.				✔	
Cocconeis placentula	***	***	***	+	+
Cymbella ventricosa	***	*	**		
C. affinis	***	*	**		
C. lanceolata	***	*	**		
Diatoma vulgare					✔✔
Gomphonema constrictum	**	-	***		
G. olivaceum	**	-	***		
G. parvulum	**	-	***		
Navicula avenacea					✔✔
Navicula gracilis					✔✔
Nitzschia acicularis				✔✔✔	
N. linearis				✔✔	
N. palea	*	**	***	✔	
N. viridula				✔✔✔	
Synedra ulna				✔✔	
Ulvella frequens	**	**	***	✔✔✔	
Blue-green (Cyanophytes)					
Chamaesiphon incrustans	***	***	***		
C. regularis	***	***	***		
Chamaesiphon spp.					✔
Homoeothrix crustaceae	N/A	N/A	N/A	N/A	✔✔
Phormidium foveolarum	*	*	*		
Phormidium incrustatum	N/A	N/A	N/A	N/A	✔✔
Pleurocapsa spp.	N/A	N/A	N/A	N/A	✔
Green (Chlorophytes)					
Gongrosira sclerococcus				✔✔✔	
Protoderma sp.	*	*	*		
Sphaerobotrys fluviatilis	**	-	**		
Stigeoclonium farctum and sp.	**	*	**	✔✔✔	

R2 = Perennial headwaters; R3 = Classic chalkstreams; R4b = Large, mixed geology.
* = in some quantity in all places; ** = usually 100-500 organisms mm^{-2} (cells, colonies or filaments); *** = 500-4,600 organisms mm^{-2}.
✔= 5-40% occurrence; ✔✔= 40-70% occurrence; ✔✔✔= 70-100% occurrence; + = Occasional.
N/A = Not applicable (does not occur on the substrate in question).

Table 3.5 Algae found in abundance on different substrata in the River Wylye at Longbridge Deverill, 1973-75 (from Moore 1977, 1978)

Species	Epilithic	Episammic	Epipelic	Epiphytic (on *Cladophora*)	Epiphytic (on water-cress)
Diatoms					
Achnanthes minutissima	*		*	*	*
A. lanceolata			*	*	*
Amphora ovalis		*			
Cocconeis placentula					*
Diatoma vulgare				*	
Fragilaria construens		*			
Gomphonema olivaceum				*	
Melosira varians			*		
Meridion circulare				*	
Nitzschia palea	*				
N. linearis	*		*		
Opephora martyi		*			
Blue-green					
Chamaesiphon incrustans				*	
Phormidium foveolarum	*				
Oscillatoria brevis	*				
Green					
Scenedesmus spp. *				*	

* Interestingly, work by D. Westlake (pers. comm.) on hundreds of riverine sites has never found *Scenedesmus* living as an epiphyte on *Cladophora*.

Table 3.6 Principal genera of algae in four habitats in the River Itchen at Otterbourne (from Shamsudin and Sleigh 1995).

Genus	Algal grouping	Epiphytic on *Ranunculus* *	Epiphytic on *Cladophora*	Epilithic on pebbles	In water column
Cocconeis	Diatom	1		6	6
Achnanthes	Diatom	2		1	7
Navicula	Diatom	3	9	7	
Phormidium	Blue-green	4	8	2	4
Meridion	Diatom	5	3	3	2
Diatoma	Diatom	6	2	9	8
Gomphonema	Diatom	7			
Oscillatoria	Blue-green	8			
Scenedesmus	Green	9			
Rhoicosphenia	Diatom		1		
Nitzschia	Diatom		4	5	5
Fragilaria	Diatom		5		
Synedra	Diatom		6		1
Chamaesiphon	Blue-green		7	8	
Gongrosira	Green			4	3
Melosira	Diatom				9

Numbers indicate the rank order of abundance in each habitat, up to a limit of 9.

* Brook water-crowfoot, *Ranunculus penicillatus* subsp. *pseudofluitans*.

The work of both Moore (1977) and Shamsudin and Sleigh (1995) points to the diatom genera *Cocconeis* and *Achnanthes* as being highly important in the epiphyte flora of brook water-crowfoot. In fact, diatoms were responsible for between 65 and 98% of algal cells on this plant in the Itchen, with the actual percentage varying with the season. The diatom flora of *Cladophora* in the Itchen was found to be very different from that of brook water-crowfoot, characterised by an almost complete absence of *Achnanthes*, the infrequent occurrence of *Cocconeis* and the dominance of *Rhoicosphenia* and *Diatoma*. Studies by Moore (1977) on the Wylye also indicate a rarity of *Cocconeis* on *Cladophora*, but an abundance of *Achnanthes*, suggesting that local conditions influence epiphytic assemblages on the species. Shamsudin and Sleigh (1995) suggest that the higher current velocities typically experienced by *Cladophora* epiphytes may be important, but other factors cannot be discounted, including defence mechanisms of the host plant and also nutrient status. Interestingly, observed algal densities on brook water-crowfoot were around 100 times higher in the Itchen than in the Wylye, which may be a function of nutrient status (even though the Wylye is quite enriched itself).

On the pebbles of the river bed, the studies of the Itchen indicate a greater importance of blue-green algae (particularly *Phormidium*), chlorophytes (mainly *Gongrosira*) and the diatom genera *Meridion* and *Nitschia* compared to the epiphyte flora on brook water-crowfoot. In the water column, algae were derived from algal communities on various attachment substrates from which they become dislodged, which is a typical feature of suspended algae in chalk streams. However, the frequency of occurrence of different genera in the water column does not appear to be well-related to the frequency of occurrence on different substrates. The diatom *Synedra ulna* was by far the most abundant alga in the water column, but was a minor component of the community in all three substrates examined. This phenomenon is presumably related to the strength of the attachment to the substrate, with *Synedra* appearing to be only weakly attached. The diatom genus *Meridion* and the blue-green genus *Phormidium* were also important in the water column, as were fragments of the encrusting green alga *Gongrosira*.

It is important to note that competition between rooted higher plants and algal species plays an important role in shaping plant communities in chalk rivers. Competition may be between seed germination of rooted higher plants and the growth of benthic (epilithic, episammic and epipelic) algae, or between the growth of higher plants stems and leaves and the growth of epiphytic algae. Individual species of submerged higher plants respond differently to this competition, with some species resisting it better than others. For instance, recent studies (Spink *et al.* 1993) have found that 200 g dry weight m^{-2} of *Cladophora* growing in submerged beds of higher plants produced a more severe effect on growth and survival of brook water-crowfoot than on fennel-leaved pondweed (*Potamogeton pectinatus*), the latter being well-known as shade-tolerant and benefiting from enriched conditions.

On the Itchen, Shamsudin and Sleigh (1995) estimated that epiphytes (not even including *Cladophora*) frequently constitute a staggering 20 - 55% of the dry mass of a *Ranunculus* shoot. Whilst it is not clear how much of this algal growth is due to nutrient enrichment or other artificial effects (such as low flows), the short algal generation times and high turnover (through grazing and sloughing) mean that epiphytes were estimated to produce around six times as much plant biomass as brook water-crowfoot on the stretch of river studied. Whilst this may be over-estimating their importance, particularly in relation to the reference conditions defined in Section 2, there is no doubt that epiphytic and other attached algae are highly important primary producers in chalk rivers. On the Bere Stream, a chalk stream less influenced by anthropogenic factors, epilithic algal production has been found to be similar to the production of higher plants (pers. comm. D. Westlake), and this may also represent a more natural relationship between higher plant and epiphytic productivity.

3.4 Invertebrates

3.4.1 Background

Chalk rivers support an abundant and diverse invertebrate community, sustained by a variety of abiotic and biotic (vegetative) habitats. Unlike all other components of chalk river communities being considered, the invertebrate community contains very large numbers of species, many of which are unknown to all but the specialist aquatic entomologist. To cope with this diversity, much of the published literature considers taxonomic groups (usually families or orders) or functional groups (such as shredders and filter feeders) rather than species. At this level of detail, community variation down the length of rivers takes the form of subtle shifts in relative abundance between groups, and conservation value can only be measured in terms of species-richness.

For this handbook, it has been possible to construct a listing of key species from studies of a number of southern chalk rivers, and assign them occurrence ratings in upper (perennial headwaters), middle (classic chalk streams) and lower reaches (large chalk rivers). Even though it is restricted to selected groups and typical species, the list is still very long (see Section 3.4.3). Winterbournes have been treated separately as they have a distinctive fauna.

3.4.2 Invertebrate communities of winterbournes

The winterbourne fauna has much in common with perennial sections but the intermittent nature of the flow favours insects that have prolonged resting stages, or those capable of colonizing quickly from other areas when flow resumes. Many non-insect groups such as snails are able to withstand relatively dry periods by sheltering amongst higher plants. Table 3.7 (from Berrie and Wright 1984) lists some of those taxa that are restricted to winterbourne sections and compares them with species found only below the perennial head. Coleoptera and Hemiptera are particularly well represented in the winterbourne since many are opportunistic colonisers and favour the richly vegetated channel. In addition to those species listed, the snails *Anisus leucostoma*, *Lymnaea truncatula* and *L. palustris* are characteristic of winterbournes, although they are not restricted to them.

Plate 15 Winter flooding of riparian pasture on the River Chitterne.

Plate 16 Tall herb fen vegetation up to bank edge - the Test at Chilbolton.

Table 3.7 Invertebrate taxa recorded at winterbourne and perennial chalk stream sites on the River Lambourn (adapted from Berrie and Wright 1984).

Taxon	Present at all sites	Restricted to intermittent sites	Restricted to perennial sites
Malacostraca (Group of crustaceans)	*Gammarus pulex*	*Niphargus aquilex*	
Ephemeroptera (Mayflies)	*Baetis vernus*	*Caenis horaria*	*Paraleptophleba submarginata* *Centroptilum luteolum* *Ephemera danica* *Caenis rivulorum*
Coleoptera (Beetles)	*Helophorus* spp.	*Coelambus impressopunctatus* *Hydroporus marginatus* *H. memnonius* *H. nigrita* *H. pubescens* *Agabus biguttatus* *A. didymus* *Colymbetes fuscus* *Dytiscus marginatus* *Hydrobius fuscipes* *Anacaena limbata*	*Brychius elevatus* *Oreodytes sanmarki* *Platambus maculatus* *Agabus chalconatus* *Hydraena gracilis* *Limnebius truncatellus* *Oulimnius tuberculatus* *Riolus subviolaceus*
Trichoptera (Caddis-flies)	*Limnephilus lunatus* *Halesus* sp. *Stenophylax* sp.	*Limnephilus vittatus* *Glyphotaelius pellucidus*	*Lype reducta* *Hydroptila* sp. *Ithytrichia* sp. *Oxyethira* sp. *Beraea maurus* *Odontocerum albicorne* *Anthripsodes albifrons* *Adicella reducta* *Brachycentrus subnubilis* *Sericostoma personatum*
Bivalvia (Bivalva molluscs)		*Pisidium personatum*	*Pisidium milium*
Hemiptera (Bugs)		*Notonecta maculata* *Corixa punctata* *Sigara concinna*	
Plecoptera (Stoneflies)		*Nemoura cinerea*	*Nemurella picteti*

For simplicity, Chironomidae and Oligochaeta have been omitted from Berrie and Wright's original table, as have taxa from sites adjacent to the Lambourn (one of which was a pond) and taxon groups which contained no species restricted to winterbournes. The damselfly *Calyopterix splendens* has also been omitted, since its inclusion in the 'winterbourne only' category was anomalous.

The fauna of temporary streams has been classed into three main groups (Williams and Hynes 1977), as outlined below.

Permanent species (e.g. *Gammarus pulex*) are represented by those, which penetrate into intermittent sections from perennial sections and because of their wide tolerance may survive a short period of water loss. They are, however, non-specialised and are eliminated by prolonged drought.

Facultative species are capable of existing in a wide variety of water bodies and have strong powers of colonisation, typically using an aerial phase. Examples of this group are found in the Coleoptera and Hemiptera (Cooling 1981). Frequently, the intermittent section may support more species than the perennial section but the fauna is more variable in composition.

Specialised species are highly adapted and may be restricted to intermittent streams. Strategies for survival include resistant life-cycle stages or the ability to use refugia such as interstitial spaces deep within the gravel bed. Included in this group are the gastropod *Anisus leucostoma* and the pea mussels, *Pisidium casertanum* and *P. personatum* all of which have a tolerance to drying out. In contrast the mayfly *Paraletophlebia werneri*, the stonefly *Nemoura cinerea* and the blackfly *Metacnephia amphora* rely on resistant eggs to overcome the dry period usually encountered in autumn. Another species, the caddis fly *Limnephilus auricula*, has an ovarian diapause in the adult stage plus a long flight period, both features that favour the exploitation of intermittent streams. Species such as *Phagocata vitta* (a flatworm), *Niphargus aquilex* (a crustacean), and the dytiscid beetles *Hydroporus marginatus* and *Agabus biguttatus*, all make use of the deep gravel substratum to survive.

From this description, winterbourne invertebrate communities can be seen as distinctive aquatic faunas, with specialised species being particularly vulnerable to long-term changes in physio-chemical conditions.

3.4.3 Invertebrate communities of perennial sections

The list of species supported by upper, middle and lower reaches of chalk rivers given in Table 3.8 is based upon southern examples and does not consider northern and eastern rivers (although these will have broadly similar communities). For the sake of simplicity, a limited number of invertebrate groups has been considered (Gastropoda, Hirudina, Crustacea, Ephemeroptera, Plecoptera and Coleoptera). The longitudinal changes in species occurrence apparent from the table reflect changes in the balance between different habitats within the channel (such as beds of higher plants and different substrate types - see Section 4), as well as changes in the specific conditions within those habitats. Thus, there is an increased occurrence of species such as *Asellus aquaticus* and certain species of pea mussel in the more sluggish and silt-dominated downstream sections, whilst certain stonefly species (such as *Leuctra nigra* and *L. hippopus*) and ecdyonurid mayflies only occur in the swift-flowing, gravel-dominated upper reaches.

In fact, strong reach-fidelity is observed in many species belonging to all of the families considered, including some threatened species. The nationally scarce caddis-fly *Ylodes conspersus* (a weed-dweller) has only been found in the lower reaches, whilst the nationally scarce riffle beetle *Riolus cupreus* has only been recorded from the upper reaches. A number of gastropods of rather local distribution, such as *Theodoxus fluviatilis* (strongly associated with chalk-rivers), *Bithynia leachi* and *Valvata piscinalis* are associated with the lower reaches. Looking at individual orders (such as the Ephemeroptera), a shift in species occurrence is evident from the upper reaches to the lower reaches, with a number of more generalist species spanning the entire perennial length of the river. A group-by-group summary of this species information is given in Table 3.9, which clearly shows the type of reach-fidelity outlined above in addition to changes in species-richness along the length of the river (the increase in gastropods in the lower reaches is particularly noticeable).

As an example of the types of longitudinal changes occurring in individual habitats, studies by IFE in the Frome system (Armitage and Cannan in press) have found that summer samples in shallow riffle, gravel habitat are dominated by Ephemerellidae and Gammaridae (49% of the total abundance at the site) in the upper reaches, but by Ephemerellidae and Brachycentridae (55% of the total) in the lower reaches. Similarly, *Ranunculus* is dominated by Simuliidae and Ephemerellidae (82%) in the upper reaches and Brachycentridae and Ephemerellidae (74%) in the lower reaches.

The native white-clawed crayfish (*Austropotamobius pallipes*, Plate 17) has always been a key feature of high quality chalk rivers and still occurs on a number of chalk river SSSIs despite recent nationwide declines. The species is widespread but restricted to hard, alkaline waters (calcium concentrations above 5 mg l^{-1} and pH values of 7 - 9 - Holdich and Rogers 1997a), meaning that chalk river systems are a natural stronghold. Unfortunately, most chalk river systems now have very limited populations of the species (Holdich and Rogers 1997b), with non-native crayfish spreading rapidly and crayfish plague causing high mortalities (see Section 5.12). The fine-lined pea mussel (*Pisidium tenuilineatum*) is a rare (but probably under-recorded) species that has been found only in calcareous watercourses, inhabiting middle and lower reaches and apparently largely confined to southern-England in rivers such as the Itchen, Hampshire Avon and a number of Thames tributaries.

Table 3.8 **The occurrence of typical invertebrate species in upper, middle and lower reaches of chalk rivers based on data from spring, summer and autumn samples in 4 southern chalk streams (the Test, Itchen, Frome and the Hampshire Avon).**

SPECIES COMMON TO ALL SECTORS	U M L
Ancylus fluviatilis Muller	9 5 6
Anisus vortex (L.)	5 3 3
Lymnaea peregra (Muller)	5 4 5
Physa fontinalis (L.)	**3 7 8**
Potamopyrgus jenkinsi (Smith)	5 7 5
Pisidium nitidum Jenyns	**5 9 7**
Pisidium subtruncatum Malm	5 7 5
Sphaerium corneum (L.)	**2 6 5**
Erpobdella octoculata (L.)	8 8 8
Glossiphonia complanata (L.)	5 8 7
Helobdella stagnalis (L.)	6 4 4
Piscicola geometra (L.)	6 4 3
Asellus aquaticus (L.)	**2 3 8**
Gammarus pulex (L.)	9 9 9
Baetis muticus (L.)	3 3 5
Baetis niger (L.)	3 4 3
Baetis rhodani (Pictet)	9 9 8
Baetis scambus group	**2 7 5**
Baetis vernus Curtis	**5 7 3**
Caenis luctuosa group	3 4 3
Centroptilum luteolum (Muller)	3 3 3
Ephemera danica Muller	5 6 6
Ephemerella ignita (Poda)	**8 9 5**
Heptagenia sulphurea (Muller)	**3 8 5**
Paraleptophlebia submarginata	**6 1 3**
Isoperla grammatica (Poda)	2 1 3
Leuctra fusca (L.)	2 1 2
Sigara (Sigara) sp.	2 2 2
Elmis aenea (Muller)	9 9 8
Limnius volckmari (Panzer)	6 9 9
Orectochilus villosus (Muller)	3 2 3
Platambus maculatus (L.)	2 1 2
Agapetus sp.	**8 9 3**
Athripsodes albifrons (L.)	2 3 4
Halesus sp.	5 3 1
Hydropsyche pellucidula (Curtis)	6 7 7
Hydropsyche siltalai Dohler	**6 8 1**
Hydroptila sp.	5 1 3
Lepidostoma hirtum (Fabricius)	2 3 6
Limnephilus lunatus group	3 4 3
Polycentropus flavomaculatus (Pictet)	2 2 5
Potamophylax group	**6 8 1**
Psychomyia pusilla (Fabricius)	2 1 3
Rhyacophila dorsalis (Curtis)	6 9 7
Sericostoma personatum (Spence)	6 8 3
Simulium (Eusimulium) aureum group	2 2 3
Simulium (Nevermannia) angustitarse group	5 3 2
Simulium (Simulium) ornatum group	8 9 6

SPECIES COMMON TO MIDDLE AND LOWER SECTORS	U M L
Theodoxus fluviatilis (L.)	**0 3 8**
Bithynia tentaculata (L.)	**0 3 7**
Pisidium amnicum (Muller)	0 3 1
Valvata cristata Muller	0 1 3
Valvata piscinalis (Muller)	0 1 2
Planorbis carinatus Muller	0 1 2
Theromyzon tessulatum (Muller)	0 2 2
Baetis atrebatinus Eaton	0 1 3
Centroptilum pennulatum Eaton	0 1 2
Procloeon bifidum (Bengtsson)	0 1 1
Leuctra geniculata (Stephens)	0 2 2
Sialis lutaria (L.)	0 3 2
Potamonectes depressus (Fabricius)	0 2 1
Oulimnius sp.	0 2 3
Athripsodes cinereus (Curtis)	**0 4 7**
Odontocerum albicorne (Scopoli)	**0 4 1**
Goera pilosa (Fabricius)	0 3 3
Anabolia nervosa (Curtis)	0 2 3
Brachycentrus subnubilus Curtis	**0 2 8**
Simulium (Wilhelmia) lineatum (Meigen)	0 3 1
Simulium (Wilhelmia) sp.	**0 1 5**

SPECIES COMMON TO UPPER AND MIDDLE SECTORS	U M L
Pisidium milium Held	**5 3 0**
Caenis rivulorum Eaton	**5 2 0**
Oreodytes sanmarkii (Sahlberg)	**6 3 0**
Brychius elevatus (Panzer)	**6 1 0**
Silo nigricornis (Pictet)	**5 1 0**
Silo pallipes (Fabricius)	**3 1 0**
Limnephilus rhombicus (L.)	2 1 0
Melampophylax mucoreus (Hagen)	2 1 0

SPECIES OCCURRING IN TOP SECTOR ONLY	U M L
Pisidium personatum Malm	3 0 0
Lymnaea stagnalis (L.)	2 0 0
Ecdyonurus sp.	**5 0 0**
Rhithrogena semicolorata group	3 0 0
Habrophlebia fusca (Curtis)	3 0 0
Nemoura cambrica group	2 0 0
Leuctra hippopus (Kempny)	2 0 0
Leuctra nigra (Olivier)	2 0 0
Agabus sp.	2 0 0
Anacaena limbata (Fabricius)	2 0 0
Elodes sp.	2 0 0
Riolus cupreus (Muller)	2 0 0
Plectrocnemia geniculata McLachlan	2 0 0
Hydropsyche angustipennis (Curtis)	2 0 0
Oxyethira sp.	2 0 0
Drusus annulatus Stephens	2 0 0
Simulium (Nevermannia) costatum Friederichs	**5 0 0**

SPECIES OCCURRING IN MIDDLE SECTOR	U M L
Brachycercus harrisella Curtis	0 1 0
Oulimnius tuberculatus (Muller)	0 2 0
Riolus subviolaceus (Muller)	0 1 0

SPECIES OCCURRING AT LOWER SECTOR ONLY	U M L
Bithynia leachi (Sheppard)	0 0 2
Bathyomphalus contortus (L.)	0 0 2
Planorbis planorbis (L.)	0 0 1
Armiger crista	0 0 2
Acroloxus lacustris (L.)	0 0 1
Pisidium casertanum (Poli)	0 0 1
Batracobdella paludosa (Carena)	0 0 1
Trocheta subviridis Dutrochet	0 0 1
Crangonyx pseudogracilis Bousfield	**0 0 6**
Austropotamobius pallipes (Lereboullet)	0 0 1
Baetis buceratus Eaton	**0 0 4**
Caenis pusilla Navas	0 0 2
Baetis digitatus Bengtsson	0 0 1
Cloeon dipterum (L.)	0 0 1
Leptophlebia vespertina (L.)	0 0 1
Calopteryx splendens (Harris)	0 0 5
Sialis nigripes Pictet	0 0 1
Aphelocheirus aestivalis (Fabricius)	**0 0 9**
Sigara falleni (Fieber)	0 0 1
Gyrinus natator group	0 0 1
Oulimnius sp.	0 0 3
Ithytrichia sp.	**0 0 6**
Hydropsyche contubernalis McLachlan	**0 0 5**
Cheumatopsyche lepida (Pictet)	**0 0 4**
Potamophylax sp.	0 0 2
Ylodes conspersus (Rambur)	0 0 2
Polycentropus irroratus (Curtis)	0 0 1
Athripsodes aterrimus (Stephens)	0 0 1
Ceraclea dissimilis (Stephens)	0 0 1

The numbers represent occurrences, where 9 represents occurrence in all rivers in all three seasons and 1 represents occurrence in 1 river in one season.. Taxa strongly associated with chalk streams and also showing a reach preference are shaded.

Table 3.9 **Distribution of species within major invertebrate groups in upper, middle and lower reaches of chalk rivers**

Group	Total	Upper	Middle	Lower
Gasteropoda	18	8 (1)	9	17 (5)
Sphaeriidae	7	5 (1)	5	5 (1)
Hirudinea	7	4	5	7 (2)
Baetidae	12	6	9	12 (3)
Other Ephemeroptera	12	9 (3)	7 (1)	7 (2)
Plecoptera	6	5 (3)	3	3
Coleoptera	14	11 (4)	10 (1)	8 (1)
Trichoptera	34	22 (4)	22	26 (7)

Figures represent the number of species, with parenthesised numbers indicating the number of species that are unique to the reach.

In terms of seasonality in perennial sections, changes in invertebrate communities are intimately linked to the seasonal patterns of flow and higher plant growth. Emergence patterns and oviposition sites are closely linked to season and habitat, creating a succession of species dominance throughout the year.

3.4.4 Riparian and floodplain invertebrate communities

Whilst the plant communities of chalk river riparian and floodplain habitats have been much more extensively studied, the invertebrate fauna of these habitats is diverse and there are various species of national importance that are highly dependent upon the hydrological regime of the river and structure of the banks. This includes species from the water edge, tall herb fen, fen pastures and associated ditches, swamp communities, and wet woodland.

The fauna of lightly grazed, shallow water margins is most characteristic of riparian areas along chalk rivers, but has been heavily impacted by river engineering activities and agricultural intensification. The habitat contains a mosaic of muddy and vegetated patches created by light poaching of the soft and shallow banks. This provides a suitable environment for a diverse assemblage of water edge species, including a range of rare and notable Diptera not found in other riparian habitats (Drake 1995). Recent research by IFE has revealed movements by a range of invertebrate species between wooded chalk river margins and open grassed margins that suggest an important role for the co-occurrence of the two riparian habitats (see Section 4.3).

The list of rare and threatened wetland species occurring in chalk river floodplains is long. Of particular note is the southern damselfly, *Coenagrion mercuriale* (scheduled under the EU Habitats Directive, Plate 18), typically associated with shallow flowing heathland headwaters with some calcareous influence, but also occurring in the drainage network associated with old water meadows along the Itchen valley. It is possible that abandoned water meadow systems in other chalk river valleys could be amenable to this highly endangered species. The internationally important Desmoulin's whorl snail (*Vertigo moulinsiana*, another EU Habitats Directive species) is associated with tall herb fen in floodplains of rivers such as the Hampshire Avon and the Kennet.

3.5 Fish

3.5.1 Background

On large chalk river systems, the combination of swift chalk stream sections and large chalk river sections provides an extremely diverse array of fish habitats, creating some of the most species-rich fish communities in Britain when considering the river as a whole (such as the Hampshire Avon). The characteristic species assemblage of each broad category of chalk river is given in Table 3.10, whilst the spawning season of each species is indicated in Table 3.11.

Most of the English chalk rivers are, or were, tributaries of east-flowing rivers that once flowed into the Rhine when the British Isles were still connected to the European mainland. They therefore had the potential to be colonised by a wide range of freshwater fish species. Further, intentional introductions or escapes from ornamental still waters have occurred over several hundred years. Considering the historical opportunities for colonisation, the current distribution of certain fish species within England's chalk river resource is curious. Good fishery records are available for many rivers, and these additionally suggest a patchy historical distribution of certain species that is difficult to reconcile with the high availability of suitable habitat in rivers where they are absent.

The grayling (*Thymallus thymallus)* is native to north west Europe and Great Britain, being found across most of England and Wales in clean, well-oxygenated, fast-flowing streams and rivers (Maitland and Campbell 1992). Fishery records suggest that the grayling was introduced into the Hampshire Avon and Frome systems, whilst there are accounts of the species being introduced into the Test (in the early 1800s) and the Itchen (early this century). Whether or not it occurred in these rivers at any time before the documented introductions is not clear, and the mechanisms which might explain why the species may be naturally present and thrive in some chalk rivers but not in adjacent ones are similarly opaque. For the purposes of this report, the species is considered to be characteristic of chalk river systems.

The barbel (*Barbus barbus*) has a much more restricted natural geographical distribution in the UK than the grayling, originally confined to east and south-east England, but distributed to other river systems by angling interests. It is widespread in Europe from western France eastwards, but does not occur in northern areas (Maitland and Campbell 1992). The species is recorded as being introduced into the Hampshire Avon and does not occur on systems such as the Frome. For the purposes of the report, the species is considered to be characteristic of chalk river systems where it occurs.

Rainbow trout (*Oncorhynchus mykiss*) is not included in this table since it is a recent introduction from North America and is, therefore, not characteristic of the native fish fauna. It does, however, constitute a considerable proportion of the standing stock of fish in some chalk streams, sustained by regular stocking for angling purposes (see Section 5.10).

Several species are listed in conservation legislation and agreements as being of particular conservation concern (Table 3.1). The Atlantic salmon (*Salmo salar*) and the three native lamprey species are probably of greatest priority in chalk rivers, and are listed under the EU Habitats Directive. Chalk streams represent the major salmonid habitat in lowland Britain - indeed, the only habitat utilised by salmon in rivers entering the sea on Britain's east and south coasts between Yorkshire and Devon. Similarly, they probably constitute important lowland habitats for lamprey species. Brown trout (*Salmo trutta*), although not listed as a priority species, is under severe pressure from a similar range of factors that affect salmon. Grayling are of additional concern, listed under the Bern Convention and often discriminated against by angling clubs. Wider conservation interest lies in the characteristic species assemblages supported by different sections of chalk river, making an important contribution to the distinctiveness of chalk river communities.

3.5.2 Fish communities of winterbournes

The ephemeral nature of winterbournes makes this habitat difficult for fish to exploit and, when flow occurs, the community supported consists of few species. When springs "break through" in winterbournes in early/mid winter, large numbers of brown trout (*Salmo trutta*) surge upstream to spawn in many areas, in some cases several miles beyond the perennial head. Trout are often accompanied by minnows (*Phoxinus phoxinus*) and three-spined sticklebacks (*Gasterosteus aculeatus*), at least for part of this journey. In the following summer, as the streams dry out, the adults and resulting young-of-the-year migrate downstream to the perennial stream. Many become stranded in pools and die as the bed dries completely. However, those juveniles that do successfully return downstream may be the major part of the local recruitment, and therefore the importance of winterbourne production must not be underestimated. In some areas (for instance the Chitterne Brook, a tributary of the River Wylye), trout rescues have traditionally been mounted to return both stranded adults and juveniles to the main river.

The effectiveness of winterbourne spawning is heavily dependent upon the springs breaking through before about mid-January. In dry winters, break-through may be delayed beyond this time or may not occur at all, so winterbourne production of juveniles varies markedly between years. However, there is anecdotal evidence to suggest that certain strains of brown trout utilising winterbournes in this way can delay spawning in years of late break-through (February and even March) to take advantage of the extra spawning habitat.

3.5.3 Fish communities of perennial headwaters and classic chalk streams

As already noted, the classic chalk stream environment is the result of hundreds of years of human management for a range of purposes. It is typified by the Piddle, the upper Hampshire Avon and its tributaries (Wylye, Bourne, Ebble), the Upper Kennet, the middle and upper Itchen and Test, and the Driffield Beck in Yorkshire. Such streams are generally actively managed for fishing for brown trout and often rainbow trout. The typical native fish assemblage is listed below.

Brown trout	*Salmo trutta*
Grayling	*Thymallus thymallus*
Pike	*Esox lucius*
Eel	*Anguilla anguilla*
Stone loach	*Noemacheilus barbatulus*
Bullhead	*Cottus gobio*
Brook lamprey	*Lampetra planeri*
Three-spined stickleback	*Gasterosteus aculeatus*
Minnow	*Phoxinus phoxinus*

It is important to stress the ecological importance of the smaller species, which have historically been given little thought in terms of river management. LeCren (1969) reported that of the order of 60% and 71% of the fish production (in terms of biomass) of two small chalk streams (the Bere Stream, and the River Tarrant respectively) consisted of bullheads (*Cottus gobio*).

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Most of the species listed above may occur in the smallest headwaters up to and sometimes beyond the perennial head. However, pike (*Esox lucius*) and grayling are generally limited to somewhat larger streams. In addition, dace (*Leuciscus leuciscus*) can feature quite strongly in the larger examples of classic chalk stream. Spawning migrations at certain times of the year (see Table 3.11) will take individuals of species such as brown trout, grayling and brook lamprey (*Lampetra planeri*, Plate 19) considerable distances upstream. Other species, however, (generally lithophilic spawners) normally associated with larger lower reaches will enter classic chalk stream habitat for short periods (see below).

Plate 17 The white-clawed crayfish, *Austropotamobius pallipes*, characteristic of chalk rivers and other hard waters.

Plate 18 The southern damselfly (*Coenagrion mercuriale*), a priority species occurring in ditches on the Itchen floodplain (in addition to its more typical habitat of heathland streams with calcareous influence).

Plate 19 Sea (*Petromyzon marinus*), river (*Lampetra fluviatilis*) and brook (*Lampetra planeri*) lampreys, priority species utilising both clean gravel and silty habitats in chalk river systems.

3.5.4 Fish communities of large chalk rivers

Lower reaches of larger chalk rivers frequently contain a much wider range of fish species associated with somewhat reduced current velocities and increased water depth. Species that may be naturally abundant in such areas include dace, roach (*Rutilus rutilus*), chub (*Leuciscus cephalus*), gudgeon (*Gobio gobio*), barbel (*Barbus barbus* - in catchments where they occur) and perch (*Perca fluviatilis*), in addition to the species already discussed as being present in the classic chalk stream. Around the time of spawning (Table 3.11), species such as dace and grayling and to a lesser extent chub and gudgeon will migrate upstream into chalk stream habitat to take advantage of the greater predominance of gravel substrate.

In recent years, the normally still-water cyprinids carp (*Cyprinus carpio*) and bream (*Abramis brama*) have been increasing in numbers and range in the lower reaches of many chalk streams, such as the Hampshire Avon, Itchen and Test. It is not possible to say if this reflects an increasing trend of introduction and escapes, or a change in environmental conditions, which is encouraging colonisation and possibly an increased spawning range.

3.5.5 Migratory fish species

These species are given separate consideration from the habitat-based descriptions of fish communities made above, as they traverse artificial habitat boundaries in an extreme way.

Eels (*Anguilla anguilla*) have already been mentioned as being a component of the typical chalk stream fish community and they penetrate most streams to their perennial heads. It is probable that they were largely absent from the Thames tributary chalk streams (e.g. Kennet, Pang, Chess) for much of the last century due to pollution in the tidal Thames, but they have recolonised many of these streams in the last thirty years where in-river obstacles (particularly weirs) do not hinder their passage.

Salmon migrate into, and occur in, the lower and middle reaches of a number of the southern chalk rivers. They occur in the Dorset Frome up to Dorchester and beyond, the Piddle to Tolpuddle, the Rivers Tarrant and Allen (Dorset Stour tributaries), Hampshire Avon and tributaries (main river to Amesbury, Wylye to Steeple Langford, Nadder, lower Bourne), the Test to Longparish and the Itchen to beyond Winchester. They also occur in small numbers in the Kentish Stour and, in recent years, in the Kennet as a result of restocking.

Salmon do not penetrate as far as the limits of brown trout, and in dry years with delayed break-through of springs their spawning distribution may be severely truncated. The limit of colonisation of the catchment is likely to be determined by obstacles to migration (such as hatches and mills) and by the physical dimensions of the channel in which the fish are willing to occupy. Winterbournes are rarely of adequate dimension and flow to attract salmon, although some are known to have been heavily used in the past but now have much reduced flows (such as the North and South Winterbournes and the Tarrant).

Until recently, stocks of chalk stream salmon have been very healthy and have supported valuable angling fisheries. Stocks have declined rapidly in the last ten years, however, and are considered endangered in the Dorset Stour and under threat in the Hampshire Avon, Test and Itchen.

The migratory form of the brown trout, the sea trout, can occur in numbers in some chalk streams (such as the Dorset Frome, Hampshire Avon, Test and Kentish Stour), but it is generally believed that they mainly originate from, and return to spawn in, the less productive low pH tributaries (including the Blackwater on the Test and New Forest tributaries on the Avon). They are, therefore, not considered as a typical chalk stream fish. It is also likely that the large concentrations that often occur near the tidal limit of some chalk rivers may not have originated from those rivers and do not ascend them to spawn. This said, sea trout spawn throughout the same range as salmon on the Frome and Piddle, and so the situation is not clear-cut.

River lampreys (*Lampetra fluviatilis*) and sea lampreys (*Petromyzon marinus*) feed in coastal waters in the adult form, migrating up rivers to spawn in gravelly substrates. Larvae (called ammocoetes) drop downstream into silty habitats, where they remain within the substrate and they filter fine organic material (such as diatoms, protozoans and detritus) from the silt surface around their individual burrows. After a number of years, the larvae metamorphose into the adult form and migrate to sea. The natural extent of upstream penetration in chalk-based and other catchments is unclear, although they are likely to be concentrated in the lower catchment where suitable habitat occurs. Future monitoring work associated with their designation under the EU Habitats Directive should provide a better understanding of the reach-preferences and distribution of both species.

Table 3.10 Characteristic fish assemblages of different sections of chalk river

Species	Scientific name	Spawning/juvenile habitat				Growing/adult residence habitat			
		R1	R2	R3	R4	R1	R2	R3	R4
Atlantic salmon	*Salmo salar*	*	*	*	*				
Brown trout	*Salmo trutta*	*	*	*	*		*	*	*
Brook lamprey	*Lampetra planeri*		*	*			*	*	
Sea lamprey	*Petromyzon marinus*				*				
River lamprey	*Lampetra fluviatilis*			*	*				
Grayling	*Thymallus thymallus*			*	*				*
Minnow	*Phoxinus phoxinus*	*	*	*			*	*	*
Bullhead	*Cottus gobio*		*	*			*	*	
Dace	*Leuciscus leuciscus*			*	*			*	*
3-sp. stickleback	*Gasterosteus aculeatus*	*	*				*	*	
Stone loach	*Noemacheilus barbatulus*		*	*			*	*	
Pike	*Esox lucius*			*	*			*	*
Eel	*Anguilla anguilla*						*	*	*
Chub	*Leuciscus cephalus*			*	*				*
Gudgeon	*Gobio gobio*			*	*				*
Roach	*Rutilus rutilus*				*				*
Perch	*Perca fluviatilis*				*				*
Barbel*	*Barbus barbus*				*				*

R1 = Winterbournes; R2 = Perennial headwaters; R3 = Classic chalk streams; R4 = Large chalk rivers.
* Occurring only in certain chalk river catchments.

Table 3.11 Spawning seasons and substrates of key fish species inhabiting chalk rivers

Species	Season	Substrate used
Atlantic salmon	December – February	Coarse gravel in fast flow
Brown trout	December – February	Gravel in fast flow
Brook lamprey	April – May	Sand or gravel
Sea lamprey	May – June	Sand and gravel
River lamprey	April –May	Sand and gravel
Grayling	March – April	Gravel
Minnow	April – May	Gravel shallows
Bullhead	March – June	Beneath large stones
Dace	February – April	Gravel shallows
3-sp. stickleback	March – June	Nests in weeds
Stone loach	May – July	Gravel and vegetation
Pike	February – April	Vegetation and sticks
Eels	Return to sea to spawn	

3.6 Birds

3.6.1 Background

There is little published material on the bird communities of chalk rivers, and most of the information presented here is gleaned from county avifaunas and bird reports. The Birds of Hampshire (Clark and Eyre 1993) provides much information on the birds found in the valleys of the Itchen, Test, Meon and lower sections of the Hampshire Avon. Much of this focuses on the bird communities of the river valleys and, in particular, the flood meadows, rather than the river channels *per se*. Information for the neighbouring counties of Wiltshire, Dorset and Sussex is rather scant while chalk rivers elsewhere appear to have been much neglected by ornithologists.

Further information has been drawn from the British Trust for Ornithology's Waterways Bird Survey, which includes 11 stretches of chalk river in southern England. Information on these reaches is provided in Appendix B, although it should be remembered that the river reaches surveyed are not necessarily optimal habitat and the bird densities recorded are, therefore, not intended to be indicative of good ecological quality. Guidance on the densities of birds that can be supported by chalk rivers of high quality is given in the text where available.

3.6.2 Bird communities of winterbournes

Birds typical of flowing water (such as grey wagtails, *Motacilla cinerea*, and kingfishers, *Alcedo atthis*) are inevitably precluded from winterbournes during the dry summer period. Chalk hills hold relatively few birds during the winter months and winterbourne streams are not likely to support many birds even when flowing. However, a wide variety of birds not specifically associated with river corridors will use them as water sources in what is otherwise a waterless landscape. The only other significant sources of water in such areas are dew ponds, many of which have disappeared in recent decades through neglect or in-filling.

In some areas, winterbourne sections occur in relatively low-lying and flat areas and here one would expect a wider variety of species to be found throughout the year. Wider valley bottoms may allow small marshy areas to develop, attracting snipe (*Gallinago gallinago*) through the winter, some of which may stay on to breed, whilst redshank (*Tringa totanus*) may also breed alongside the more widespread lapwing (*Vanellus vanellus*). Such conditions exist around the upper reaches of river systems such as the Hampshire Avon in Wiltshire and River Nar in Norfolk. The development of scrub and reeds in these areas would allow species such as sedge warbler (*Acrocephalus schoenobaenus*) and reed bunting (*Emberiza schoeniclus*) to colonise, along with a range of other species less tied to wetlands.

As long as riparian meadows are managed in a sympathetic manner, wetland birds can capitalise on waterlogged conditions in winterbourne areas even though the channel has been dry for several years beforehand due to poor aquifer recharge. On the Bourne (River Avon tributary - near Salisbury) in 1994, redshank, lapwing, mallard and coot all nested within a stretch of winterbourne floodplain that had been dry from 1989 to 1992.

3.6.3 Bird communities of perennial headwaters

Summary information on species considered to be characteristic of this category is given in Table 3.12. A perennial flow provides feeding opportunities for species such as the kingfisher and grey wagtail, which can reach densities of one pair per kilometre on reaches of high quality. Even the dipper (*Cinclus cinclus*), a species normally associated with upland streams, breeds in some chalk headwater localities such as the Wylye and tributaries of the Frome. Common waterfowl such as the moorhen (*Gallinula chloropus*) and mallard (*Anas platyrhynchos*) can reach densities of up to ten pairs per kilometre. Little grebes (*Tachybaptus ruficollis*) can breed in high densities in the associated back channels and ditches, such as in the valleys of the Candover Stream and the Meon, reaching one pair per kilometre.

Under non-intensive management of wet meadows, the riparian areas of low-gradient perennial headwaters can provide suitable habitat for high breeding and overwintering densities of characteristic wetland birds such as snipe, redshank and lapwing. Unfortunately, the habitat has undergone extensive change in recent decades (see Section 5), leading to catastrophic declines in bird numbers. Considerable contractions in the range of these species have been recorded in some chalk river systems such as the Hampshire Avon (Gibbons 1993), and numbers along the Hampshire rivers have declined dramatically in recent years (Green and Cade 1997).

Perennial headwaters are capable of providing good habitat for the rare water rail (*Rallus aquaticus*), with small breeding populations occurring on the upper reaches of the Meon and other rivers such as the Test and Itchen. With an estimated British population of only 450-900 pairs and a notable decline in recent decades (Gibbons 1993) the small populations in chalk headwaters are of conservation importance.

The watercress beds found along the headwaters of chalk streams offer a unique habitat with a distinctive bird community. They are well known as a wintering site for water pipits (*Anthus spinoletta*) and green sandpipers (*Tringa ochropus*). Hampshire watercress beds held around 30 water pipits during a survey in the winter of 1978/79 (Pain 1990), while up to 21 green sandpipers have been counted at single sites during the winter months (Clark and Eyre 1993). However, numbers of water pipits have subsequently declined and only one was found in the whole of Hampshire in a 1989/90 survey. Under traditional management, watercress beds support many other waterbirds, especially during the winter months when suitable habitat is provided for water rail, snipe, pipits and wagtails.

Table 3.12 Key bird species of the headwaters of chalk rivers

Species		Main season	Habitat	Range in England
Water rail	*Rallus aquaticus*	All	Reedbeds and areas of lush emergent vegetation	Very scarce in all suitable areas
Lapwing	*Vanellus vanellus*	All	Flood meadows and farmland	Widespread and common but declining in some areas
Snipe	*Gallinago gallinago*	All	Flood meadows	Widely but thinly distributed. Declining
Redshank	*Tringa totanus*	Sp/Su	Flood meadows	Widely but thinly distributed. Declining
Green sandpiper	*Tringa ochropus*	W	Watercress beds and chalk streams	Widely but locally distributed
Kingfisher	*Alcedo atthis*	All	Rivers and streams, usually slow-flowing with suitable riverbank breeding sites	Widely distributed but never common
Water pipit	*Anthus spinoletta*	W	Watercress beds	Localised and declining
Grey wagtail	*Motacilla cinerea*	All	Rivers and streams, especially where there are riffles or weirs	Widely distributed. Common in west but scarce in eastern counties
Dipper	*Cinclus cinclus*	All	Fast-flowing rivers and streams	North and West only. On chalk rivers, localised in Dorset and Wiltshire, rarely elsewhere
Cetti's warbler	*Cettia cetti*	All	Dense scrub in damp areas	Rare and restricted to southern England
Sedge warbler	*Acrocephalus schoenobaenus*	Sp/Su	Reedbeds and scrub	Widespread and common in suitable areas
Reed warbler	*Acrocephalus scirpaceus*	Sp/Su	Reedbeds	Widespread and common in suitable areas
Reed bunting	*Emberiza schoeniclus*	All	Reedbeds and scrub	Widespread but rapidly declining nationally

Where marshy, reedy areas occur, numbers of reed warbler (*Acrocephalus scirpaceus*), sedge warblers and reed buntings can reach high densities. The nationally rare Cetti's warbler (*Cettia cetti*) is now well established in the upper Itchen Valley, with a peak of 8 males in 1989 (Clark and Eyre 1993) and is establishing territories on the Hampshire Avon.

3.6.4 Bird communities of classic chalk streams and large chalk rivers

Changes in the bird community from headwaters to the middle and lower reaches of chalk valleys reflect the reduced gradients and increased river size. The two largest categories of river section have been grouped together as their avifaunas have much in common, and summary information is provided in Table 3.13.

The feeding opportunities for grey wagtail are likely to be reduced compared to reaches further upstream, although high densities will occur on classic chalk streams where riffles, weirs and other areas of disturbed water occur. The classic chalk stream provides ideal feeding habitat for kingfishers, although densities may be constrained by the number of suitable nesting locations (this is the likely explanation of the patchy distribution of the species on the middle reaches of the Itchen and Meon).

Table 3.13 Key bird species of the middle and lower reaches of chalk rivers

Species		Main season	Habitat	Range in England
Little grebe	*Tachybaptus ruficollis*	All	Slow-moving rivers with emergent vegetation	Widespread.
Mute swan	*Cygnus olor*	All	Slow-moving rivers	Widespread.
Bewick's swan	*Cygnus columbianus*	W	Flood meadows	Widespread but local. In chalk river systems, Hampshire Avon and Frome, scarce elsewhere.
White-fronted goose	*Anser albifrons albifrons*	W	Flood meadows	Mainly coastal and southerly. In chalk river systems, Avon Valley in Hampshire.
Golden plover	*Pluvialis apricaria*	W	Flood meadows	Widespread.
Lapwing	*Vanellus vanellus*	All	Flood meadows and farmland	Widespread and common but declining in some areas.
Snipe	*Gallinago gallinago*	All	Flood meadows	Widely but thinly distributed. Declining.
Redshank	*Tringa totanus*	Sp/Su	Flood meadows	Widely but thinly distributed. Declining.
Kingfisher	*Alcedo atthis*	All	Rivers and streams, usually slow-flowing with suitable riverbank breeding sites	Widely distributed but never common.
Yellow wagtail	*Motacilla flava*	Sp/Su	Flood meadows	Widespread but declining.
Grey wagtail	*Motacilla cinerea*	All	Rivers and streams, especially where there are riffles or weirs	Widely distributed. Common in west but scarce in eastern counties.
Cetti's warbler	*Cettia cetti*	All	Dense scrub in damp areas	Rare and restricted to southern England.
Sedge warbler	*Acrocephalus schoenobaenus*	Sp/Su	Reedbeds and scrub	Widespread and common in suitable habitats.
Reed warbler	*Acrocephalus scirpaceus*	Sp/Su	Reedbeds	Widespread and common in suitable habitats.
Reed bunting	*Emberiza schoeniclus*	All	Reedbeds and scrub	Widespread but rapidly declining nationally.

The riparian areas of classic chalk streams and larger chalk rivers are the most important areas for flood meadow habitat, with the best remaining examples lying next to chalk streams such as the middle reaches of the Hampshire Avon. Flooded meadows provide overwintering habitat for large flocks of characteristic species such as white-fronted geese (*Anser albifrons*), Bewick's swan (*Cygnus columbianus*), lapwing, golden plover (*Pluvialis apricaria*), snipe and redshank. The practice of deliberate winter flooding is now scarce, but the birds attracted to areas which are still prone to inundation (such as the Hampshire Avon downstream of Fordingbridge) give an indication of the immense value of the habitat to bird communities. In the spring as floods recede, such meadows become ideal breeding habitat for species such as redshank and snipe, which can attain densities approaching 1 pair per 10 hectares. Lapwings can attain large breeding populations, with yellow wagtail (*Motacilla flava*) also present in good numbers. Even where flooding does not occur, land that is maintained as lightly grazed meadow will offer good nesting habitat for such species.

The wetland mosaics of the middle and lower reaches of chalk river valleys provide areas of ideal habitat for wetland passerines such as reed and sedge warblers and reed buntings. Reed warblers breed in good numbers wherever there are suitable *Phragmites* reed-beds along the river and in dykes peripheral to the river. Sedge warblers also utilise chalk river valleys extensively, preferring scrubbier areas. Both of these warblers can attain population levels of more than 50 pairs per kilometre of valley bottom (encompassing 1 km of river and its associated floodplain from valley side to valley side) where good habitat occurs. Reed buntings are also characteristic, reaching 6 pairs per kilometre of river in southern chalk valleys.

The chalk river valleys of southern England support a high proportion of the British population of Cetti's warbler, with around half of the 125-127 singing males recorded in a 1990 Hampshire survey being located in the river valleys. Although by no means restricted to wetlands, the grasshopper warbler (*Locustella naevia*) finds favourable habitat in chalk river valleys. Although it has undergone a considerable decline since the 1970s, it is still present but localised in the Avon, Test, Itchen and Meon valleys.

Both tufted duck (*Aythya fuligula*) and pochard (*Aythya ferina*) can occur in reasonable numbers on such watercourses (particularly the lower reaches), with up to 11.4 and 2.7 breeding pairs per kilometre of river respectively being found in the middle reaches of the Test in a 1980 survey (Evans 1981). Since the British breeding population of pochards has recently been estimated to lie between 251 and 406 pairs, such densities are nationally important. The classic chalk stream probably represents the optimal habitat for little grebes in terms of chalk rivers, with numbers rising to nearly 10 pairs per kilometre. Both the middle and lower reaches are important year-round feeding sites for the grey heron (*Ardea cinerea*).

Swifts (*Apus apus*), swallows (*Hirundo rustica*), house martins (*Delichon urbica*) and sand martins (*Riparia riparia*) find excellent feeding opportunities in these areas, the rich aquatic life of the river providing a bounty of airborne insects. Despite this, sand martins do not breed along most chalk rivers, probably due to a lack of sand or earth banks suitable for them to colonise.

On chalk rivers, great crested grebe (*Podiceps cristatus*) are only found on the lower reaches, whilst mute swans (*Cygnus olor*) probably reach their highest levels in the same habitat. Many riverine species move downstream into the lower reaches during the winter, such as kingfishers, grey wagtails and little grebes, which thereby provide an important haven for birds that will subsequently repopulate upstream reaches.

Specialists associated with large reedbeds, such as bittern, marsh harrier and bearded tit (the first two on the Red List and the last on the Amber List of birds of conservation concern - see Table 3.1), disappeared from chalk river systems at an early stage of land drainage and agricultural intensification, such that it is now difficult to depict them as characteristic of chalk river communities. Along with other lowland river types, chalk river floodplains would have supported extensive reedbed habitat up to perhaps two centuries ago, when all three of these species were distributed widely across

England and Wales. They therefore should be seen as species, which should be, accommodated by future restoration plans in chalk river catchments.

3.7 Mammals

Chalk rivers provide favourable habitat for all native mammal species associated with lowland rivers, although none are likely to have a distinct preference for the river type. Most perennial sections are potentially suitable for the otter (*Lutra lutra*), water vole (*Arvicola terrestris*) and water shrew (*Neomys fodiens*), depending upon the way in which riparian habitat is managed. Bat species utilising river corridor habitat prefer the smooth water surfaces provided by the middle and lower reaches.

Nationally, otters are currently recolonising lowland Britain following the large-scale declines of the 1960s and 70s. It is safe to assume that prior to this decline, which coincided with the introduction of organochlorines and extensive habitat destruction, chalk rivers would have supported thriving populations. Today, plentiful evidence of otter activity can be found throughout the Itchen catchment, particularly associated with the excellent habitat provided by the upper and lower reaches. However, there is little evidence of activity in the neighbouring Test or the Hampshire Avon. Populations in Norfolk survived the national declines, although no signs of activity were found on the Nar in the most recent national survey (Strachan and Jefferies 1996) despite the high quality habitat offered by the upper catchment. The Hull lies on the southern fringe of the species' contracted range in the north, and may well support the species in its upper reaches. Evidence of activity is becoming increasingly common in the Thames tributaries, including the Kennet and Lambourn catchments.

The water vole has declined across Britain at an alarming rate in recent years, possibly associated with the spread of American mink (*Mustela vison*) and exacerbated by habitat impoverishment, but is present on chalk rivers where there are good habitat and low mink numbers. As with the otter, chalk rivers supported widespread thriving populations of water vole prior to recent problems. In terms of current distribution on chalk rivers, the 1989-90 national survey (Strachan and Jefferies 1993) indicates good densities in systems such as the Hampshire Avon, Test, Itchen and Hull, associated with good riparian habitat. On the Test and Itchen, the intense control of mink for fishery protection is likely to contribute to the healthy populations that are found. Under optimal conditions, population densities can reach up to 40 territorial females per kilometre of waterside habitat (Morris 1993).

Although little work has been carried out on the water shrew, a broad understanding of its habitat requirements suggests that it would be a common component of chalk river systems under conditions of high environmental quality. Although it can occur in terrestrial habitats, it is known to thrive in swiftly flowing watercourses and in still water habitats such as ditches and ponds (Churchfield 1997). Watercress beds, a habitat unique to chalk rivers, and reedbeds are also favoured habitats. This wide range of suitable conditions means that the species would be expected to occur in chalk rivers from the perennial headwaters right down to the ditch systems of the lower reaches. Under optimal conditions, densities reach 3-10 individuals per hectare, although locally densities may be even higher (Churchfield 1997). The indications from largely casual observations are that the water shrew is also suffering from increased predation by mink.

There appear to have been few ecological studies of bat populations in relation to lowland river valleys (Racey 1995), but the high production of winged insects and the gently flowing, often tree-lined waters of the lower half of chalk rivers provide ideal feeding conditions. Roost sites are most likely to limit populations, although a good quality chalk river valley should be able to provide sufficient old trees, bridges and houses of a suitable nature to allow populations to thrive. The species most associated with river valleys in Britain is Daubenton's bat (*Mysotis daubentonii*), which feeds low over water at high densities.

4. Habitat requirements of characteristic wildlife communities

4.1 Introduction

The focus of this section is on the physical habitats required by wildlife communities, with the implicit assumption that water quality and flow regime need to be conducive to their maintenance and high quality if the biota is to thrive. Special reference is made to certain aspects of water and sediment quality (in relation to nutrient status and siltation) and river flow where these factors are particularly important. The section is divided into major components of the biota as with the preceding section, with the main habitat issues being summarised at the end.

4.2 Plants

4.2.1 Instream plant species

In physical terms, the distribution of instream plant species is driven by substrate type and flow conditions, which are inevitably interlinked. Table 4.1 outlines the conditions with which characteristic chalk river species are associated. Although many species can survive in a range of substrates and flow types, most have preferences and a good range of conditions is clearly required to support a thriving and diverse flora. The level of shading of the river channel is a further important consideration, with most characteristic higher plants (including *Ranunculus* species) faring poorly in low light intensities. Additional information on the requirements of individual species to that given below is provided in Appendix A.

Brook water-crowfoot, a species strongly associated with chalk rivers, has much more exacting requirements than most species, along with a number of lower plants (including the red alga *Hildenbrandia rivularis*). The preference is for coarse substrates, and for brook water-crowfoot this means gravels with a low silt content. Strongly linked with coarse substrates, turbulent currents are extremely important for brook water-crowfoot, creating lateral and vertical variations in current velocities in which species such as lesser water-parsnip find it difficult to compete. The establishment of weirs and other structures on slow-flowing stretches of chalk stream that are devoid of *Ranunculus* has been found to stimulate growth where higher current velocities are generated upstream or downstream. Where water is shallower and smoother over gravels, lesser water-parsnip competes more effectively and can become locally dominant.

The build-up of silt in the gravels over a period of years will make the substrate less suitable for *Ranunculus*, particularly affecting the establishment of new plants and therefore the long-term viability of the species. The reduced light intensities and oxygen levels in the top layers make successful seed germination and the rooting of shoot material from existing plants unlikely. In general, germination of seed seems to be less important than vegetative dispersal in brook water-crowfoot, with the majority of new plants appearing to be established from shoot fragments that can root at the stem nodes. Mature plants tend to migrate across the riverbed by sending out rooting shoots into new areas of substrate as the existing root mass senesces. The root masses of mature plants are likely to be smaller in silted substrates, making them more vulnerable to wash-out, and are also likely to suffer from low oxygen availability in the root zone.

In contrast to brook water-crowfoot, seed germination is very important for *Ranunculus peltatus* (characteristic of winterbourne sections), where rapid recolonisation following the dry phase is essential. Silted reaches only appear to support seed germination following a period of drying, which is only relevant for *Ranunculus peltatus* in winterbourne sections. After the dry phase the substrate is oxygen-rich and firm and amenable to initial plant development. However, unless silt is subsequently flushed out and current velocities are sufficiently fast and turbulent, shoot growth is generally poor (presumably largely due to deoxygenation of the substrate).

In deeper sections with gravel beds, crowfoot may still dominate, but if there is underlying clay mare's-tail, river water-dropwort, flowering rush (*Butomus umbellatus*), arrowhead, spiked water-milfoil (*Myriophyllum spicatum*), perfoliate pondweed (*Potamogeton perfoliatus*) and bulrush (*Schoenoplectus lacustris*) are much more likely to be present. It is for this reason that these plants are more associated with chalk-dominated catchments that include other geology types. Marginal plants such as water-cress, blue-water speedwell and fool's water-cress require shallow, slack water, from where they will invade the channel as flows decline through the summer.

In winterbourne sections, the critical factor dictating community composition is the period of inundation. The main growing season for most species is between April and August, and flows at this time are crucially important; non-aquatics are killed by submergence at this time and most true aquatic species require it to survive. Table 4.2 shows the effect of different periods of desiccation on key species. As can be seen, species such as lesser water parsnip, brook water-crowfoot and whorl-grass are eliminated by even the smallest periods of regular desiccation, whilst *Ranunculus peltatus* competes well as long as the dry period is no longer than around 4 months. Non-aquatic grasses and herbs dominate increasingly as the dry period increases up to and beyond 6 months.

The grass, marsh foxtail is a classic indicator of water regimes with high winter flows and dry out in summer. If dry conditions are maintained for more than 18 months it usually disappears, being replaced by non-aquatic grasses. As soon as winter inundation returns, the foxtail out-competes the non-aquatic grasses in the following summer; if inundation continues through the summer the foxtail may also be lost and replaced by wetland and aquatic species.

Table 4.1 **Typical substrates and flow features associated with plants of perennial sections**

Species	Substrate						Flow feature			
	Cobble	Gravel/ Pebble	Sand	Silt	Clay	Tree Roots	Chaotic Flow	Rippled Flow	Smooth Laminar Flow	No Perceptible Flow
Hildenbrandia rivularis	5	3					3	2	2	
Verrucaria (sp(p))	5	3					3	2	2	1
Fontinalis antipyretica	5	2				4	3	3	3	3
Ranunculus pen. subsp. *pseudofluitans*	1	5	2	1			5	5	3	1
Batrachaspermum	3	5	1			1				
Rhynchostegium riparioides	5	1				1	5	3	1	
Pellia endiviifolia	5	2				2	3	3	3	
Cladophora glomerata	4	3					1	5	3	2
Vaucheria agg.	2	2	1	5	1			4	5	3
Oenanthe fluviatilis		3	2		5		5	5	3	
Berula erecta		4	1	1			2	4	3	
Groenlandia densa		5	2	1	3			2	5	4
Hippurus vulgaris		3	2	2	5		2	5	5	1
*Elodea canadensis**		3	3	3	3		2	3	5	3
*Elodea nuttallii**		1	4	4	3		1	2	3	5
Callitriche obtusangula		3	3	3			2	5	5	1
Veronica anagallis-aquatica		4	2	3	3			3	3	3
Apium nodiflorum		5	2	1	3		1	2	5	5
Butomus umbellatus		2	1		5		1	4	4	4
Scirpus (Schoenoplectus) lacustris		1		1	5		1	3	5	2
Myriophyllum spicatum		2	1	1	4		1	2	5	4
Potamogeton pectinatus		3	2	2	4		3	5	5	5
Potamogeton perfoliatus		1	1	2	5			1	5	4
Zannichellia palustris		1	5	4				4	4	4
Nuphar lutea		1	1	1	5			1	5	5
Rorippa nasturtium-aquaticum		4	2	4	3			1	5	5
Sparganium erectum		1	2	3	5				4	5
Sparganium emersum			1	3	5			2	5	3
Callitriche stagnalis			2	5	3			2	4	5
Lemna trisulca			N/A						2	5
Sagittaria sagittifolia				2	5			1	5	4
Catabrosa aquatica				5	1				1	5

5 = Most associated; 4 = Very often, 3 = Frequently, 2 = Occasionally, 1 = Rarely.
* Introduced, widespread species

Table 4.2 **Effect of periodicity of flow on key plant species (based on survey of >120 headwater and winterbourne sites in 1992-95 - Holmes 1996)**

	Months dry in summer						
Species	**>6**	**4.5-6**	**3-4.5**	**1.5-3**	**0.5-1.5**	**± Perennial**	**Always perennial**
Non-aquatic grasses	5	5	4	3	1		
Non-aquatic herbs	4	3	1	1	1		
Alopecurus geniculatus	4	5	5	2	1		
Stachys palustris	3	3	1				
Mentha aquatica	3	3	2	1			
Myosotis scorpioides	3	3	2	1			
Glyceria fluitans/plicata	1	1	4	5	5	1	1
Apium nodiflorum		1	3	5	5	5	5
Rorippa nasturtium-aquaticum		1	3	5	5	5	5
Rhynchostegium riparioides	2	2	2	2	2	2	2
Fontinalis antipyretica	1	1	1	1	2	2	3
Veronica anagallis-aquatica		1	3	5	5	5	5
Ranunculus peltatus			3	4	4	2	1
Catabrosa aquatica						1	4
Callitriche obtusangula						2	4
Verrucaria spp.						4	5
Hildenbrandia rivularis						3	4
Ranunculus penicillatus. subsp. pseudo.						3	4
Berula erecta						3	4

Key: 5 = expected, 4 = very likely, 3 = typically found, 2 = occasional, 1 = rare on streambed

Lastly, there is much debate over the role of nutrient status in shaping instream plant communities in rivers. In chalk rivers, it is often considered that phosphorus (the major nutrient that is generally most likely to be limiting growth in freshwaters) is naturally available at levels in excess of that which would limit plant growth. However, consideration of uptake kinetics shows that the growth rates of many algal species increase greatly over the phosphorus concentration range 20 to 300 μg SRP l^{-1}. Moreover, differences in growth characteristics between species mean that shifts in species composition within the algal community will occur over this concentration range. Even if overall community growth rates do not change, such shifts can easily lead to changes in the standing crop of algae in the river (see Section 5.6).

Since background levels of phosphorus in the water column of chalk rivers are likely to reside at the lower end of this concentration range (see Section 2.3), the potential for increased algal growth and/or standing crop following nutrient enrichment is clear. The improved conditions for algal dominance provided by enhanced phosphorus levels are likely to be critical for riverine algae in terms of competition with higher plants, and the conclusion must be that phosphorus levels close to background levels are required to control this form of ecological risk. Unfortunately, the effects of phosphorus enrichment are confounded with other environmental factors, particularly low flows and siltation, such that the relative importance of each in any given situation is difficult to disentangle. *It is crucial that this interlinkage between different mechanisms of impact does not obscure the need to strive for low concentrations of phosphorus in chalk rivers.* This issue is dealt with in more detail in Section 5.6.

4.2.2 Bankside and wetland plant communities

The composition of wetland plant communities is critically dictated by the soil moisture regime through the year, particularly over the winter and spring periods (see Gowing and Spoor 1998). Local water table levels (which is influenced to a greater or lesser extent by river levels) and soil type (which determines the relationship with river and ditch levels amongst other things) dictate soil moisture regime. For many wet meadow species, water levels close to the surface are preferred over the winter months, with levels slowly receding through the spring months (to perhaps 30 cm below ground level in March) as plants start active growth. Drier soils through the spring will result in heavy competition from non-wetland species, whilst prolonged waterlogging in the spring and early summer causes 'aeration stress' (essentially deoxygenation of the root zone). This results in dominance by swamp species such as *Glyceria maxima* (water-meadows maintained diverse wet meadow communities by keeping water moving through the root zone and thereby preventing aeration stress). Wet meadow communities can, therefore, be seen to occupy a very narrow ecological niche in hydrological terms. It is also evident that spatial variations in soil moisture regime, induced either by differences in water levels or topographical variation, are required to support the full diversity of wetland vegetation.

If the riverbank is shallow in gradient, the wetland communities of the banks will merge imperceptibly with those of the wet valley floor in a manner characteristic of chalk rivers prior to agricultural intensification (Plate 20). Fortunately, most good chalk rivers and streams still retain some stretches that flow through significant areas of fen and swamp communities. Examples include river reaches purely on chalk, such as on the Test, Itchen, Nar and Hull, and those on mixed geology, such as the Wensum, Wissey, Bure, Avon, Kennet and Frome. Typically the most characteristic species include great water-dock, lesser pond-sedge, great tussock sedge, common reed, reed sweet-grass and herbs such as yellow loosestrife, fleabane (*Pulicaris dysenterica*) and purple loosestrife.

Shallow banks can support very different plant communities depending on their management, with routinely (but not excessively) trampled and grazed banks contrasting markedly with those of fenced or only very lightly grazed ones. Plates 16 and 20 provide an indication of the contrasting vegetation types that can be produced. Trampled and grazed banks will often have many annual wetland species present alongside grasses that recover from grazing and thrive in waterlogged muddy habitats. Examples include tripartite bur-marigold (*Bidens tripartita*), marsh yellow-cress (*Rorippa amphibia*), blue and pink (*Veronica catenata*) water-speedwell, water-cress, celery-leaved buttercup (*Ranunculus sceleratus*), brooklime, whorl-grass, small sweet-grass species and marsh foxtail. Where shallow banks are fenced, or receive no management or disturbance, these species will normally be absent or rare, but species such as lesser pond-sedge, common reed, branched bur-reed and bittersweet (*Solanum dulcamara*) will be common and frequently merge with the emergent flora of the channel itself.

Drier, steeper slopes provide a contrasting habitat and can support species such as lesser and greater pond-sedge, great willow-herb (*Epilobium hirsutum*), hemp agrimony (*Eupatorium cannibinum*), water figwort (*Scrophularia auriculata*), comfrey (*Symphytum officinalis*) and soft and hard rush (*Juncus effusus* and *J. inflexus*).

The plant associations described above are characteristic of open grassland and, whilst no significant changes would be expected by the presence of occasional trees and shrubs, more extensive tree presence would shift community composition towards shade-tolerant species. Plant communities of riparian woodland are ecologically valuable in their own right, but tree growth in the now characteristically open riparian grassland of chalk river valleys can be damaging to existing ecological interest.

4.3 Invertebrates

4.3.1 Instream invertebrate communities

The invertebrate communities of chalk rivers utilise a wide range of ecological niches that are created by a mosaic of substrate and vegetation types (Plate 21). These so-called mesohabitats (Armitage *et al.* 1995) arise through the interactions of hydrological and geomorphological forces. Inevitably, they are not static in the river system and will move, develop and recede in response to natural and artificial forces imposed upon the channel. However, the faunal assemblages residing in each habitat are relatively stable, with the exception of longitudinal changes taking place down the length of river systems (see Section 3.4).

Although a definitive list of mesohabitats supporting characteristic assemblages has yet to be produced, the list below provides a reasonable inventory. With adequate river flows and water quality, maintenance of these distinct habitats in a balanced way will provide the niches required by instream invertebrate assemblages of chalk river systems. In winterbournes, maintenance of the natural pattern of flow is critical if the specialised fauna inhabiting them is to survive.

Vegetative habitats	
Instream submerged	*Ranunculus, Potamogeton, Zannichellia, Callitriche.*
Instream emergent	*Rorippa, Apium/Berula.*
Bankside emergent	*Phragmites, Phalaris, Glyceria, Sparganium, Carex, Juncus, Rorippa, Apium/Berula*, mixtures of all three with or without terrestrial plant components.
Tree roots	*Salix, Alnus.*
Mineral habitats	
Main channel gravel	Areas of pebbly gravel situated in main flow.
Fast gravel	Areas of riffly gravel in relatively fast flow (40-90 cm s^{-1}).
Sand	Patches of sand.
Silt	Accumulations of silty sand, usually out of the main flow.
Miscellaneous	
Debris dams	Accumulations of organic material caught up on submerged twigs and branches.
Leaf litter/detritus	Drifts of decaying vegetable material usually in marginal areas.
Bridge pilings	Stone or concrete supports.
Revetments	Stone, concrete, metal or wood bank-protection material.
Cattle drinks	Shallow marginal areas with silty/mud bottoms (Plate 22).
Weirs and sluices	Usually wood or metal constructions for water level and/or flow regulation.
Side channels	Additional channels, frequently artificial.

As might be expected, the preference of each species for different mesohabitats is dictated by its mode of life. This is illustrated in a study of a smaller list of mesohabitats identified by multivariate analysis on a short reach of chalk stream in southern England (Table 4.3). In this study (Pardo and

Armitage in press), five principal habitats were identified (*Ranunculus* in spring; silt; sand; gravel; and higher plants in both summer and autumn), with sub-habitats based largely on season. The fauna of *Ranunculus* beds in spring (Mesohabitat MH I) was found to be different to all submerged higher plants (including *Ranunculus*) at other times of the year (MH V), supporting a species-poor but specialised community able to withstand high flows in the main channel. Within MH V, *Rorippa* was found to support a more diverse and abundant fauna than *Phragmites* owing to its greater structural complexity. Very diverse faunas were found in the spring in marginal plant habitats, suggesting that these areas act as refugia against high flows at this time. In summer, all plant species contain very similar invertebrate communities since the influence of current velocities is minimised.

The species found to be indicative of each mesohabitat in the study are shown in Table 4.4. The high current velocities associated with *Ranunculus* beds (I) in spring is reflected in the dominance of Simuliid species. Burrowers such as various species of pea mussel (Sphaeriidae) are indicative of the bare silt habitat of Group IIIa. Within the gravel mesohabitat, seasonal shifts in species composition are linked to changes in the most effective mode of living (or 'habitus') and methods of food acquisition. In terms of habitus, the community moves from a dominance by burrowers in the spring to surface sediment dwellers in the summer, with co-occurrence in the autumn. In this way, surface dwellers avoid the highest current velocities during the spring months (allowing the less vulnerable infauna to dominate at this time), and achieve a higher prominence once velocities decline in the summer months. The community shifts are reflected in changes in principal feeding mechanisms, from a dominance of collector-gatherers (burrowers such as the mayfly *Ephemera danica*) in spring, to shredders and scrapers (surface dwellers such as the stonefly *Leuctra fusca*) in summer, and back to collector-gatherers in autumn.

Plate 20 Characteristic pattern of riparian vegetation, with strong hydrological continuity between the bank and channel allowing a continuous transition between aquatic and meadow communities.

Plate 21 Characteristic habitat mosaic of *Ranunculus* beds and bare gravels, with marginal plants encroaching into the channel.

Plate 22 Cattle drink, important for annual wetland plants and a range of invertebrates, as long as livestock densities are low (densities are too high in this example).

Table 4.3 **Morphological adaptations (habitus) and feeding mechanisms of dominant species assemblages in different mesohabitats of the Mill Stream, River Frome, Dorset (after Pardo and Armitage 1997).**

Mesohabitat	I	II		III		IV			V		
Characteristics of dominant spp.	I	IIa	IIb	IIIa	IIIb	IVa	IVb1	IVb2	Va1	Va2	Vb
Habitus											
Water column	3										1
Water column/sediment surface					1	1		2			1
Sediment surface	3			3	4	1	7	1	3		6
Sediment surface/burrowers			2					4	1		1
Burrowers		2	4	5	6	1	2	2			
Burrowers/climbers				1							
Climbers/sediment surface					2						
Trophic group											
Collector-filterers	3			3			1	1	1		4
Collector-gatherers	3	2	5	3	5	2	1	6	1		4
Shredders					4		4				
Grazers				2	2		3		2		1
Predators				1	1	2	2				

Numbers in the tables represent the number of species within the mesohabitat that have the habitus or feeding mechanism in question.
I = *Ranunculus* in spring.
II = sandy substrates; IIa = summer/autumn; IIb = spring.
III = silted substrates: IIIa = summer/autumn; IIIb = *Rorippa/Phragmites* in spring.
IV = gravel substrates; IVa = autumn; IVb1 = summer; IVb2 = spring.
V = macrophytes in summer and autumn; Va1 = *Nast./Phrag.* in autumn; Va2 = *Ranunc.* in autumn; Vb = all macrophytes in summer.

Table 4.4 **Indicator species of mesohabitats identified on the Mill Stream, River Frome, Dorset (after Pardo and Armitage 1997).** See Table 4.3 for group descriptions.

Mesohabitat	Indicator species	Mesohabitat	Indicator species
Group I	*Batis buceratus*	Group IVa	*Ephemera danica*
	Baetis muticus		
	Simulium gr. equinum	Group IVb1	*Hydropsyche contubernalis*
	S. posticatum		*Ancylus fluviatilis*
	S. gr. ornatum		*Leuctra fusca*
Group IIa	*Chironomus* sp.	Group IVb2	*O. (Euorthocladius) rivulorum*
			Stylodrilus heringianus
Group IIb	*Prodiamesa olivacea*		*Cladotanytarsus* sp.
	Limnodrilus hoffmeisteri		*Cheumatopsyche lepida*
	L. claparedeanus		
	Cryptochironomus sp.	Group Va1	*Physa fontinalis*
			Anisus vortex
Group IIIa	*Aulodrilus pluriseta*		*Metriocnemus* sp.
	Ostracoda		*Gyraulus albus*
	Sphaerium corneum		
	Pisidium spp.	Group Vb	*Baetis gr. scambus*
			Ephemerella ignita
Group IIIb	*Crangonyx pseudogracilis*		*Rheotanytarsus* sp.
	Oulimnius major		*Cricotopus (Isocladius)* spp.
	Halesus radiatus		*Simulium gr. angustitarse*
	Limnephilus lunatus		*Ithytrichia* sp.

In broad terms, the faunas of principal mesohabitat types within the river channel can be described as below (Ladle and Westlake 1995).

- **Instream plants** are dominated by suspension feeders, particularly Simuliidae and Trichoptera.
- **Gravels** are characterised by detritivores, such as *Gammarus pulex*, and aufwuchs grazers (see glossary), including Chironomidae and Ephemeroptera.
- **Soft sediments** support mainly deposit feeders such as Tubificidae and suspension feeders including Sphaeriidae and the mayfly *Ephemera danica*.
- Beds of **emergent plants** are dominated by Chironomidae, Crustacea, Gastropoda and Oligochaetes, with winged stages of Trichoptera, Ephemeroptera, Neuroptera and Odonata utilising aerial shoots for emergence, hardening-off, feeding and mating. They also provide a useful refuge for the native crayfish.

To this list might be added **overhanging/trailing bankside vegetation** and **submerged tree-root systems**, both of which provide ideal cover for the native crayfish and the former providing insects such as Calopterygid damselfly nymphs with well-vegetated slack water margins.

The value of riparian woodland to the aquatic invertebrate communities of chalk rivers has been an area of some uncertainty, resulting in difficulties in ascribing conservation value to wooded reaches. On-going research by IFE (described by pers. comm., Iain Harrison, IFE Rivers Laboratory) has shown that wooded river sections have considerably higher abundances of certain instream taxa compared to open grassed (ungrazed) banks; these being caddis-fly larvae of the family Glossosomatidae (particularly *Agapetus fuscipes*) and riffle beetles of the family Elmidae (largely *Limnius volckmari*). Inevitably, *Ranunculus* beds and their associated fauna (particularly *Simulium* spp. and *Baetis* spp.) are reduced in wooded reaches, but taxon diversity across all instream habitats combined does not appear to be significantly lower than river sections with open banks. Abundances of taxa occurring in both wooded and open reaches do not appear to be much different, even though reductions in primary and secondary production are often reported for shaded river reaches. The high abundances of Elmid beetles in wooded reaches is likely to be due to the moister, cooler, well-structured and well-aerated soils, providing good conditions for larval pupation. The presence of the larval stages of many other species (such as *Limnius volckmari*) is probably due to adult habitat choice rather than larval choice (see next Section).

4.3.2 Riparian/floodplain invertebrate communities and habitats

The invertebrate fauna supported by the banksides of chalk river systems varies greatly depending upon bank form and management. The most characteristic habitat (relating to the reference conditions defined in Section 2) consists of a shallow bank profile with light grazing and poaching, creating shallow water with a soft substrate merging into a bankside mosaic of muddy and vegetated patches. This habitat generates diverse habitat opportunities for a wide range of invertebrate species. This is illustrated by a brief study on the River Itchen (Drake 1995), where a higher number of river edge species was found on unfenced banks with light grazing, than on fenced banks (Table 4.5), with the unfenced banks containing most occurrences of uncommon species. Importantly, the unfenced banks appeared to contain all of those species supported by fenced banks.

In apparent contrast, work undertaken by IFE in riparian chalk stream areas (Harrison and Harris in prep) found that, in the channel margins, the diversity of invertebrate taxa was higher along ungrazed (fenced) sections, and the abundance of numerous families was greater in ungrazed than grazed sections. Those taxa taking most advantage of the rank, overhanging and trailing vegetation of ungrazed sections were caddis-flies (particularly Hydroptilidae and Hydropsychidae), elmid and dytiscid beetles, caenid and heptageniid mayflies and calopterygid damselflies. The diversity and abundance of aerial adults of aquatic species using the bankside were also higher in ungrazed sections, particularly in the case of caddis-flies.

Table 4.5 Occurrence of invertebrate species at fenced and unfenced sites along the River Itchen (after Drake 1995)

Species group	No. of species	Unfenced (n=10)	Fenced (n=4)
Water edge species	80	51.3±7.3	36.8±9.9
Fen species	33	14.8±3.9	17.5±7.4
Grassland species	36	20.0±3.7	24.3±8.3
'Tourists'	22	9.5±5.0	12.5±6.7

n = the number of sites surveyed, values in the third and fourth columns are the mean number of species observed along with the 95% confidence interval.

The widely differing conclusions that might be drawn from these two studies highlight the different levels of importance that can be assigned to different aspects of the biological community. The work of Drake (1995) was highly detailed, involving the identification of 240 'water edge' species dominated by 210 flies, and undertaken over the course of only two consecutive days in July. IFE work (Harrison and Harris in prep.) was undertaken largely at the family level of identification (genus in some cases), in the fully aquatic channel margin and the fully terrestrial bankside, and throughout the summer (May to September). Drake considered species rarity (in a national context) important to the nature conservation value of the river, but the IFE work did not. The IFE work provided information on invertebrate abundances, important to the overall productivity of the river, but the work of Drake did not.

Quite apart from biological considerations, there are also important differences in the nature of ungrazed sites between the two investigations that need to be considered. The lightly grazed habitat described by Drake contains moderately tall tussocks and high plant species diversity, and therefore has a reasonable vegetative structure for those species favouring coarser vegetation. The grazed sections studied by IFE were actually heavily grazed with a uniformly short sward and low plant species diversity, providing a very poor habitat for most invertebrate species and a stark contrast with ungrazed reaches. Application of the IFE monitoring approach to the study sites of Drake would be likely to produce very different conclusions about grazed and ungrazed reaches. In future studies, quantitative assessments of grazing intensity would help to avoid confusion over these types of comparison.

The most sensible conclusion to draw from such information is that, for grazed riparian areas to be of high ecological value, they must be grazed at livestock densities well below those used by modern agriculture. Where such light grazing regimes cannot be achieved, fencing provides a way in which a diverse and productive assemblage of riparian species can be generated in place of the impoverished communities occurring in heavily poached conditions.

On-going research by IFE (described by pers. comm., Iain Harrison, IFE Rivers Laboratory) has suggested an important role for riparian woodland in supporting the aerial adult stages of many riverine invertebrate species. The diversity of aquatic invertebrate families occurring in the adult form in wooded reaches has generally been found to be higher than in open grassed (ungrazed) reaches, whilst abundances of adult Trichoptera and Diptera are significantly higher. Additional research has shown diurnal movements by the adults of nearly all taxa studied (including Tipulids, Chironomids, Simuliids, Culicids, Psychodids, caddis-flies and mayflies) between wooded riparian zones and open zones. The interspersion of open river sections with occasional wooded reaches would therefore appear to be highly important to chalk river invertebrate communities. The caddis-fly *Agapetus fuscipes* lays eggs under or near trees, leading to high larval abundances of the species in wooded sections. It may be that the adults of other species use wooded reaches for ovipositing as well as for shelter, with subsequent downstream drift of larvae helping to populate open reaches.

The soil moisture conditions of riparian and floodplain areas is very influential on the composition of the invertebrate community. Many species rely on high soil moisture levels over the winter and spring months, partially mediated by the effects of soil moisture levels on the plant community. The maintenance of water levels in ditch systems is also important, as well as management to provide suitable vegetation structure. Some ditch species are associated with the later stages of ditch succession whilst others prefer open water habitat. Maintenance of a range of successional stages within a ditch system is therefore necessary to support the highest invertebrate diversities.

It is clear from these discussions that a habitat mosaic, consisting of tall herb vegetation, lightly grazed meadows and associated ditches, wet woodland, swamp communities, and scattered isolated trees in riparian areas, is highly important in maintaining the full invertebrate diversity of chalk river systems, in the river itself, the riparian zone and the wider floodplain. The key is generating the right balance between these different habitats to maintain or restore the ecological character of chalk river systems.

The requirements of the southern damselfly in water meadow habitat are worthy of detailed description, being scheduled under the EU Habitats Directive and having quite exacting needs. They consist of slow or intermediate flows of calcareous water through the ditch system in the summer months, with a substrate dominated by detritus and unconsolidated silt and only a sparse and patchy covering of emergent plants (Hold 1998). Whilst the species is restricted to a small area of the Itchen catchment in this type of habitat at present, there is no reason why populations could not be enhanced on the Itchen or develop in other chalk river floodplains in southern England, if water meadow carriers and drains can be restored in a sympathetic manner.

4.4 Fish

4.4.1 Introduction

As all of the fish inhabiting chalk streams also commonly occur in other types of river and stream, there are no specific features associated with characteristic water quality or flow regime that can be considered as an absolute requirement for any of the species. Most of the species listed in Table 3.10 (see Section 3.5) require running water to spawn, the exceptions being pike, roach and perch which often spawn in still waters, and eels which spawn at sea. It is difficult to establish the exact habitat factors dictating the presence and abundance of each species; what can be done is to describe the conditions under which they generally occur or breed, and infer from that what conditions are limiting. Table 4.6 provides a summary of the main habitat requirements of each fish species, separated out into different life stages. As with other components of the biota, it is evident from the table that a wide range of habitat conditions is required to fulfil the requirements of the different life stages of all fish species typical of chalk rivers. Variations in factors such as water depth, substrate type, current velocity and plant growth, along with free access between the different habitats this variation creates, are crucial to the well being of the fish community. Table 4.7 attempts to summarise the habitat information in the previous table into a list of generic habitat features, indicating for each species whether the feature is used by the three main life stages.

4.4.2 Trout and salmon

Brown trout are very widespread in chalk streams, including winterbournes, but their population density in chalk streams rarely approaches that evident in many upland soft water streams. As those which do occur in chalk streams enjoy high growth rates it would appear unlikely that factors such as food, water chemistry and water temperatures are generally responsible for the limited numbers observed. Evidence points towards spawning conditions and cover for juveniles being major limiting factors.

It has long been known that the gravel in chalk streams is at times marginal for salmonid spawning in terms of its fine solids content. Brayshaw (1960) stated that:

> "The chalk streams are on the very fringe of true salmon and trout rivers. They are in fact understocked because of their silt content and sluggish flows".

The recent series of droughts in groundwater areas has focused attention on the spawning failure of both salmon and trout, which is believed to be largely due to increased siltation of gravel. Experimental studies have shown that egg and alevin survival is reduced when fine solids exceed 10% of substrate volume, and may be very low indeed when 'fines' exceed 20%. However, it may be that chalk stream populations can withstand somewhat higher 'fines' levels than populations in other river types due to the presence of upwelling springs along the river bed. Failure of these springs in any given year may reduce spawning success even though fines levels are unaltered.

Juvenile trout require areas of shallow water to avoid predatory fish, with adequate overhead cover to evade avian and other predators. These requirements are typically met by shallow marginal areas with active fringing vegetation, or riffle areas with submerged vegetation and/or larger stones. A study on the Candover Brook (Itchen tributary) linked juvenile recruitment with stream flow and suggested that the higher population in years of high flow could be due to the tenability of bankside areas by young fish, with their associated cover (Solomon and Paterson, 1980). The presence of large growths of submerged plants (such as *Ranunculus*) reduces the dependence of juveniles on marginal areas compared to other river types, but river margins are still important where active plant fringes are maintained.

Adult trout require a reasonable depth of water with cover from submerged beds of plants, overhanging bankside vegetation and/or tree root systems. Such habitat can be in particularly short supply at times of low flow if the channel is over-wide or is not allowed to regulate its own width through encroachment of marginal vegetation.

Salmon have broadly similar requirements to brown trout. Spawning sites tend to be focused on steeper gradients and the juveniles are also more concentrated in areas of faster water, with the brown trout occupying slightly slower water where the two species occur together. Symons and Heland (1978) found highest densities of juvenile salmon at current speeds of $0.5 - 0.65$ m^3 sec^{-1}. In terms of spawning, salmon have a similar requirement to trout for clean gravel substrates.

A major limiting factor in the distribution of salmon spawning and nursery areas is access by adult fish from the sea to the upper reaches. Many chalk streams have mills and other head-retaining structures along their length, which can represent major obstacles to migration. This is particularly so in dry autumns, when the spawning distribution of salmon may be seriously truncated. Such obstacles can also interfere with within-river spawning migrations of brown trout, including movements into winterbourne sections.

4.4.3 Other species

As with salmon and trout, deeper water is required for the adults of other large fish species such as grayling, dace, pike and eel. Shallow riffle and marginal areas are a key requirement for all species in the juvenile form, whilst smaller species such as stone loach, minnow, stickleback and bullheads also require such habitat in the adult form. A number of species, including the lampreys, grayling, and dace, bury their eggs in gravel in the manner of salmon and trout and require coarse, clean substrates to fulfil their life cycle. The bullhead is also a lithophilic spawner, requiring the presence of large stones under which eggs are placed.

The larvae of all three lamprey species live in silt banks for several years and the presence of suitable undisturbed sediment is likely to be a limiting factor. Chalk streams naturally contain considerable banks of suitable detritus, but the practice of "mud shifting" and general tidying-up of the stream in heavily managed fisheries tends to restrict this habitat.

In common with salmon, migratory movements are a key feature of the life cycles of all three lamprey species and the eel. Significant spawning migrations are also made by species such as dace and grayling, such that there is a strong requirement for unhindered passage throughout the river system across much of the fish community.

Table 4.6 Key habitat requirements of the principal fish species of chalk river systems

(It is stressed that the habitat descriptions are indicative and do not represent absolute requirements.)

Species	Spawning requirements	Nursery requirements	Adult requirements
Atlantic salmon	Coarse gravel with less than 20% material below 2.2 mm dia., in fast flow	Shallow, fast flowing water over gravel and stones. Highest densities at 0.5 – 0.65 m/sec	At sea. On return to river, deep water resting areas and unhindered passage.
Brown trout	Gravel in fast flow with low levels of fine material	Shallow flowing water, good cover from stones, banks, or macrophytes.	Flowing water. Cover. Depth 0.3 m or more. Access to spawning areas.
Brook lamprey	Sand or gravel Water depth 3 – 30 cm. Current speed 0.2 – 3.0 m/sec	Silt banks	Silt and cover material. Unhindered passage to spawning areas.
Sea lamprey	Sand and gravel with 1 - 5 cm stones. Water depth 40 - 60 m. Current speed 1- 2 m/sec	Silt banks	Adults in the sea. On return to river, unhindered passage to spawning areas.
River lamprey	Sand and gravel Water depth 0.2 - 1.5 m. Current speed 1 – 2 m/sec	Silt banks	Adults in the sea. On return to river, unhindered passage to spawning areas.
Grayling	Gravel	Shallow flowing water	Deeper water in glides. Unhindered passage to upstream areas.
Minnow	Gravel shallows	Shallow flowing water with plant cover	Shallow flowing water with plant cover
Bullhead	Beneath large stones	Fast-flowing shallower water over stones	Fast-flows shallow water over stones
Dace	Gravel shallows	Margins in flowing water	Flowing water in larger streams. Unhindered passage to upstream areas
3-sp. stickleback	Nests in weeds	Low-flow margins etc.	Low-flow margins etc
Stone loach	Gravel and vegetation	Fast-shallow shallow water over gravel	Fast-flowing shallow water over gravel
Pike	Vegetation and sticks	Low-flow margins etc	Slow-flowing deep water above mills, backwaters etc
Eels	Migrate to sea to spawn	In the sea	Everywhere except fast flowing, shallow water. Unhindered passage.

4.5 Birds

The information given in this section is derived largely from unsystematic observation (see also RSPB *et al.* 1994), since little work has been undertaken on the precise relationships between the occurrence of waterway birds and habitat features. The key requirements of bird species found in chalk rivers are summarised in Table 4.8, divided into winter and breeding habitat, specific nest site requirements, and food. Those considered to be most characteristic of chalk rivers are highlighted. It is important to note the diversity of habitats required to support the characteristically rich bird communities associated with chalk rivers. Table 4.9 lists the requirements of key bird species on a habitat basis, indicating the species most associated with each.

In the upper reaches, riffles and other areas of fast-flowing water (especially those with exposed rocks) are important features for grey wagtails and may also attract dippers, with the former preferring channel gradients of more than 2.5 metres km^{-1}. Both species are particularly sensitive to pollution that reduces the diversity and abundance of aquatic invertebrates. Grey wagtails are most likely to be found if riparian areas are wooded, which may serve to increase the amount of invertebrate food available. On middle and lower reaches, slow-flowing stretches or quiet backwaters with emergent or overhanging vegetation are necessary for species such as little grebe and mute swan.

Table 4.7 General habitat features required by the fish communities of chalk river systems

Habitat feature	AS	BT	BL	SL	RL	Gr	Mi	Bu	Da	Sti	Sto	Pi	Eel
Substrate													
Large stones	S	S						S					
Gravels with low fines content	S	S	S	S	S	S	S		S		S		
Sand with low fines content			S	S	S								
Silt banks			J,A	J	J								
Flow features													
Shallow flowing water over stones	J	J				J	J	J,A					
Shallow flowing water over gravel	J	J				J	J				J,A		
Shallow margins in flowing water									J				
Shallow margins with small currents			J,A	J	J					J,A			
Deeper water (pools or glides)		A				A			A				
Slow-flowing deep water	A											A	
All types exc. fast-flowing shallow water													J,A
Vegetation/Cover													
Submerged macrophyte beds		A				A	J,A			S,A	S	S	J,A
Marginal emergents										S		S,J	J,A
Submerged tree roots		A											J,A
Access													
Unhindered passage up and down river	J,A	J,A	J,A	J,A	J,A	J,A			J,A				J,A

A = Adult, J = Juvenile, S = Spawning.
AS = Atlantic salmon, BT = Brown trout, BL = Brook lamprey, SL = Sea lamprey, RL = River lamprey, Gr = Grayling, Mi = Minnow, Bu = Bullhead, Da = Dace, Sti = 3-spined stickleback, Sto = Stoneloach, Pi = Pike.

Emergent reeds and other aquatic vegetation are extremely important as nesting sites for many species, whilst more extensive areas can support water rails and Cetti's warbler. Areas of damp scrub are important sites for breeding sedge warblers, reed buntings and other passerines. Species such as bearded tits, bittern and marsh harrier require the re-creation of large reedbeds if they are to return to chalk river valleys.

Vertical riverbanks are essential for breeding populations of sand martins and highly important for kingfishers. The relatively low hydraulic energy of chalk rivers does not lend itself to the creation of actively eroding vertical banks, and so this habitat tends to be in short supply. However, the high energy of the upper Nar has created a strong riffle-pool geomorphology with vertical banks and supports good populations of both species. Kingfishers can utilise upturned tree roots as a replacement habitat, but there is no alternative for sand martins. For grey wagtails and dippers, artificial structures such as bridges and weirs can provide important nesting habitat.

Water-cress beds managed non-intensively (or ones that are no longer in use) are a key winter habitat for uncommon species such as water rail, water pipit and green sandpiper, and are also favoured by more common species including snipe and wagtails. They are one of the most characteristic man-made habitats of chalk river systems, being found on no other river type (although similar but poorer habitat opportunities can be afforded elsewhere by structures such as effluent filter beds).

Wet meadows (and their associated ditch systems), whether flooded accidentally (Plate 15) or deliberately through management as water meadows, are a vital component of the habitat mosaic required by the bird communities of chalk river valleys. Winter inundation provides ideal habitat conditions for a range of over-wintering wetland birds, whilst the maintenance of a high water table through the breeding season is required to provide the soft, damp soils and shallow pools used by species such as snipe and redshank.

Table 4.8 Key habitat requirements of bird species associated with chalk rivers and their floodplains

Species	Winter habitat on chalk rivers	Breeding habitat on chalk rivers	Nest site	Food
Key species				
Little grebe	Slow-flowing lower reaches; adjacent still waters	Still or slow-flowing with emergent vegetation; high water quality; undisturbed	Emergent vegetation or in open water anchored to underwater vegetation or branch	Chiefly invertebrates in summer: mayflies, stoneflies, dragonfly larvae, molluscs and crustaceans; small fish (5-7 cm long) predominate in winter
Mute swan	Still or slow-flowing with abundant subaqueous vegetation	Still or slow-flowing with abundant subaqueous vegetation	On well-vegetated island or riverbank; in emergent reedbeds	Subaqueous vegetation taken from water depths of less than 1 metre
Bewick's swan	Extensive, undisturbed flood-meadows and adjacent arable	-	-	Grazes soft-grasses; also waste crops, especially potatoes
White-fronted goose	Extensive undisturbed flood-meadows	-	-	Grasses; favours heavily grazed pastures
Wigeon	Flood-meadows with ready access to open shallow water	-	-	Grazes grasses and other vegetable matter; occasionally takes seeds
Water rail	*Phragmites* reedbeds and other areas of lush aquatic vegetation; watercress beds	*Phragmites* reedbeds and other extensive areas (>1.5 ha) of lush aquatic vegetation	Hidden deep within dense beds of reed or sedge	Principally animal matter, takes a wide variety of invertebrates and small vertebrates
Golden plover	Flood meadows; adjacent bare arable or young crops	-	-	Principally earthworms and beetles
Lapwing	Flood meadows; adjacent bare arable or young crops	Flood meadows; adjacent arable, especially spring-sown cereal	Makes a scrape exposed on grass tussock or ridge between furrows on arable land; nest susceptible to trampling or overgrazing by livestock	Small ground-living invertebrates
Snipe	Marshes and flood meadows; favours areas of vegetation such as sedge and rush; watercress beds; muddy water fringes.	Extensive marshes; flood meadows that remain damp during breeding season; favours dense sedge and rush	Tussock of grass, sedge or rush; nest susceptible to trampling or overgrazing by livestock	Earthworms, larval and adult insects taken by probing in wet ground

Species	Winter habitat on chalk rivers	Breeding habitat on chalk rivers	Nest site	Food
Redshank	Estuaries	Extensive marshes; damp flood meadows	Tussock of grass, sedge or rush; nest susceptible to trampling or overgrazing by livestock	Invertebrates, chiefly cranefly larvae, beetles and earthworms
Green sandpiper	Watercress beds; muddy fringes	-	-	Aquatic invertebrates
Kingfisher	Still or slow-flowing water, especially backwaters with overhanging branches; requires high water quality	Still or slow-flowing water, especially undisturbed backwaters with overhanging branches; requires high water quality	Sand or earth bank at least a metre in height	Mainly fish, especially bullheads, minnows and sticklebacks; occasionally other animal matter
Sand martin	-	Vertical riverbanks; sand and gravel pits	Colonial in sand bank, nest holes usually at least 1 metre above water; singly in pipes in concrete banks; may be attracted to artificial nest-sites	Small airborne insects
Water pipit	Watercress beds; flood meadows	-	-	Mainly insects
Yellow wagtail	-	Flood meadows, favours areas with low and dense herbage close to shallow water; adjacent arable	Hidden in tussock of grass or sedge; sometimes in crops	Small invertebrates, especially larval and adult flies and midges
Grey wagtail	Muddy or stony fringes to running or still water; sewage works	Flowing water with riffles or spillways	Recesses in man-made artefacts; close to fast-flowing or falling water	Mainly insects taken from waterside rocks or vegetation or in flight
Dipper	Fast-flowing water; high water quality	Extensive fast-flowing stretches; high water quality	Under bridges or in rocks; sometimes in trees; always over water	Large aquatic invertebrates, especially larvae of caddisflies and mayflies
Cetti's warbler	Dense scrub in damp areas; reedbeds	Dense scrub in damp areas; reedbeds	Thick vegetation close to ground in damp areas rather than over water	Insects and other invertebrates found on ground under dense scrub or in dense vegetation
Sedge warbler	-	Dense waterside vegetation: sedges, rushes and reeds; damp scrub and areas of dense herbage	Low in dense patches of nettles, sedge or grasses	Chiefly insects
Reed warbler	-	*Phragmites* reedbeds	Among emergent reeds; sometimes in grasses or herbage	Chiefly insects and spiders

Species	Winter habitat on chalk rivers	Breeding habitat on chalk rivers	Nest site	Food
Reed bunting	Reedbeds, damp scrub and farmland	Reedbeds; watermeadows with reeds or scrub; farmland	On ground in dense low vegetation	Mainly seeds and other plant matter in winter; insects in summer
Other species				
Gadwall	Slow-flowing or still water; shallow, eutrophic waters preferred	Slow-flowing or still water; shallow, eutrophic waters preferred	Generally close to water, hidden in grass or other vegetation	Roots, leaves and seeds of aquatic plants such as pondweeds, sedges, rushes and stoneworts
Teal	Flood meadows	-	-	Seeds in winter, obtained from shallow water; insects and other small invertebrates in summer
Mallard	All freshwater habitats	All freshwater habitats	In thick cover; sometimes holes in pollards; not always near water; nests most successfully on islands	Omnivorous and opportunistic
Pochard	Ponds and gravel pits; lower reaches of rivers	Slow-flowing rivers; ponds and gravel pits; favours areas with prolific submerged vegetation but little floating matter	In dense bankside cover or emergent vegetation	Plant matter including seeds, shoots and tubers of stoneworts, pondweeds, sedges and grasses; aquatic crustaceans and molluscs
Tufted duck	Ponds and gravel pits; lower reaches of rivers	Slow-flowing rivers; ponds and gravel pits	Close to water in dense vegetation; favours islets	Omnivorous: mainly insects in summer and zebra-mussels, other molluscs and freshwater shrimps in winter; some vegetable matter, mainly seeds
Moorhen	All freshwater habitats, including ditches and small ponds; riverside pasture	All freshwater habitats, including ditches and small ponds	In emergent vegetation; on anchored floating debris; sometimes in thorn bushes	Omnivorous: aquatic and terrestrial plant and animal matter
Coot	Still or slow-flowing water; avoids small isolated ponds; riverside pasture	Still or slow-flowing water; avoids small isolated ponds	In lush emergent vegetation	Mainly aquatic plants and seeds; occasionally molluscs and insects
Curlew	Estuaries	Flood meadows; adjacent arable	In tussock of grass or rushes	Mainly insects such as beetles and cranefly larvae; other invertebrates and occasionally small vertebrates
Pied wagtail	Wide range of habitats; often associated with human areas and wetlands	Wide range of habitats; often associated with human areas and wetlands	Recesses such as in walls, buildings and tree cavities or under banks	Small invertebrates taken from ground or vegetation or in flight

Table 4.9 Principal habitats required by the bird communities of chalk river valleys

Only characteristic bird species are considered, i.e. those for which chalk rivers provide particularly favourable habitats or those for which habitat requirements on chalk rivers are very specific.

Key habitat features	Key species in summer	Key species in winter
Fast-flowing stretches/weirs	Dipper, grey wagtail	Dipper, grey wagtail
Slow-flowing stretches	Little grebe, mute swan, coot	Little grebe, mute swan, coot
Wooded stretches	Grey wagtail	
Flood-meadows	Lapwing, snipe, redshank, yellow wagtail	Bewick's swan, white-fronted goose, wigeon, golden plover, lapwing, snipe
Emergent vegetation	Little grebe, mute swan, water rail	Water rail
Reedbeds	Water rail, cetti's warbler, sedge warbler, reed warbler, reed bunting. *Bittern, marsh harrier, bearded tit.*	Water rail, cetti's warbler, reed bunting. *Bittern, marsh harrier, bearded tit.*
Dense scrub in damp areas	Cetti's warbler, sedge warbler, reed bunting	Cetti's warbler, reed bunting
Vertical riverbanks	Kingfisher, sand martin	
Man-made artefacts	Grey wagtail, dipper	
Watercress beds		Water rail, green sandpiper, water pipit

Italicised species are not generally considered characteristic of chalk river systems, but would have thrived in such systems as elsewhere prior to the destruction of extensive reedbeds.

4.6 Mammals

A summary of the key habitat requirements of the principal mammalian species associated with river corridors is given in Table 4.10. The otter's habitat requirements have been dealt with extensively in other published documents, e.g. (Chanin 1993), but it is worth reiterating the need for extensive, undisturbed and impenetrable (to humans) habitat where breeding holts may be located, together with smaller areas of similar habitat at strategic locations for 'laying-up'. Additionally, an abundant fish supply and tranquil areas are required for feeding. Tall herbacious vegetation, reed and sedge beds and dense scrub are favoured riparian and floodplain habitat, whilst preferred tree root systems for holt formation are those of oak, ash and sycamore (willow and alder have fibrous root systems which do not form cavities). Of our three aquatic mammals, it is by far the most vulnerable to disturbance and so requires suitable habitat in areas remote from human activity.

The water vole requires quite steeply sloping and well-vegetated banks to support its characteristic multi-level maze of burrows and to provide cover from predators (note that tree-lined sections of river are not favoured). Abundant emergent vegetation is also required as a food source and for cover. The species inhabits a range of sites in chalk river valleys, normally associated with sluggish or still water, including large lowland reaches and well-vegetated ditches and ponds. More detailed information can be found in Strachan (1997).

Like the water vole, water shrews require quite steep banks for burrowing and long grass swards in riparian areas for cover (although the species has been found to forage in short swards where long swards are nearby). Swift-flowing or still shallow water with an abundant invertebrate food supply (major prey species are crustacea and caddis-fly larvae) and emergent vegetation for cover are also key requirements. The foraging strategy is one of repeated short dives, generally to depths of 30 cm, with gravelly, swift-flowing streams appearing to be the most favoured habitat (Churchfield 1997).

The high productivity of chalk stream headwaters probably makes them the best habitat of all for the water shrew.

Daubenton's bat prefers to forage over smooth water surfaces, generally associated with the deeper water of the lower reaches of chalk rivers, between tree-lined banks (Warren *et al.* 1997). Roost sites for this species and others utilising river corridors may be cavities in trees, or crevices under bridges, or in the roofs of riparian buildings. A good diversity and abundance of insect life on the wing is required as a food source throughout the summer months.

Table 4.10 Key habitat preferences of mammal species associated with chalk rivers

	Otter	Water vole	Water shrew	Daubenton's bat
Channel				
Abundant emergent vegetation		✔	✔	
Shallow water			✔	
Smooth water surface				✔
Abundant invertebrate supply			✔	✔
Abundant fish supply	✔			
Minimal human disturbance	✔			
Banks				
Steeply sloping		✔	✔	
Well-vegetated		✔	✔	
Exposed tree root systems	✔			
Old trees with high cavities				✔
Tree-lined				✔
Scrub	✔			
Riparian areas				
Well-vegetated ditches/ponds		✔	✔	
Dense and tall sward	✔	✔	✔	
Scrub	✔			
Woodland with old trees				✔

4.7 Summary of the ecological requirements of chalk river communities

The common theme running through the outline of habitat requirements given above is the over-riding need to maintain the wide range of physical habitats that good quality chalk rivers and their riparian areas provide (summarised in Table 4.11), from winterbourne sections to the lowest reaches. Not only must these habitats be present, but they must be of sufficient physical and chemical quality to allow the characteristic flora and fauna to thrive. This requires that a number of key management issues are addressed:

- sensitive engineering and maintenance of river channels and their riparian areas, to allow the establishment of the mosaic of physical and vegetative habitats so characteristic of chalk rivers and to maintain/re-establish the vitally important hydrological links between channel, banksides and floodplain;

- the maintenance of sufficiently energetic flow regimes to create the characteristic habitat mosaic and to prevent excessive deposition of fine organic sediment;

- the management of solids and nutrient loads to the river so that characteristic habitats do not become degraded through enrichment or excessive siltation;

- the maintenance of flushing flows over the winter months to help remove fine sediment from the coarser substrates and allow recolonisation by characteristic flora and fauna;

- the management of water quality so that contaminants do not reach ecotoxicologically damaging levels.

In addition to these issues, it is important to recognise that all species require access between different habitats to fulfil their life cycle requirements and to colonise/recolonise uninhabited areas. Many species can complete their life cycle within a very small area of watercourse or have aerial mechanisms of dispersal, such that longitudinal continuity within the river is not a problem. Others undergo upstream (in the adult form) and downstream (in the juvenile form) migrations that require freedom of movement over extensive lengths of river (species such as salmon and eel are extreme examples of this). In terms of colonisation, aquatic species without aerial life stages are dependent upon free access within the channel to reach new areas or river sections which have lost their original populations (due to low flows or pollution incidents, for instance). The maintenance of continuity between riverine habitats at a range of spatial scales is therefore vital to the well-being of chalk river communities.

It should be noted that Table 4.11 indicates principal direct associations between the biota and physical or vegetative habitats. In addition, trophic interdependencies between different components of the biota produce important indirect associations with habitat that should always be borne in mind.

Table 4.11 Summary of key habitats required by characteristic chalk river communities.

Habitat	Plants	Invertebrates	Fish	Birds	Mammals
Channel					
Gravels	✔	✔	✔		
Sands	✔	✔	✔		
Silts	✔	✔	✔		
Leaf litter/detritus		✔			
Debris dams		✔			
Side channels	✔	✔	✔	✔	✔
Exposed tree roots		✔	✔		✔
Higher plants					
a) Instream submerged/floating	-	✔	✔		
b) Marginal emergents	-	✔	✔	✔	✔
c) Reedbed		✔		✔	✔
Commercial watercress beds		✔		✔	✔
Depth variation	✔	✔	✔		
Banks					
Gently sloping and shallow	✔	✔		✔	
Steeply sloping					✔
Vertical				✔	
Tall herb vegetation	✔	✔		✔	✔
Short sward with light poaching	✔	✔		✔	
Damp scrub		✔		✔	✔
Cattle drinks		✔			
Trees (esp. *Salix* and *Alnus*)		✔		✔	✔
Floodplain areas					
Wet meadow					
a) Tall herb	✔	✔		✔	✔
b) Short sward	✔			✔	
Ditches/drains	✔	✔	✔	✔	✔
Woodland carr	✔	✔		✔	✔
Damp scrub		✔		✔	✔

5. Human activities and their impacts

5.1 The inherent vulnerability of chalk rivers

Before embarking on an account of the effects of specific human activities, it is important to note that the intrinsic nature of chalk rivers makes their characteristic communities particularly vulnerable to certain impacts. This vulnerability should be borne in mind when assessing the importance of different impacting activities. The essential elements of chalk river vulnerability are given below.

- The structure and function of characteristic communities is based upon a relatively stable flow regime with a predictable annual pattern, which is easily disrupted by activities such as abstraction, urban development and agricultural improvement.
- The characteristically low drainage densities of chalk river systems mean that there are few refugia for mobile animals from major environmental perturbations (such as pollution incidents) from where recolonisation can be initiated. However, this is partially offset by upwelling groundwater along the streambed, along with the consequent presence of high quality refuge opportunities for smaller organisms in the interstitial waters of deeper substrates (i.e. the hyporheic zone).
- Chalk river systems have relatively low hydraulic energy compared to flashy rivers draining impermeable areas, meaning that they are naturally less able to self-clean coarse substrates, particularly in the face of elevated particulate loads (although again this is partly offset by instream springs upwelling through the channel bed at various distances down the river).
- Chalk rivers are generally located in areas of England that have below-average rainfall and above-average populations, imposing an intrinsically high pressure on water resources that are highly valued for their purity.
- The historical management of chalk rivers for water power and water meadow irrigation has led to the construction of numerous instream features (such as weirs and hatches) that can both restrict the distribution of migratory species and hinder recolonisation of impacted areas.
- Chalk river headwaters characteristically have very thin, nutrient-poor and erosion sensitive soils, which can generate high particulate and nutrient loads to the river network if converted to arable production, despite having a natural propensity towards limited surface run-off.

5.2 An inventory of activities and their links to ecological impact

Key human activities occurring in chalk river catchments are listed in Table 5.1, along with their principal direct effects upon the riverine environment and associated floodplain areas. As is evident from the table, the direct effects of activities are often abiotic, which then have secondary consequences for flora and fauna. However, in some instances, such as with fish stocking or removal, the direct effects are biological. It is also evident that a number of human activities can often bring about the same abiotic impact (such as reductions in current velocity or changes in water depth), meaning that the causal mechanism is not necessarily consistent between sites and the link between activities and observed impact is typically obscure. This overlap in abiotic impacts caused by different activities is illustrated in summary in Table 5.2.

Table 5.1 An inventory of key human activities undertaken in chalk river systems and their links to ecological impact

Note: Some activities can have beneficial effects (in italics), depending upon how they are performed.

Sphere of activity	Specific activity	Further detail	Potential direct effects
Discharge of polluting substances (point sources)	Domestic sewage (including sewer overflows)		Organic pollution, nutrient enrichment, increased solids load
	Fish farms		Organic pollution, nutrient enrichment, increased solids load Contamination with fish farm chemicals
	Cress farms		Increase solids load Pesticide contamination
	Livestock farms (yard areas)	Yard washings, silage liquor, slurry etc	Organic pollution, nutrient enrichment, increased solids load
	Road run-off		Hydrocarbon and heavy metals contamination, solids load.
	Other (e.g. industrial such as quarrying)		Organic/toxic/nutrient/solids pollution
Abstraction (Groundwater and river)	Domestic supply, crop irrigation, fish farm supply, cress farm supply, industrial use.		Reduced flows, usable habitat, current velocity and scour. Restriction of access for migratory species and entrapment of young fish in intakes. Alteration to natural seasonal variations in flow (particularly cress farms).
Flood defence/land drainage	Channel modifications	Deepening*	Loss of hydrological continuity with banks, reduced floodplain water table.
		Straightening*	Reduced physical diversity, particularly depth, current velocity and substrate type. Loss of riffle-pool sequence.
		Longitudinal reprofiling*	Reduced variation in channel gradient and hence current velocities, depth and substrate type.
		Widening*	Reduced water depth, current velocity and floodplain water table. Loss of hydrological continuity with banks.
	Bank reinforcement	'Hard' (concrete, piling etc)	Loss of habitat structure and riparian flora/fauna
		'Soft' (geotextiles, willow hurdles etc.)	*Encouragement of natural regrowth* but altered habitat structure and flora/fauna.
	Channel maintenance	Weed-cutting	Loss of fauna in cut weed, loss of vegetative habitat/cover, flow diversity and *focused substrate scour*, reduction in summer and winter water levels. Removal of marginal fringe and exposure of banks to erosion. Reduction in winter scouring of gravels (through root mass wash-out).

Sphere of activity	Specific activity	Further detail	Potential direct effects
Flood drefence/land drainage (cont.)		Disposal of cut weed (caught d/s)	Smothering of riparian and floodplain vegetation (which can also cause bank instability), pollution via run-off, soil enrichment, encouragement of ruderal vegetation.
		Dredging	Reinstatement of overlarge channel (see channel modifications above), loss of benthic infauna, high solids remobilisation within channel.
		Disposal of dredgings	Smothering of riparian and floodplain vegetation (which can also cause bank instability), steepening of bank edges (also increasing instability), soil enrichment, encouragement of ruderal vegetation, pollution via run-off.
		Weed dredging (Bradshaw bucket)	Combination of effects generated by weed-cutting and conventional dredging.
	Water level monitoring	Weirs and gauging stations	Restriction of access for migratory species.
	Removal of bankside vegetation	Trees, scrub.	Potential loss of habitat for fish, bats, birds, otters, specialised invertebrates and shade-tolerant plant species. Increased light to river and encouragement of submerged plant growth.
Development	Construction of urban/industrial buildings, road construction	Increase in the area of hard, impermeable surfaces.	Increased run-off from hard surfaces, in terms of water volume and pollutant load. Reduced percolation to groundwater and hence reduced water retention capacity within the catchment.
Agriculture	Intensive livestock grazing (including application of herbicides, pesticides, livestock excreta and inorganic fertilisers to pastures)	In riparian areas with free access to river	Bank destabilisation, soil erosion, nutrient enrichment and disturbance of bankside vegetation, enrichment and siltation of channel. Loss of wetland/meadow plant species and associated fauna in favour of ruderal species.
		In wider catchment (chalk downland and floodplain)	Soil erosion and loss of particulates, nutrients and agrochemicals to river network. Nutrient/agrochemical contamination of groundwater and subsequent baseflow.
	Ploughing/arable cropping (including application of herbicides, pesticides, livestock excreta and inorganic fertilisers to fallow land and crops)	In riparian areas	Bank destabilisation, soil/nutrient loss to river, damage to marginal and riparian flora/fauna from pesticide/herbicide spray drift, nutrient enrichment of bankside vegetation and encouragement of ruderal species. Pesticide/herbicide run-off to river.

Sphere of activity	Specific activity	Further detail	Potential direct effects
Agriculture (cont.)		In wider catchment (chalk downland and floodplain)	Soil erosion and loss of particulates, nutrients and agrochemicals to river network. Nutrient/agrochemical contamination of groundwater and subsequent baseflow.
	Land drainage	Deepening of drains and side channels.	Reduced floodplain water table, reduced water retention capacity, increased peak flows during rainfall events. Loss of ditch/wetland flora/fauna.
		Ditch maintenance	Regular loss of flora/fauna, loss of species associated with late stages of ditch development.
	Intensive cress bed management	Frequent cutting and bed cleaning, close mowing of banks, application of pesticides.	Loss of habitat for nesting and overwintering wetland birds Loss of habitat and feeding opportunities for water shrew
Fisheries management	Weed-cutting		Depends on intensity and nature of cutting programme. Over-enthusiastic cutting can denude channel margins, remove too much submerged vegetation, and reduce gravel scour. Good practice mimics a natural patchwork of submerged plants and bare gravel with active marginal vegetation.
	Application of herbicides in or near river		Risk to flora/fauna of river channel and riparian area
	Cleaning of spawning gravels		*Improvement in gravel habitat for a range of fish species and some flora, including brook water crowfoot.* Possible destruction of silty habitats used by lampreys and other species. Smothering of gravels downstream.
	Stocking of commercial species	Brown trout, Atlantic salmon	Artificial increase in species dominance, competition with wild populations, possible increase in predation pressure, genetic introgression, disease transfer.
		Rainbow trout	As above except for genetic introgression. Introduction of non-native species.
	Removal of other species	Grayling, pike, eels	Artificial reduction in abundance, with the risk of encouraging younger year classes and exacerbating fishery problem.
		Avian predators	Possible damage to population viability.
		Mink	*Reduced predation pressure on water vole populations*
		Rats	Possible incidental mortalities of water vole

Sphere of activity	Specific activity	Further detail	Potential direct effects
Fisheries management (cont.)	Riparian management for angling access	Depends on regime but in some cases this involves close mowing to bank edge, bank stabilisation and bank raising.	Loss of tall herb species and associated invertebrate fauna, loss of flowering and seed-setting potential in smaller herb species. Loss of cover for birds, mammals and herpetofauna. Loss of soil moisture and ecological continuity with riparian areas.
Accidental/deliberate introductions (other than legitimate fish stocking)	Escape of farmed fish	Atlantic salmon, brown trout, rainbow trout	Genetic introgression, disease transfer, competition
	Escape of farmed non-native crayfish	Range of different species	Disease transfer to, and loss of, native crayfish.
	Accidental spread of non-native species from other sources	Plants/animals from gardens and garden centres	Competition with native flora/fauna, disease.
	Deliberate, illegal introductions	Fish for angling purposes Others (unwanted pets)	Any of the above
Recreation, amenity and access	Public use of riparian areas and main channel for walking, canoeing etc.		Disturbance to sensitive mammals (e.g. otters) and nesting birds. Trampling of sensitive habitats. *Possible benefit to water voles from mink disturbance.*

* Largely historical except where flood risk to urban developments is particularly high.

Table 5.2 Summary of physico-chemical effects caused by human activities in chalk river systems. ↘ indicates detrimental impacts, ↗ indicates beneficial effects.

General activity	Specific activity	WQ	Flow	Subst q	Chan	Rip	Floodpl
Discharge of contaminated water (point sources)	Domestic sewage	↘	↗	↘			
	Fish farms	↘	↗	↘			
	Cress farms	↘	↗	↘			
	Livestock farms	↘		↘			
	Other (e.g. industrial, such as quarrying)	↘	↗	↘			
Abstraction	Domestic supply	↘	↘	↘			
	Crop irrigation	↘	↘	↘			
	Fish farm supply	↘	↘	↘			
	Industrial use	↘	↘	↘			
	Cress farms	↘	↘	↘			
		↘	↘↗	↘			
Flood defence/ land drainage	Channel modifications						
	a. widening		↘	↘	↘	↘	↘
	b. deepening		↘	↘	↘	↘	↘
	c. straightening		↘	↘	↘	↘	↘
	Bank reinforcement						
	a. Hard				↘	↘	
	b. Soft				↘↗	↘↗	
	Channel maintenance						
	a. weedcutting and disposal	↘	↘	↘	↘	↘	↘
	b. dredging and disposal	↘	↘	↘	↘	↘	↘
Development	Construction of urban/industrial buildings	↘	↘	↘	↘	↘	↘
	Road construction	↘	↘	↘	↘	↘	↘
Agriculture (including biocide and fertiliser application)	Intensive livestock grazing/management						
	a. Free access to river	↘		↘	↘	↘	
	b. On downland and floodplain	↘		↘			↘
	Ploughing/arable cropping						
	a. In riparian areas	↘		↘		↘	
	b. On downland and floodplain	↘		↘			↘
	Establishment of under-drainage systems	?	↘	?		↘	↘
	Erection of fencing in riparian areas					↘↗	
Fisheries management	Weed-cutting and disposal	↘	↘↗	↘↗	↘	↘	↘
	Application of herbicides in or near river	↘				↘	
	Cleaning of spawning gravels			↘↗			
	Stocking of commercial species						
	Removal of other species						
	Riparian management for angling access				↘	↘	
Accidental/ deliberate introductions	Escape of farmed fish						
	Escape of farmed crayfish						
	Accidental spread of non-native species from other sources						
	Deliberate illegal introductions						
Recreation, amenity and access	Walking					↘	↘
	Canoeing						
	Swimming						

Note that severity rankings are not assigned to impacts, as the importance of different activities will vary greatly between rivers and river sections.

WQ	All aspects of water column quality
Flow	Flow regime, including flow rate, current velocity and diversity of velocities
Substr q	Substrate quality, including levels of siltation, quality of pore waters and diversity of substrate types
Chan	Channel form, including cross-section, variation in cross section and water depth
Rip	Riparian areas
Floodpl	Floodplain habitats, including flood meadows, ditch systems and other habitats dependent upon water levels.

The situation is further complicated when actual impacts upon the biota are considered. Declines in the status of different aspects of the biological community can be caused by a number of abiotic impacts, and it is usually unclear in any given situation which particular factors are principally to blame. In reality, it is likely that a range of abiotic impacts has brought about the decline, each of which has been generated by a combination of human activities. Detailed investigation of causal mechanisms may reveal which activities contribute most to the observed impacts, but action across a range of fronts is often necessary to bring about the desired improvement in biological status.

In the following sections, a number of key mechanisms of ecological impact on the chalk river environment are discussed, indicating general linkages between human activities, abiotic impacts and biological consequences. However, the complex interplay between different mechanisms should be borne in mind, particularly in relation to channel modifications and maintenance, low flows, siltation and nutrient enrichment.

5.3 Channel modifications and river/floodplain consequences

As has been pointed out in Section 2.2, chalk river systems have been restructured by human activity for centuries for the purposes of agriculture and water power, and until recent decades this has largely served to add value to their ecological character. The last 60 years have proved most destructive to the physical form of lowland watercourses in general, caused largely by flood defence and land drainage operations and followed by agricultural and urban development. In many instances, chalk rivers have fared better than other river types during this period due to the angling interests of riparian landowners. The trend towards enhanced drainage and agricultural improvement of riparian meadows has been less acute on prime angling reaches of chalk rivers (particularly the classic chalk stream), since the revenue generated from angling has reduced the need for high agricultural returns from riparian land. However, abandonment of water meadow operation may have resulted in lower soil moisture levels in some areas despite a lack of agricultural improvement. In addition, angling has not particularly helped the smaller chalk streams that are too small to hold high angling interest, or the lower reaches of chalk rivers that support less lucrative coarse fisheries.

The causes and consequences of channel modifications in chalk river systems are outlined in Figure 5.1. Dramatic resectioning has occurred on some chalk rivers (see Plate 23), involving straightening, deepening, widening and reprofiling (such as on the Wylye, lower Nar, the Lark, and on rivers such as the Kennet in the vicinity of urban areas). Post-war engineering works are often likely to have had land drainage motivations, permitting intensive livestock grazing and arable production. There has been less need for extreme flood defence activity on chalk rivers compared to catchments dominated by impermeable substrates, since the flow regime of chalk rivers is relatively stable and does not tend to induce such dramatic overbank flooding. This said, the high baseflow component tends to sustain peak flows for longer periods, creating long-term waterlogging of affected soils.

Where such works have occurred, the result has been considerable losses of habitat structure and diversity within the channel, detrimental modifications to bank profile, and the loss of hydrological continuity between the river channel and its banks, with consequent impoverishment of channel and riparian communities. Channel deepening results in the loss of gravel substrates that are so characteristic of chalk rivers (particularly the upper and middle reaches) and so necessary to chalk river communities. These substrates take centuries to acquire and are effectively irreplaceable by natural processes, due to the lack of downstream delivery of coarse material and the lack of movement of modern chalk rivers across alluvial sediments (that would otherwise allow historical deposits of alluvial gravels to be tapped).

Data from the River Habitat Survey database (RHS, developed by the Environment Agency) suggests that today there is an extremely low incidence of riffles across all chalk river sizes, with few sites having even one riffle in the standard 500m RHS survey reach (Figure 5.2). To put this in perspective, in rivers that form pools and riffles the longitudinal frequency of the sequence is generally 5-7 channel widths, equating to perhaps eight riffles in 500m if the river is around 10 metres wide. It is unclear to what extent this picture is dictated by natural geomorphological processes or man-made modification at this coarse scale of observation (see Section 2.2); more detailed local investigation of geomorphological history would yield more tangible information in any given situation.

Modern channel widening in chalk rivers is more often the result of indirect processes rather than intentional engineering. The natural channel form of chalk rivers appears to be wider and shallow than other river types (see Section 2.2), possibly due to bank erosion through groundwater seepage from riparian areas (Keller *et al.* 1990). However, widespread and severe bank erosion has been caused in recent decades by high densities of livestock with unrestricted access to the river, trampling and destabilising river banks and allowing the river to eat away at the exposed and unconsolidated soil. This artificially induced widening is exacerbated by heavy weed-cutting programmes (Section 5.8), which have denuded river banks of protective marginal vegetation and left them exposed to the full force of the river (Madsen 1997). In addition to altering the physical dimensions of riverine habitats, such channel widening has served to dissipate hydraulic energy and reduce the river's ability to maintain solids in suspension, thereby contributing to siltation problems (see Section 5.5).

On the floodplain, the lowering and widening of the channel bed has reduced water table levels throughout the year and decreased the incidence of winter flooding, exacerbated by enhanced land drainage often made possible by channel resectioning. The consequence has been the large-scale conversion of lightly grazed wet meadows to improved grassland and arable production. Whilst widespread losses of plant and animal species of wet meadows have occurred as a result, the impact of post-war engineering and subsequent agricultural improvement is probably best recorded in long-term observations of bird populations dependent upon the habitat. Declines in these bird species are mirrored by a wide range of wetland plant and invertebrate species. Species such as lapwing, redshank and snipe have undergone dramatic declines in numbers in Hampshire chalk river valleys in recent years (Green and Cade 1997). The yellow wagtail has become much more localised in the chalk river valleys of southern England and elsewhere such as in the Nar valley. It became virtually extinct in the Meon valley between the 1970s and the late 1980s, whilst numbers on the Hampshire Avon plummeted from an estimated 50 pairs in 1982 to only 5 pairs in 1990 (Clark and Eyre 1993).

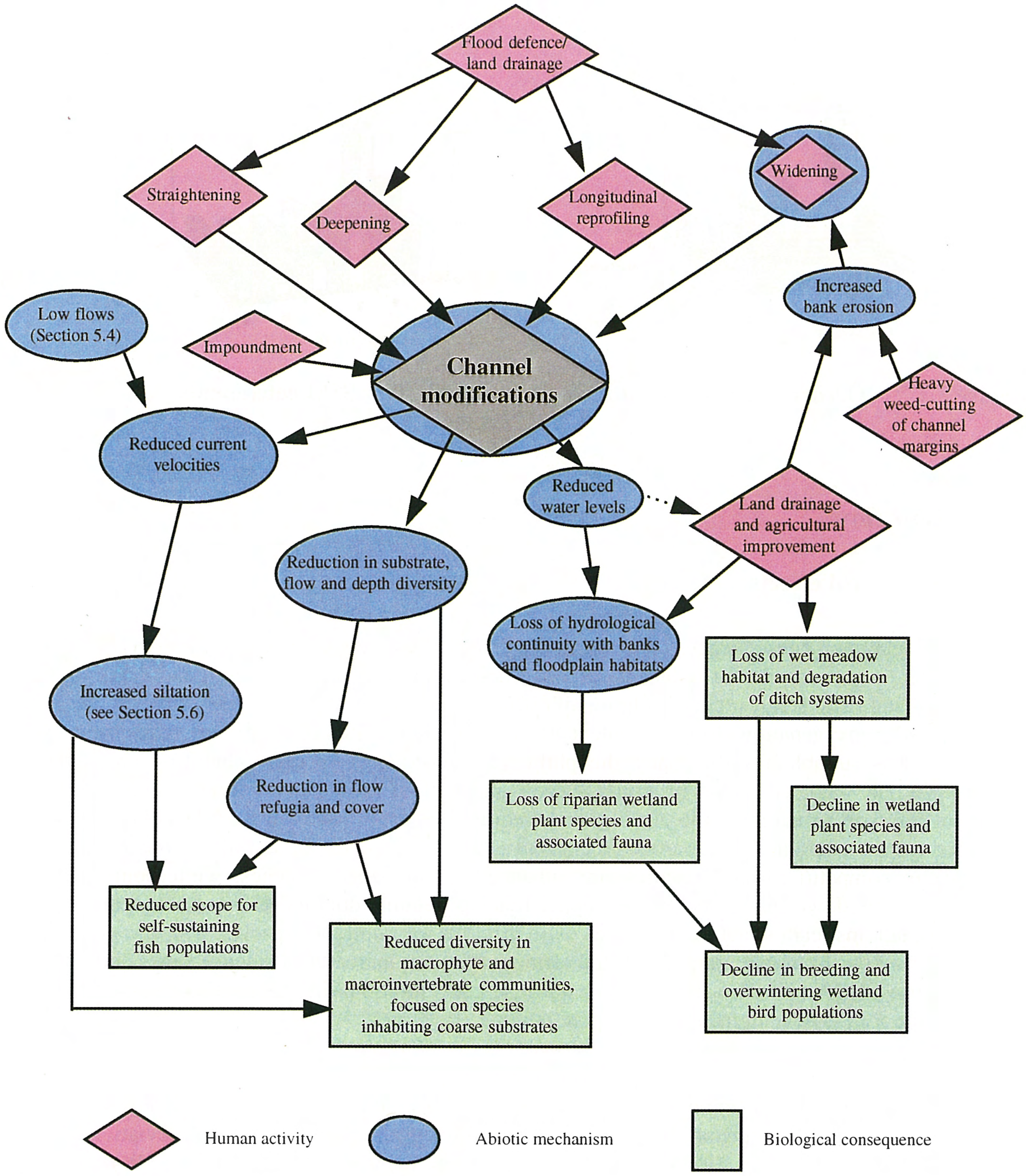

Figure 5.1 **Causes and consequences of channel modifications in chalk river systems.**