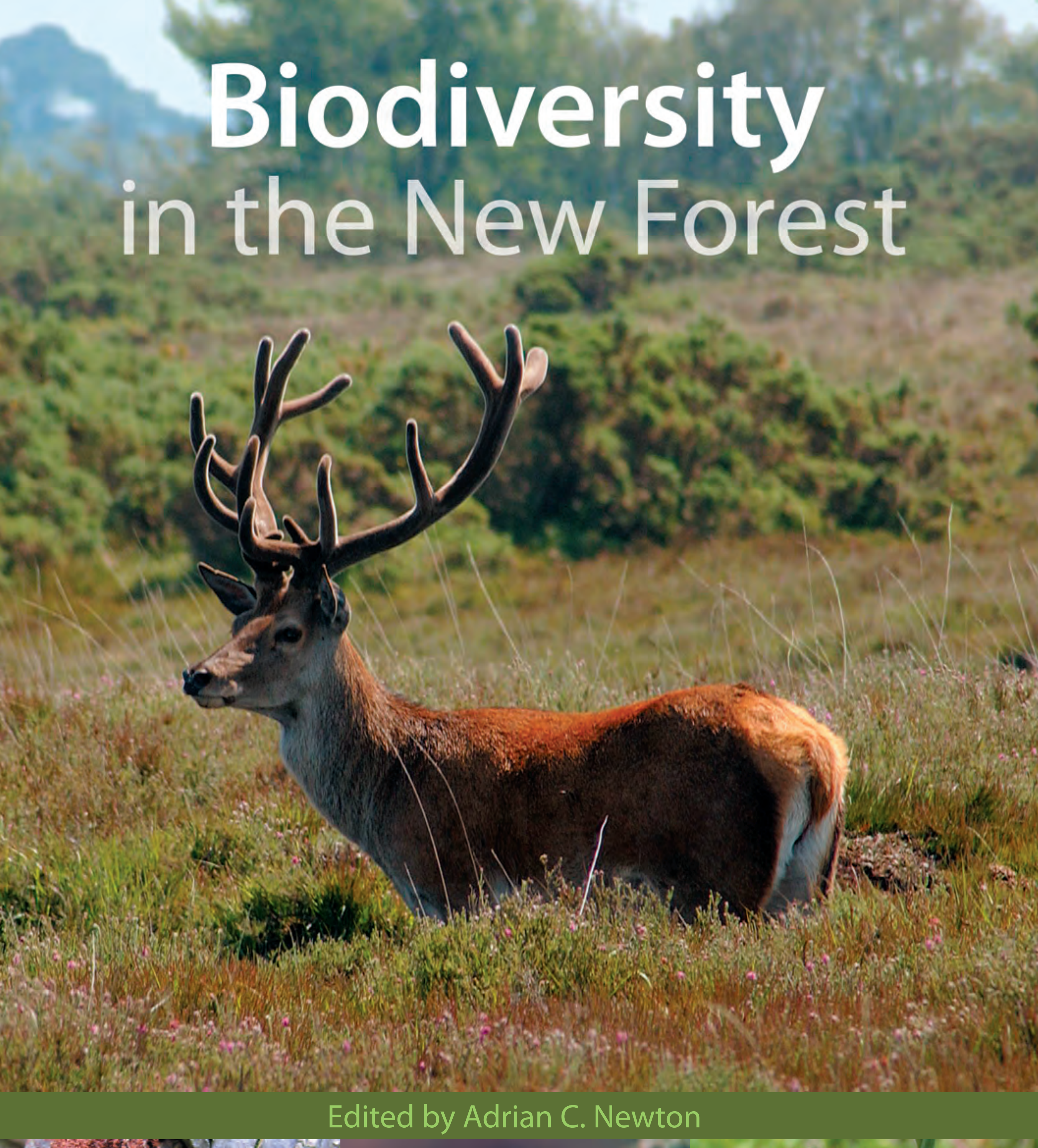
Biodiversity in the New Forest



Edited by Adrian C. Newton



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Dedicated to the memory of
Muriel Eliza Newton (1929–2009),
who loved the New Forest,
especially the donkeys.

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Front cover: Red deer *Cervus elaphus* (Isobel Cameron / Forest Life picture library, Forestry Commission); noble chafer *Gnorimus nobilis* (Matt Smith); Dartford warbler *Sylvia undata* (David Kjaer); wild gladiolus *Gladiolus illyricus* (Adrian Newton)
Back cover: Wood Crates (Adrian Newton)

The maps in this book are for illustrative purposes only, and do not represent the legal definition of National Park boundaries or any other feature

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15 **Biological diversity in New Forest streams**

Terry Langford, John Jones, Samantha Broadmeadow, Patrick Armitage, Peter Shaw and John Davy-Bowker

'The distinctiveness of New Forest streams is in the composition of their ecosystems, their biogeographical isolation, the special assemblages of plants, fish and invertebrates and the near-natural characteristics of some stream reaches and sub catchments. The preservation and protection of the drainage system and its ecosystems in their entirety, rather than single species or habitat types, should be our aim for the future'

(T.E.L. Langford, September 2007).

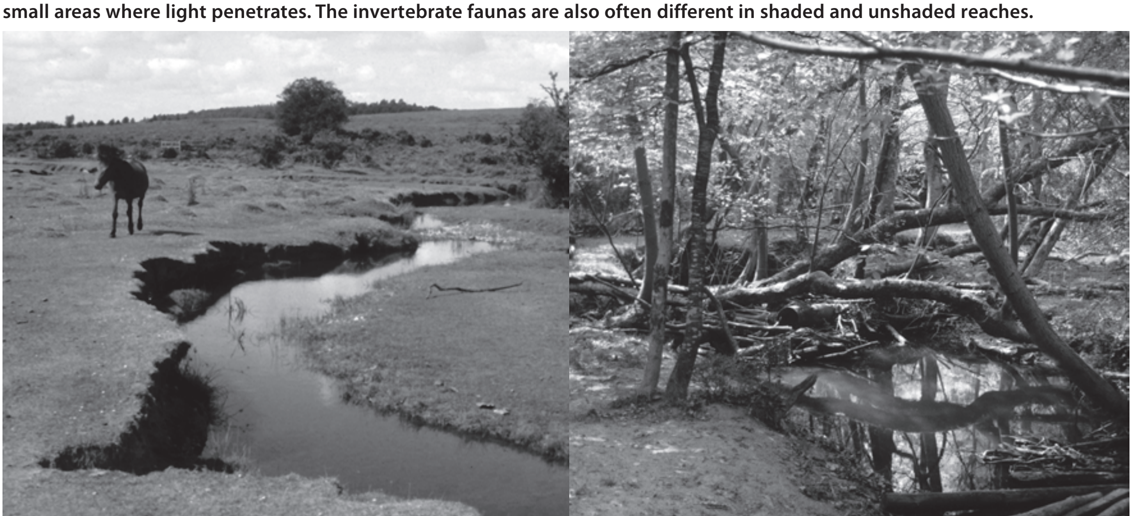
Introduction

The drainage system of the New Forest comprises a network of small, chemically circum-neutral streams with wide temporal variations in flow, varying degrees of shade and of physical modification (Plate 9) (Langford 1996, Tubbs 2001). The streams can be regarded as separated into three main topographical groups: those flowing westwards to join the Hampshire Avon, those flowing south to the sea and the Solent and those flowing eastward to the River Test and Southampton Water (Figure 66). All of the river systems are less than 30 km from source to mouth and have sources at altitudes less than 125 m ODN. These sources are mostly within a relatively small area of the higher Forest and all drain to rivers or the sea on the Forest borders. The catchments comprise mainly areas of heathland, open grazing lawns, forested Inclosures and ancient pasture woodlands (Langford 1996, Tubbs 2001). A few streams flow through small urbanised areas, notably Brockenhurst, Lyndhurst and Burley in the centre of the Forest and New Milton, Highcliffe and Ashurst on or just beyond the margins of the Forest perambulation. In addition a few short streams, all less than 5 km long, flow in the southern and eastern fringes of the Forest directly to the Solent or Southampton Water.

Despite the unique socio-economic and ecological history of the New Forest and despite many studies of the terrestrial flora and fauna (Tubbs 1968, 1986, 2001), the ecosystems of the streams received relatively little attention until the 1990s (Langford 1996). Prior to that, data on macro-invertebrates had been collected for routine monitoring by the Environment Agency and its predecessors and for the development of the RIVPACS biological monitoring programme (Wright *et al.* 2000) since the 1970s. There are still, even today, few peer-reviewed publications dealing with the flora and fauna of Forest streams, although there have been extensive published accounts of their geomorphology and hydrology over more than 40 years (e.g. Everard 1957, Tuckfield 1964, Gregory *et al*. 1985, Jeffries *et al.* 2003).

This chapter aims to provide an account of the flora and fauna of the New Forest streams, concentrating on the total taxonomic richness and broad distribution of species as far as is recorded in published papers, known grey literature and unpublished personal records. As a background to the ecological data, general descriptions of water chemistry, stream morphology, hydrology and temperature are also presented.

Plate 9
Open unshaded reaches of streams (left) alternate with wooded reaches (right) in the New Forest. Open reaches typically contain in-stream plants such as starwort and bog pondweed. Shaded reaches contain very few in-stream plants except in small areas where light penetrates. The invertebrate faunas are also often different in shaded and unshaded reaches.



Sources of data and methods

Records of fish, plants and invertebrates have been obtained from four main sources, namely:

- routine surveys by the Environment Agency (EA) and its predecessors in two regions. Wessex Region of the EA is responsible for the science and management of the western streams, and Southern Region for the streams flowing south and east (Figure 66);
- successive surveys by the Freshwater Biological Association (FBA), Institute of Freshwater Ecology (IFE) and the Centre for Ecology and Hydrology (CEH) for compiling the original database for the predictive studies that produced the RIVPACs programme (Wright *et al.* 2000);
- spatial studies of the macro-invertebrate and fish communities of the streams using 108 sites across the range of Forest streams (e.g. Langford 1996, Langford and Hawkins 1997, Langford 2000 and unpublished data), and including data from MSc and BSc projects at the University of Southampton (see Acknowledgements);
- archival records from the *Proceedings of the Hampshire Field Club* (1890 *et seq.*) and *Transactions of the Hampshire and Isle of Wight Natural History and Archaeological Society* (courtesy of the Archives and Special Collections, Southampton University);
- published literature from various journals (see References).

Chemical and flow data mainly originate from the records of the EA and its predecessors. Temperature data come from work in progress by Forest Research and Southampton University, and other data are from published work by various authors as named in the text.

Historical background

Historical ecological information on the streams is mostly anecdotal (Langford 1996, Tubbs 2001), the earliest published ecological records being lists of adult insect species with aquatic larvae produced in the early 20th century. The in-stream and marginal plant species present reflect both the degree of shade and the relative lengths of the wet and dry seasons. The original streams have been extended by the cutting of drainage channels and ditches over many years in both wooded and open reaches, producing a network of natural and artificial channels with variable flows.

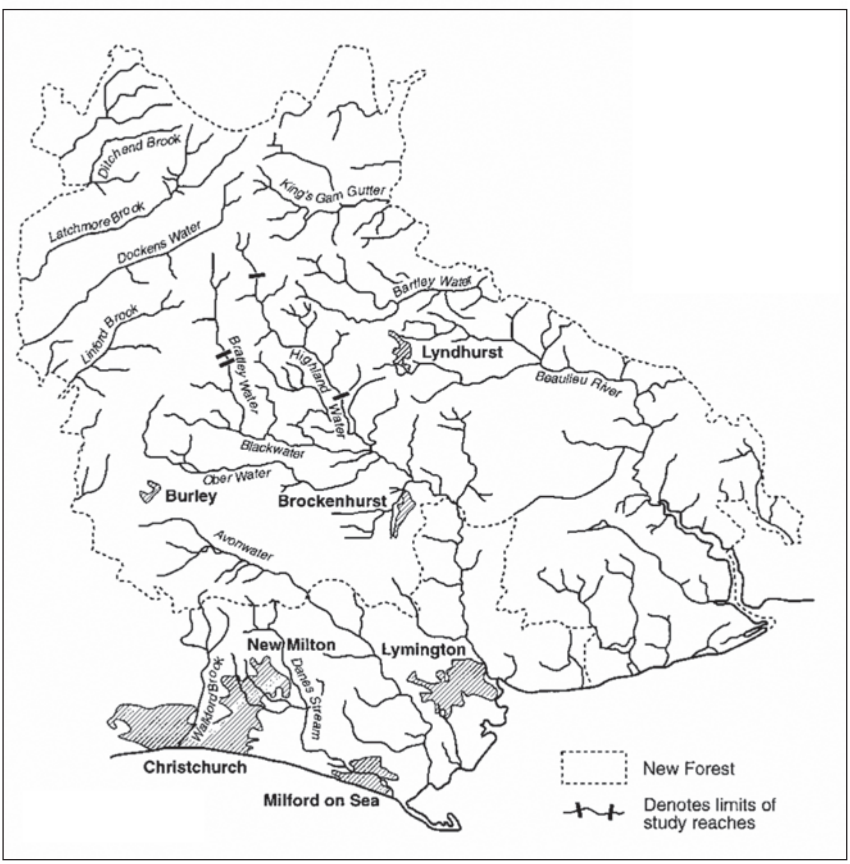


Figure 66
Drainage system of the New Forest in southern England. The major areas of village and urban development are indicated by diagonal shading. The Highland Water forms part of the Southampton University Research catchment where long-term studies have been conducted for over 30 years.

Plate 10
Typical catch from a shaded stream (Highland Water) (left) and an unshaded stream (Ober Water) (right). Species in the Highland water include trout, minnows, bullheads and brook lampreys. Ober Water species include chub, pike, minnows and perch.

Over many years, the management of the New Forest for timber and coppicing resulted in many of the streams being deepened and straightened to improve drainage, particularly for oak and conifer plantations (Tubbs 1986, 2001). This led to increased erosion in many reaches where bankfull channel depths exceeded 2 m instead of the more natural depths of 0.3–0.5 m. Stream management also included the routine removal of timber debris from channels, reducing their structural and hydraulic diversity. However, some streams have retained their natural sinuosity and many of the characteristics of pristine lowland forest streams (Sear and Arnell 2000).

Over centuries, travellers and naturalists visiting or working in the New Forest have commented on the streams (e.g. Cornish 1895, Begbie 1934, Everard 1957), but they have rarely attracted the great attention afforded to the sparkling chalk streams that characterise the remainder of Hampshire, Dorset and Wiltshire. For the most part, the Forest streams are small with peat-coloured water, which can vary in depth from 2–5 cm to more than 1.5 m within short distances. Latchmore Brook, flowing westward, was described as comprising '*deep grottos, fox holes (so large that they look more like dens for wolves) and bogs which heave*' (de Bairacli-Levy 1958). The iron-rich (chalybeate) springs and stream-waters in some areas were noted for their value as treatments for leprosy in the Middle Ages, for example Iron or Lepers' Well near Fritham in the northern area of the Forest (SU 22951485). In the 19th century, chalybeate springs and streams such as Passford Brook were recommended as cures for mange in dogs and for treatment of eye disorders (SZ 91053175) (Langford 1996).

The streams have never been regarded as significant venues for angling despite records of sea trout *Salmo trutta* of above 5 kg in weight (de Crespigny and Hutchinson 1899, Langford 2000). Only one fishing club regularly uses the streams, mainly the Lymington River, and pleasure angling mostly takes place only in a few artificial pools on the Forest. An opinion expressed in the 19th century was that '*practically speaking there is no fishing on the Forest*', although the authors did note the presence of '*large sea-trout*' in the Avon Water and remarked that timber and trees were a hindrance to fly-fishers. Today, most visitors to the Forest are surprised to see large numbers of fish such as minnows *Phoxinus phoxinus*, bullheads *Cottus gobio* and small trout *Salmo trutta* caught during research sampling in various streams. Large chub *Leuciscus cephalus*, pike *Esox lucius* and other coarse fish are present in streams such as the Ober Water and Dockens Water but are rarely seen by the casual visitor (Plate 10).

Channel structure and hydrology

Land use in the stream catchments comprises mostly woods, open grazing lawns, heathland and a few small urban areas, but no significant arable areas. The wooded areas include conifers and managed young stands of hardwoods with old-growth woodland (see Chapter 13). Oak, ash and beech dominate the deciduous trees, often interspersed with holly. Alder lines the margins of many streams. In the unfenced areas the vegetation pattern is mostly maintained through a mixture of grazing by large herbivores and anthropogenic forest and lawn management practices. This system has been maintained for many centuries (Tubbs 1968, 1986, 2001). The pattern of riparian vegetation and land use can, as noted below, have significant implications for the ecology of the streams.

Stream channels rarely exceed bankfull widths of 7 m across the Forest, although the lower reaches of the Lymington River are up to 10 m wide. Straightened and deepened reaches of all streams are interspersed with more natural, meandering reaches. There is a defined riffle-pool structure in most streams, with minimum depths on riffles at base-flow of between 2 and 7 cm. Pools vary in depth from 20 cm to 1.3 m, and in dry periods upper reaches of streams may consist only of pools interspersed with dry riffles. At moderate discharge rates, some reaches show smooth,

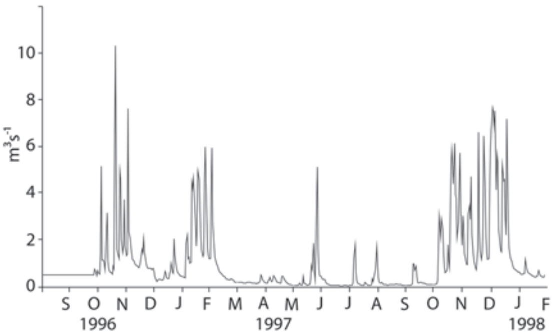


Figure 67
Hydrograph of the Lymington River at Brockenhurst, 1996–1998. The 'flashy' nature of the flow patterns is typical of New Forest streams and rivers.

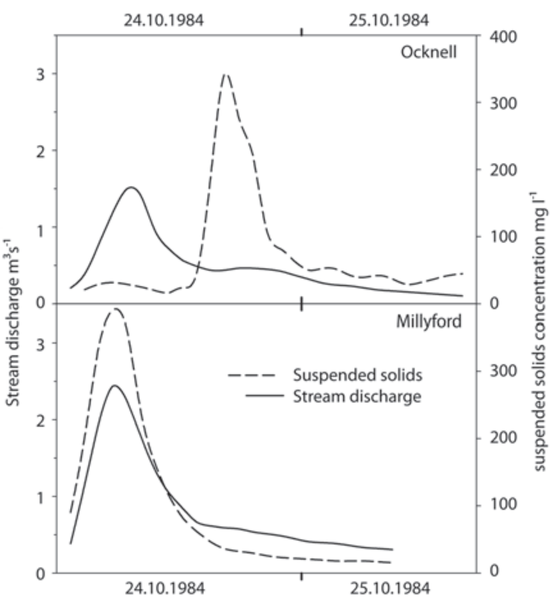


Figure 68
Effects of heavy rainfall on stream discharge and suspended solids concentrations over a two-day period. Highland Water, New Forest, 1984. (After Futter 1985.)

laminar flow and can be categorised as glides. In extremely dry years, such as 1976 and 2006, some streams dry out completely in their upper reaches, sometimes for up to 1 km, and historically such dry periods may last for up to 6–8 weeks (Shore 1890). Typically, riffles tend to be between 5 and 15 m long and pools from 5 to 30 m long, depending on the location within the stream system. Pools become more common in lower reaches. The substrate is dominated by sand and clay overlain with gravel, pebbles and small flint cobbles with diameters from approximately 1 cm to 12 cm. The phi scale, describing substrates, is typically from 3 to minus 6, indicating small to moderate-sized particles. There are no large rocks, boulders or bare bedrock reaches. Common depositing substrates are silt, leaf packs, sand and silt-sand with small twigs and small woody debris.

Hydrologically, New Forest streams are described as 'flashy' (Gurnell and Gregory 1987), with a tendency to rise and fall quickly after rainfall (Figure 67). Streams with extensive mires and bogs in their catchments tend to have more consistent flows in summer (Tubbs 1986). Run-off from the few large roads that cross the area and from the small urban areas would be expected to affect stream flows. For example, Gregory (1992) suggested that increases in the peak flow of the upper Highland Water were caused by storm run-off from a large dual carriageway following road improvements in the 1980s.

The streams can carry large amounts of sediments during spates with even tiny streams removing from 0.64–0.75 $m^3\ yr^{-1}$. Such values increase where human impact or cattle access occurs (e.g. Tuckfield 1964, 1973, 1976, 1980). As an extreme example, 1084 m^3 of sediment was removed from one gulley in 10 years. Channelisation of unshaded reaches also leads to large growths of silt-loving plants such as Nuttall's waterweed *Elodea nuttalli* (Brookes 1983). Suspended solids concentrations can rise from between 5 and 25 mg l^{-1} at low discharge to over 300 mg l^{-1} during high discharge (Figure 68) (Futter 1985). The rate of erosion and sediment removal from the riparian zone depends upon the dryness of the soils, the intensity of the rainfall and the stream discharge (e.g. Gregory 1992). Spores and pollen may reach concentrations of 230 grains ml^{-1} at high discharge, although at low flows the values are typically 1–2 grains ml^{-1}. Tree pollen can dominate the contributions at high flows, though not at lower flows (Brown 1985).

Water chemistry

The waters of the New Forest are typically circum-neutral with pH values normally ranging from 6 to 7.3 in the larger streams, but in the headwaters draining mires pH may be as low as 3–4 (Arbuthnott 1996). Nutrient and calcium concentrations are naturally very low, although they can vary with underlying rocks, soils and with riparian land use (Table 38). Natural acidity was measured in the late 19th century when Brierly (1890) noted the '*very great corrosive nature of the waters….upon metals*' and the presence of humic acids. A good measure of the mineral content of the water is 'conductivity' or 'specific conductance' (Buttle *et al.* 1970), which is measured by passing an electric current though a sample of the water in a cell of known dimensions and represented in units of micro-siemens per centimetre (μS cm^{-1}). Forest streams show typical conductivities (adjusted to be 25 °C) of 120– 200 μS cm^{-1} with less common higher and lower values depending on the underlying geology. In the smallest feeders conductivities can be as low as 50–75 μS cm^{-1} and where sewage effluents, road drainage or small domestic effluents enter streams, conductivities can range from 500 to 1150 μS cm^{-1}, usually for very short distances (Le Rossignol 1977). In comparison, chalk streams range naturally from 350 to 600 μS cm^{-1}, a

Table 38
Typical chemical constituents of New Forest stream water in relation to underlying geology. Values are means of five samples (from Langford 1996, after Le Rossignol 1977). Lead (Pb) and Copper (Cu) were below detection level.

Rock type	Conductivity	TDS	Ca	Mg	Na	K	Li	Fe	Mn	Zn
Headon Beds	396	428	41.5	12	27.5	8.44	25	2,300	600	47
Headon Beds	486	540	62.5	16	42	4.7	33	460	1525	33
Barton Clay	156	193	11.0	6.3	12.7	3.2	36	1,840	119	34
Plateau Gravel	120	124	5.0	4.5	12.7	1.05	25	1,250	113	30
Barton Sand	156	170	6.0	5.2	16.9	3.2	14	630	80	25
Barton Sand	147	212	13.5	6	12	4.35	24	4,800	381	72
Barton Clay	373	349	26.0	25.8	17.9	6.1	86	460	440	440
Barton Clay	129	123	6.5	4	11.2	2.43	16	2,010	116	1

factor of 2–3.5 greater than natural Forest streams. There is some variation in the mean natural concentrations of the major constituents (Table 38), but in streams draining urban areas, improved farm land or standing waters, conductivities, nutrient concentrations and pH may be higher than in the more natural streams (Environment Agency data 1988–96). Marker (1976) recorded nitrate (as NO_3-N) concentrations of 0.1–0.8 mg l^{-1} and 0.1–1.4 mg l^{-1} in the Ober Water and Dockens Water, respectively, during 1969–1972, which were very similar to the values for 1996–2000 (Langford 2000). The chemical characteristics of the Forest streams are a main defining factor in their ecology and they form a hydrological and biochemical geographical and ecological island, surrounded by calcareous lands and high-quality chalk streams.

Sources of pollution

Pollution has been, historically, relatively rare. The most serious consistent polluting industrial discharge was that from the Schultze Gunpowder Factory at Fritham to the Latchmore Brook, where leakages of various acids '*so tainted the water that cattle refused to drink it and the fish, holding their noses, fled, in the case of the salmon never to return*' (Begbie 1934). In 1871, soon after the opening of the factory, dead eels and fish were found in the brook five miles downstream of the factory (Pasmore 1993), although as the pollution problems became worse, the Company suggested that because the substances in use were '*nitre and sulphuric acids*', both used in medicine and as tonics, '*there was no cause for alarm*' (Pasmore 1993). The factory closed and the discharge ceased in the 1940s. The Company also built a substantial reservoir for water supply to the factory by blocking the Latchmore Brook and tapping into springs nearby. This is now known as Eyeworth Pond (SU 22851470).

Present discharges to Forest streams now mainly originate from sewage disposal works serving the small towns and villages such as Lyndhurst, Brockenhurst, Fritham and Burley (Tubbs 2001). Occasional discharges from some of these works, usually as a result of storms or the breakdown of equipment, exceed threshold limits and cause fish mortalities and ecological damage downstream. Other point-sources may be sited at farms, businesses or factories that discharge effluents intermittently (usually accidentally). Also, storm overflow pipes designed only to operate during heavy precipitation may cause occasional problems. Diffuse pollution, mainly run-off from roads and impervious urban surfaces can introduce sediments, oil and rubber residues and organic material deposited on the hard surface. These sources are relatively rare in the Forest proper, and are restricted to the small central urban areas, the urbanised fringe and the few large roads that cross the Forest. Diffuse run-off from agriculture, trackways and areas where ponies and cattle congregate also contribute nutrients and nitrogenous materials, though concentrations tend to be low.

Large woody debris

A noted feature of New Forest stream channels is the presence of varying amounts of large wood debris in the form of fallen trees, large fallen branches and cut tree sections (see also Chapter 13). These may be in the form of single items or, more commonly aggregated into larger accumulations forming matrices or dam-like structures traversing the channel. The effects of such woody debris on channel structure and sediments have been studied for over 30 years (e.g. Gregory *et al.* 1985, Gregory and Davis 1992, Gurnell and Sweet 1998, Jeffries *et al.* 2003). The number and density of dams has varied over the years, mainly as a result of stream and forest management practices. Until the 1980s, debris dams were often removed from channels to enhance drainage but more recently, many dams have been retained to try to reinstate a more natural regime of flow and sediment transport (e.g. Jeffries *et al.* 2003).

The presence of debris dams is not universally appreciated by the various users of the New Forest. For example, ecologists and conservationists mostly consider woody debris as an integral part of the natural stream habitat, which also influences floodplain inundation. In contrast, the impoundment of streams by dams and the resulting overbank flow can, according to Forest users, have adverse effects on the drainage of grazing lawns and Inclosures and hence on

Forest livestock. Furthermore, some anglers believe that the upstream spawning migrations of sea trout are hindered by the dams, although this is doubtful (e.g. Langford and Hawkins 1997, Langford 2000, 2006). Debris dams at densities of up to four per 100 m (Gregory *et al.* 1985) may delay flood peaks by up to 10 minutes at high flows and 100 minutes at low flows. Over-bank flows and increased sediment deposition also occur at discharge rates less than flood levels where in-stream debris dams are present (Jeffries *et al.* 2003). The number and density of dams varies with land use with the greatest loading originating from deciduous forest (Gregory *et al.* 1993). In the most studied habitat, the Highland Water, debris dams tend to be concentrated in the upper third of the stream (Gregory *et al.* 1993) and an increased density of pools tends to be associated with an increased density of debris dams, although pools are not formed exclusively by such dams (e.g. Gurnell and Sweet 1998).

The flora and fauna

Micro-organisms and algae

There have been few taxonomically based studies of micro-organisms and algae in New Forest streams. Densities of ciliate protozoa were found to be lower than in chalk streams (Baldock and Sleigh 1988), but densities of photosynthetic flagellates, mainly *Synura* spp. reached 148×10^3 cm^{-2}. *Carchesium* spp, *Vorticella* spp. and *Platycola* spp. were the dominant peritrich ciliates (Harmsworth *et al.* 1992). McCollin (1993) sampled 15 sites and recorded 30 species of diatoms (Bacillariophycae) living on stones and plants. *Fragillaria* cf. *pinnata* was the most common species and more abundant than others, where nutrient concentrations and light availabilities were low. Where phosphate concentrations were higher, *Cocconeis placentula* and *Achnanthes miniutissima* were the most common species. The growth and standing crop of *Achnanthes saxonica* on stones were related to water velocity (Moore 1977), although they were also affected by shade. Dominant diatoms on woody debris were *A. saxonica* with *Suirella ovata* var. *minuta*.

Common epipelic species in the Highland Water were *A. minutissima* v. *cryptocephala*, *A. saxonica*, *Cymbella naviculiformis, Synedra ulna*, *Opephora martyi*, *Pinnularia biceps* and *P. biceps* f. *peterseni*. Epilithic communities included the *Achnanthes* spp., plus *Gomphonema acuminatum* v. *coronatum*, *G. constrictum* v. *subcapitum*, and *Achnanthes* spp., which accounted for the majority of the standing crop in both epipelic and epilithic communities (Moore 1977). Epihytic and planktonic communities were also dominated by *Achnanthes* spp., with *Gomphonema parvulum*. The epiphytes were mainly on decaying tree branches as macrophytes were scarce in this heavily shaded stream. Diatoms and unicellular algae formed the basis of the diet of the four main herbivores in the Highland water, namely the shrimp *Gammarus pulex*, the mayflies *Ephemera danica* and *Ecdyonurus* sp., and larval brook lamprey *Lampetra planeri*.

Macrophytes

The abundance of in-stream macrophytes in New Forest streams is closely related to the amount of shade, with both species richness and total abundance greater in unshaded reaches (Figure 69). The macrophyte flora (Table 39) of the sandy New Forest streams is regarded as comprising a unique assemblage of species (Haslam

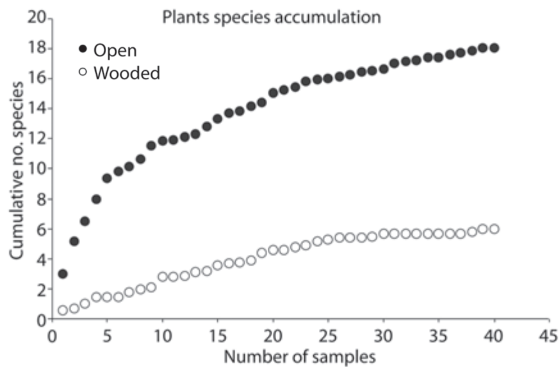


Figure 69
Species accumulation curves for aquatic plants in shaded and unshaded reaches of New Forest streams. The exclusion of light limits both the number and the abundance of species. (From Samuel 2004.)

Table 39
Species of macrophyte recorded in New Forest streams.

Species
Agrostis stolonifera Creeping bent, fiorin *
Alisma plantago-aquatica Water-plantain *
Apium nodiflorum Fool's watercress, water celery *
Callitriche hamulata Intermediate water-starwort *
Callitriche obtusangula Blunt-fruited water-starwort
Callitriche stagnalis Common water-starwort *
Catabrosa aquatica Whorl-grass
Eleogiton fluitans Floating club-rush
Elodea canadensis Canadian waterweed *
Elodea nuttallii Nuttall's waterweed
Glyceria fluitans Flat-grass, floating sweet-grass *
Groenlandia densa Opposite-leaved pondweed
Lemna minor Common duckweed
Ludwigia palustris Hampshire-purselane *
Myosotis scorpioides Water forget-me-not **
Myriophyllum alterniflorum Alternate-flowered water-milfoil
Nuphar lutea Yellow water-lily
Oenanthe crocata Hemlock water-dropwort *
Potamogeton polygonifolius Bog pondweed *
Ranunculus omiophyllus Round-leaved crowfoot **
Ranunculus peltatus Pond water-crowfoot **
Ranunculus trichophyllus Thread-leaved water-crowfoot
Rorippa nasturtium-aquaticum Summer watercress *
Scrophularia auriculata Water figwort
Sparganium erectum Branched bur-reed **
Veronica scutellata Marsh speedwell

* indicates from Samuel (2004)
** indicates regarded as typical of sandy New Forest streams

and Wolseley 1981, Holmes 1983). Samuel (2004) added eight species to the list given by Langford (1996), making 26 species in total, and included both *Elodea canadensis* and *E. nuttalli. Elodea* spp. are sporadically distributed but can become very abundant in some reaches, notably the Ober Water downstream of Markway Bridge (SU 24850385). In the upper reaches of most streams, the commonest macrophyte is bog pondweed *Potamogeton polygonifolius*. Its spearhead-shaped leaves can be seen in both very wet mires and bogs and in stream channels and temporary ponds across the Forest. It is often found where dappled shade prevents the growth of other macrophytes. Among the riparian macrophytes, the marsh St John's-wort, *Hypericum elodes*, appears to be associated with the occurrence of some of the damselfly species along specific streams (Jenkins 1986). Haslam (2006) shows at least 31 plant species associated with clean chalk streams, typically with 10 or 11 species at any one site. In New Forest streams, the number of species at any one site is typically 2–5 (Samuel 2004). In-stream vegetation is also generally more abundant in chalk streams even than in unshaded Forest streams (Samuel 2004, Haslam 2006).

Macro-invertebrates

To date some 296 taxa of macro-invertebrates have been recorded from various studies of the Forest streams (Appendix). Historically, the most commonly studied groups were insects, notably Trichoptera (caddisflies) and Plecoptera (stoneflies) (Langford 1996). By 1940, 20 species of the former and ten species of the latter had been recorded as adults in the Forest. Mayflies were relatively scarce according to early records (Lucas 1932). To date 16 species of stonefly, 20 species of mayfly, 53 species of caddis and 34 species of beetle are listed from the streams, although the list may not yet be complete. The New Forest drainage system typically contains between 10 and 40% of the British species in various freshwater invertebrate groups (Langford 1996), although records of water mites (Hydracarina) and true flies (Diptera) may be affected by the number of specialist taxonomists in the area. The most obvious group of insects to the casual observer is the Odonata (damselflies and dragonflies; see also Chapter 4) (e.g. Welstead and Welstead 1984, Winsland 1994), particularly the large black and yellow golden-ringed dragonfly *Cordulegaster boltonii*, often seen patrolling along the streams, particularly in the wooded reaches. In late May and early June, large numbers of the spectacular blue-green damselfly, the beautiful demoiselle *Calopteryx virgo*, are also visible on certain streams, particularly where a lack of shade allows in-stream vegetation and overhanging bank grasses to flourish. In the open upper reaches of some streams, where in-stream vegetation is present, the keeled skimmer *Orthetrum coerulescens* is more common than golden-ringed dragonfly (Langford, unpublished data).

The southern damselfly *Coenagrion mercuriale* is listed as rare in Britain (Red Data Book category 3) and is an Annex II listed species in the EU Habitats Directive. It is found in the New Forest in a small number of streams and drainage channels, and has been the subject of many studies over more than 40 years (e.g. Goodyear 1967; Welstead and Welstead 1984, Winsland 1994, Jenkins 1995, Watts *et al.* 2007; see also Chapter 4 this volume). The reasons for the discontinuous distribution of the species across the Forest are not known. The most abundant and consistent populations occur along the Crockford Stream (SU 99003505) (Watts *et al*. 2007) draining Beaulieu Heath. This stream also contains the only population of the stonefly *Taeniopteryx nebulosa* in the main Forest drainage system (Langford, unpublished data), although it is similar chemically and physically to other small Forest streams. Among the other aerial insects few are very obvious being mostly small or various shades of brown in colour as adults. The large diving beetle *Dytiscus semisulcatus*, glossy brown with a bold yellow margin to its body, can be found among tree roots, small woody debris or in weed beds in both wooded and open streams. Another diving beetle, *Agabus brunneus*, classed as 'Vulnerable' has been found in Linford Brook in the western area of the Forest, the only site among 26 New Forest streams surveyed (http://www.ukbvap.org.uk, accessed 28/07/2008).

Despite the unusual characteristics of the New Forest drainage system in the region and its biogeographical isolation, there are few rare or protected invertebrate species occurring in the streams. A few relatively rare species occur in cut-off meanders, marginal or floodplain habitats, for example the snail *Omphiscola glabra* and the beetle *Graptodytes flavipes* (Thomas 2006). In the main stream channels no species is classified above 'notable' (see Appendix). Mollusca and Gammaridae are of relatively low abundance in New Forest streams because of the lack of calcium, which they need to construct shells or exoskeletons. The lesser water measurer *Hydrometra gracilenta* was recorded from streams until the 1950s, but not more recently (Kirby 1993). Most other rare or protected aquatic invertebrate species occur in ponds or pools on the Forest (Langford 1996) (see Chapter 16).

Life-history studies of aquatic invertebrates in Forest streams are rare, limited to species inhabiting the gravel interstices, notably the small oligocheate worm *Nais elinguis* (Ladle 1971), the phreaticolous water mite *Neocarus hibernicus* (Gledhill 1969), and the subterranean spring-dwelling crustacean *Niphargus aquilex*.

Fish

Twenty-two species have been recorded in Forest streams of the 55 species found in freshwaters in Britain (Maitland and Campbell 1992, Langford 1996, Quinlan 2000) (Table 40). Brown trout (sea trout), bullheads, brook lampreys, minnows, eels, and stone loach are the most widely distributed. The most numerically abundant species are trout, minnows and bullheads (Langford and Hawkins 1997, Langford 2000). Of the other species, most are found in streams with unshaded reaches (Langford 2000, Quinlan 2000) and are not widespread. Sticklebacks have been found to be most abundant in the upper Dockens Water (SU 21401200), but are rare elsewhere. In the case of salmon, under-yearlings have usually only been found in the western streams in small numbers (Mann and Orr 1969). Unusually, bullheads were not found in the upper reaches of Dockens Water near Holly Hatch in early surveys (SU 21401200), although they are present downstream (Mann and Orr 1969, Downes 1999, Langford 2000). Recent surveys in 2005–2007 by two of the authors (Jones and Broadmeadow, unpublished data) have still not recorded bullheads at Holly Hatch. The reason for their absence in this reach is unknown. Both the bullhead and the brook lamprey are species protected by the European Habitats Directive (92/43 EEC).

Effects of wood debris on the stream faunas

The published literature on the geomorphological effects of wood debris accumulation in rivers of many countries is extensive (e.g. Montgomery *et al.* 2003). Specific data from New Forest streams are also well documented (e.g. Gregory *et al.* 1985, Gurnell and Sweet 1998, Jeffries *et al.* 2003). In contrast, published data on ecological effects of wood debris are less extensive (see Montgomery *et al.* 2003, Schneider and Winemiller 2008). Typically, woody debris in streams increases cover for some fishes and increases pool areas and the habitat for lentic fish or life-history stages. As noted above, wood provides a suitable substrate for colonisation by microscopic algae in New Forest streams. The effect on invertebrate communities is not clear (Langford 1996), although the species that inhabit wood debris piles are also common in marginal habitats where current velocities are lower than in midstream (Langford 1996). The accumulation of leaves in the wood accumulations provides a suitable habitat for leaf shredder species such as leptophlebiid mayflies. Some invertebrate species feed directly on decaying wood, but no specific studies of this have been made on these in New Forest streams (see Langford 1996, 2000).

More detailed studies on fish (Plate 11), particularly in the Highland Water, have shown that woody debris increases pool habitat, which benefits species such as minnows and trout over 1 year old (Langford and Hawkins 1997, Langford 2000, 2006). Where debris dams cause pools to extend over riffles, the area of riffle habitat for under yearling trout and for the EU-protected bullhead decreases. Densities of small trout and bullheads were found to be negatively correlated with amounts of woody debris in a reach, while densities of larger trout and minnows were positively correlated. Seasonal densities of small trout on riffles in the Highland Water averaged from 0.1 to 0.9 fish m^{-2}, bullheads from 0.8 to 2.8 fish m^{-2}. In pools older trout averaged from 0.1 to 0.35 fish m^{-2}, and bullheads 0.1 to 1.4 fish m^{-2}. Minnows averaged 0–0.2 fish m^{-2} in riffles and 0.1 to 0.4 fish m^{-2} in pools. Only very large sea trout and eels were more common and abundant in wood piles than in pools or riffles (Langford 2000, 2006) (Figure 70). Furthermore, as trout, minnows, brook lampreys and bullheads all spawn on riffles, potential spawning areas for these species may be lost if debris dams, and hence pool areas, increase. Thus, although there is a current fashion for encouraging wood debris accumulation in streams generally 'to enhance biodiversity", there may be both beneficial and adverse effects on fish and the effects on other biota may be neutral or very small. The use of wood debris as a

Plate 11
Electric fishing in a woody debris dam matrix. Despite the complexity of the dam the matrices can be sufficiently open for stunned fish to be seen and caught as they drift downstream.

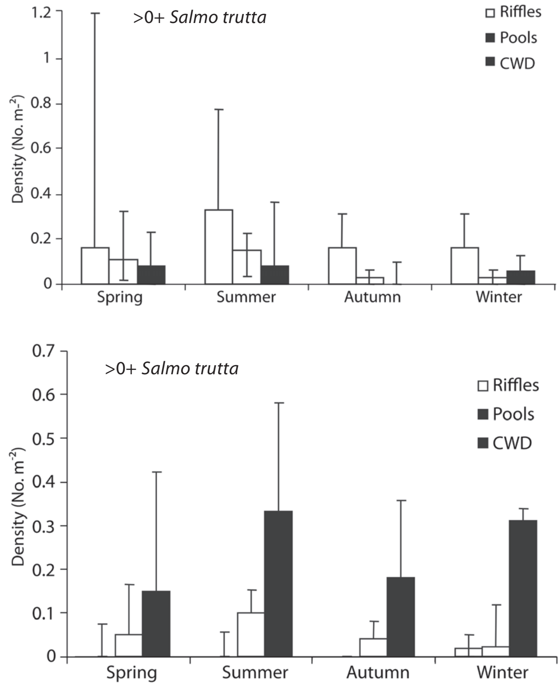


Figure 70
Median and quartile seasonal densities of 0+ and >0+ age groups of *S. trutta* in riffles, pools and CWD matrices in New Forest streams. Samples taken monthly from September 1996 to February 1998, augmented by data from 2000, 2001 and 2003. Highland Water, Bratley Water and Bagshot Gutter data combined. CWD refers to Coarse Woody Debris.

management tool should therefore only be used if the total ecological effects have been considered.

Effects of shade on stream ecology

Two main categories of stream and reach on the New Forest can be identified by their bankside and riparian vegetation. Along most streams, wooded reaches with relatively little or low riparian vegetation beneath the trees alternate with open lawns or heathland, with bankside vegetation trailing in the water. The lack of shade obviously exposes the stream to direct sunlight and heat. In the unshaded reaches, therefore, maximum summer temperatures can be 8–10 °C higher than in fully shaded reaches (Figure 71). The diurnal temperature range can be up to 8 °C in open streams but only 1–3 °C in heavily shaded streams. On the hottest days in some years, water temperatures may exceed the optimal temperatures for coldwater fish such as trout.

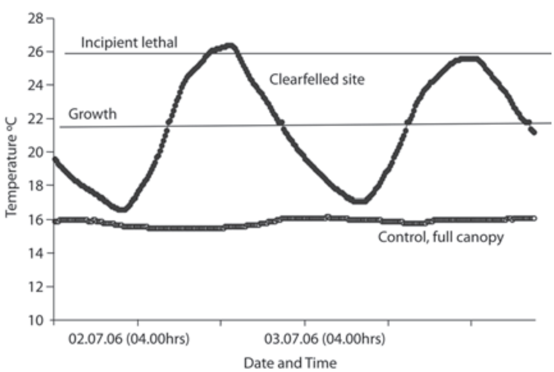


Figure 71
Diurnal temperature variations in the Highland Water following clearfelling over about 200 m of riparian trees compared with a fully shaded reach downstream. Temperatures at which trout growth may cease (22°C) and at which trout may begin to die (26°C) are shown.

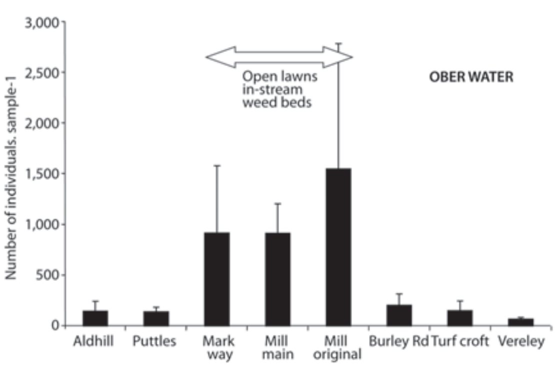


Figure 72
Average numbers of macro-invertebrates collected per sample from shaded and unshaded reaches of the Ober Water. Samples are composite kick samples from midstream and marginal habitats.

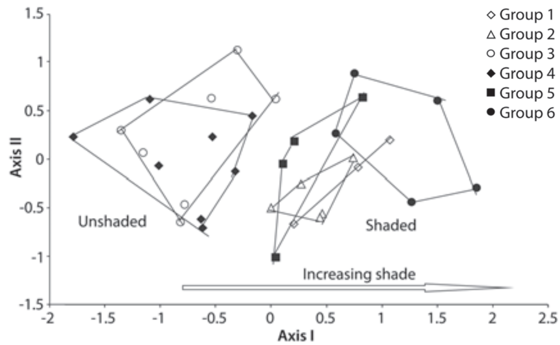


Figure 73
Ordination of macro-invertebrate community samples from shaded and unshaded reaches along the Ober Water. Groups 1, 2, 5 and 6 are from shaded reaches, groups 3 and 4 are from unshaded reaches. The linked symbols indicate similar communities. The separation of unshaded and shaded communities is clear even along one stream. Ordination is a technique for comparing similarity of samples based on the species/taxa present and their abundance in a sample.

Table 40
Fish species found in New Forest streams.

Species
Salmon *Salmo salar* *
Brown (sea) trout *Salmo trutta* **
Chub *Leuciscus cephalus* ***
Minnow *Phoxinus phoxinus* **
Gudgeon *Gobio gobio* *
Bleak *Alburnus alburnus* *
Common bream *Abramis brama* *
Roach *Rutilus rutilus* *
Goldfish *Carassius auratus* *
Rudd *Scardinius erythrophthalmus* *
Dace *Leuciscus leuciscus* *
Grayling *Thymallus thymallus* *
Stone loach *Barbatula barbatula* ***
Bullhead *Cottus gobio* **
Three-spined stickleback *Gasterosteus aculeatus* *+
Perch *Perca fluviatilis* *
Pike *Esox lucius* *
European eel *Anguilla anguilla* ++
Brook lamprey *Lampetra planeri* **
Sea bass *Dicentarchus labrax* +++
Thick-lipped grey mullet *Chelon labrosus* +++
Flounder *Platichthyes flesus*

* rarely found
** common and abundant
*** common but most abundant in unshaded streams
*+ not widely distributed but abundant in a few places
++ was common, but has become rarer in recent years, and never abundant
+++ only in brackish lower reaches

Where there are no trees, light encourages weed growth. In-stream water weeds are therefore common and sometimes abundant. Species richness is far greater than that of streams with wooded banks (Figure 69). Some wooded streams such as the Highland Water were devoid of in-stream plants for almost the whole length, though tree clearance in some reaches for planting or stream restoration allowed colonisation (Smith 2006).

Open stream reaches often have more abundant invertebrate faunas (Figure 72), and the species composition of the invertebrate faunas may be different in shaded and unshaded reaches even along one stream (Figure 73). Where weed beds are present, species of invertebrates that graze on epiphytic algae and diatoms become more abundant and frequent. Furthermore, the streams with open lawns in their catchments also contain more fish species (Langford 2000). Heavily wooded streams contain up to six species (see Table 40), but more open streams can contain 15–16 species, with coarse fish such as chub *Leusicus cephalus*, roach *Rutilus rutilus* and three-spined sticklebacks *Gasterosteus aculeatus* being present and sometimes abundant where shade is absent. The influence of shade is therefore one of the primary features, along with water chemistry, determining the composition of the ecosystem along the streams and can cause both physical and biological discontinuities even at the reach and stream scale.

Table 41
Numbers of species of invertebrates recorded from New Forest streams compared with the numbers in the UK faunal records of established or indigenous species. Data from the authors, RIVPACS lists and Maitland (1977). Numbers of records to 31 July 2008 from known sources. Other records may exist from unknown sources.

Major taxa	Number of spp. in UK	Number of spp. in New Forest	% of UK spp. found in New Forest
Flatworms			
Turbellara/Tricladida	11	4	**36**
Molluscs			
Gastropoda	52	18	35
Bivalvia	27	9	33
Worms and leeches			
Oligochaeta	118	21	18
Hirudinea	14	5	36
Insects			
Ephemoptera	49	20	43
Plecoptera	34	16	47
Odonata	45	8	18
Hemiptera	62	7	11
Coleoptera	300	34	11
Megaloptera	3	2	67
Neuroptera	4	1	25
Trichoptera	193	49	25
Diptera	1,138	72	7
Crustaceans			
Malacostraca	33	5	15
Water mites			
Hydacarina	322	11	3
Vertebrates			
Agnatha (lampreys)	3	1	33
Teleosti	55	22	40

New Forest streams in a wider context

There are relatively few published spatial studies of the macro-fauna of specific regional or areal stream systems in Britain, despite the long series of routine surveys carried out by statutory authorities over more than 50 years (Langford and Bray 1969, Hildrew 2009). In comparison with national records (Wright *et al.* 2000), the streams of the New Forest contain a good proportion of macro-invertebrate and fish species recorded in Britain (Table 41). The numbers of stonefly and mayfly species were similar to the nearby Moors River in Dorset, which is fed by both chalk and heathland streams (Table 42), even though the number of sites sampled differed markedly. In comparison with a single clean reach of a large lowland river, the Severn near Ironbridge (Langford 1975), there were twice as many species of stoneflies in the Forest streams (24/12) but about the same number of mayfly species (24/23). In a survey of three Wessex chalk and limestone lowland stream systems, 18 species of mayflies and only four species of stoneflies were recorded (Langford *et al.* 2000). The stonefly fauna is more diverse than in nearby chalk streams, but is similar to those of upland streams in other parts of the UK and to streams of the Ashdown Forest to the east (see Langford 1996 for

Table 42
Comparison of species richness of Plecoptera (Stoneflies) and Ephemeroptera (Mayflies) between selected stream systems. (Full references for the datasets are given in Langford 1996). Data for the Wessex streams are from Langford *et al*. (2000).

Area of survey	Scale of survey	Numbers of species		
		No. sites	Plecoptera	Ephemoptera
New Forest	22 streams	108	16	20
Moors River	Single catchment	28	11	21
North Lincolnshire	24 streams / rivers	50	8	17
Scotland	50 streams/rivers	50	18	17
Ashdown Forest	Riffle sites only	34	13	12
Cow Green Streams	Single catchment	8	23	20
Wessex streams	3 rivers (calcareous)	44	4	18

references), which is also drained by circum-neutral or slightly acidic water.

The abundance of more calciphile taxa such as gammarids or molluscs is much lower in New Forest streams than in chalk streams (Langford 1996, Langford *et al.* 2000). Although the chalk streams of the southern lowlands are commonly perceived as having high biological-diversity, taxon richness at family level at any one site may not be universally greater than in the Forest streams. For example, in the fully shaded Highland Water, standard sampling by the same operator collected between 10 and 30 families. In the partly unshaded Ober Water, the range was 9–36 families, whereas in the Ironbridge reach of the Severn 16–21 families were recorded, and in three Wessex stream systems values were obtained of 18–31 families per sample. The overall abundance of macro-invertebrates is typically lower than in chalk streams and total numbers of individuals per sample varied from 31 to 207 in the Highland Water and from 48 to 2,043 in the Ober Water compared with 262–2,394 in the Wessex chalk streams. The unusually high numbers in the Ober Water were a result of large populations of the small Jenkins' spire shell snail *Potamopyrgus antpodarum* among beds of Nuttall's waterweed at one or two sites (Langford, unpublished data).

Future management and research

The streams of the New Forest have been managed and modified over centuries, either directly through deepening or straightening for drainage or indirectly through the modification of their catchments. The clearance of trees to create open lawns has obviously resulted in changes in both the diversity and composition of the flora and fauna. It is likely that the natural condition of the streams prior to human intervention was not very different from the wooded streams of today, although unshaded areas would exist as a result of natural tree fall or fires. These would typically have been smaller than the open areas of grazing lawns that exist today.

Since 1996, there have been considerable changes in the management of the streams. Woody debris is now retained to encourage overbank flow (e.g. Millington and Sear 2007), trees have been thinned along many stream margins and physical modifications to stream channels in upper and middle reaches have been made to combine potential flood mitigation with the long-term recovery of alluvial floodplain forest and riparian habitats. It was also intended that the reconnection of old meanders and the raising of the stream bed as part of the EU funded LIFE 3 project (see Chapter 17) might provide increased physical diversity in channels, although the rarer invertebrate species were actually found in the unconnected meanders (Thomas 2006). Initial reductions of the stream fauna were caused by the physical alteration of the streams and by displaced silt (Langford 2006). There is now strong evidence of recovery and recolonisation in most reaches (Thomas 2006), although overall biological diversity is unlikely to change from the pre-modification state, being mainly controlled by water chemistry and shade. Tree clearances in some reaches have caused elevated water temperatures and invasion of in-stream plants where none existed previously.

Management of the streams will continue as part of the overall management of the New Forest, especially where this might encourage conservation or restoration of natural or rarer habitats and species. A comprehensive account of the New Forest wetlands shows that there are wide-ranging proposals for future management and conservation of the stream systems (Smith 2006). It is hoped that the management will take into account the unique nature of the drainage system as stated at the beginning of this Chapter.

The streams are the centre of continuing ecological research. Major programmes are focused on the ecological effects of shade, particularly in view of the potential effects of climate change. Forest Research and the University of Southampton are currently studying the effects of shade on water temperatures, invertebrates and fish. Longer-term monitoring of the ecological and geomorphological recovery of the restored reaches of the Highland Water is also in progress, and analysis of the effects of woody debris on fish assemblages is continuing, based at Southampton University.

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Appendix
Macro-invertebrates identified from New Forest streams 1977–2007.

No asterisk: FBA/IFE/CEH lists for RIVPACS database.
* T.E.L. Langford personal records. *** Environment Agency surveys (mainly Thomas 2006). + denotes "group" followed in parentheses by species difficult to distinguish that are included in the group. Species in some Dipteran "groups" have not been listed to save space. For details of these groups see Murray-Bligh (1997).

Caenis pseudorivulorum Kieffermuller and *Caenis beskidensis* Sowa are both new to Britain and though not identified in the New Forest, are included in the *Caenis rivulorum* group. **RDB** = species listed in Red Data Books under various headings (see text).

*Rivers and stream surveyed for fish, plants and invertebrates were Lymington River, The Weirs, Ober Water, Highland Water, Bratley Water, Blackwater, Blackensford Brook, Avon Water, Beaulieu River, Cadnam River, Bratley Water, Mill Stream (Lyndhurst), Darkwater, Plummers Water, Crockford Stream, Hatchet Pond outlet stream, Dockens Water, Linford Brook, Millersford Brook, Sopley Stream, Huckles/Latchmore Brook plus small feeders to the various streams not always shown on the 1:25,000 map. Different numbers of sites were used on the streams as a result of various projects and surveys.

TRICLADIDA (Flatworms)
Polycelis felina (Dalyell)
Polycelis nigra group+ (*P. nigra* Muller, *P. tenuis Ijima*)
Dugesia polychroa group+ *D. polychroa* (Schmidt), *D. lugubris* (Schmidt)
Dendrocoelum lacteum (Müller)*

GASTROPODA (Water snails)
Valvata piscinalis (Müller)
Potamopyrgus antipodarum (Gray)
Bithynia tentaculata (L.)
Physa fontinalis (L.)
Radix balthica (Müller)
Galba truncatula (Müller)
Omphiscola glabra (Müller)*** **RDB**
Radix auricularia (Linn.)*
Succinea putris Linnaeus*
Hippeutis complanatus (Linn.)***
Planorbis carinatus Müller
Tropodiscus planorbis (Linn.)*
Bathyomphalus contortus (L.)
Gyraulus albus (Müller)
Armiger crista (L.)
Ancylus fluviatilis Müller
Acroloxus lacustris (L.)
Zonitoides nitidus (Müller)

LAMELLIBRANCHIATA (Pea shells, freshwater mussels)
Sphaerium corneum (L)
Pisidium amnicum (Müller)
Pisidium casertanum (Poli)
Pisidium nitidum Jenyns
Pisidium hibernicum Westerlund
Pisidium milium Held
Pisidium personatum Malm
Pisidium subtruncatum Malm
Pisidium obtusale Lamarck ***

OLIGOCHAETA (Worms)
Stylodrilus heringianus Claparède
Lumbriculus group (Müller)+ (*L. variegatus* (Muller), *Rhynchelmis limnosella* (Hoffmeister))
Ophidonais serpentina Müller
Nais alpina Sperber
Nais pardalis Piguet
Nais communis group+ (*N. communis* Piguet, *N. variabilis* Piguet).
Stylaria lacustris (L.)
Slavina apendiculata (d'Udekem)
Pristina idrensis group
Tubifex tubifex (Müller)
Tubifex ignotus (Stole)
Limnodrilus claparedianus Ratzel
Limnodrilus hoffmeisteri Claparède

OLIGOCHAETA (Worms) ... continued
Psammoryctides barbatus (Grube)
Potamothrix hammoniensis (Michaelsen)
Spirosperma ferox (Eisen)
Aulodrilus pluriseta (Piguet)
Rhyacodrilus coccineus (Vejdovsky)
Rhyacodrilus falciformis Bretscher
Branchiura sowerbyi Beddard ****
Eiseniella tetraedra (Savigny)*

HIRUDINEA (Leeches)
Piscicola geometra (Linnaeus 1761)*
Hemiclepsis marginata (Muller)
Glossiphonia complanata (L.)
Helobdella stagnalis (L.)
Erpobdella octoculata (L.)

HYDRACARINA (Water mites)
Sperchon clupeifer Piersig
Sperchon setiger Thor
Teutonia cometes (Koch)
Lebertia (Pilolebertia) inaequalis (Koch)
Lebertia (Pilolebertia) insignis Newman
Lebertia (Pilolebertia) porosa Thor
Hygrobates fluvialtilis (Stroud)
Hygrobates longipalpis (Herman)
Hygrobates nigromaculatus Lebert
Atractides nodipalpis (Thor)
Nautarachna crassa (Koenike)

CRUSTACEA (Shrimps and slaters)
Asellus aquaticus (L.)
Proasellus meridianus Racowitza
Crangonyx pseudogracilis Bousfield
Gammarus pulex (L.)
Niphargus aquilex Schiodte **RDB**

EPEHEMEROPTERA (Mayflies)
Baetis fuscatus (Linnaeus)*
Alainites muticus (L.)
Nigrobaetis niger (L.)
Baetis rhodani (Pictet)
Baetis vernus Curtis
Baetis scambus group+ (*B. scambus* Eaton, *B. fuscatus* (L.))
Centroptilum luteolum (Muller)
Cloeon dipterum (L.)
Procloeon bifidum Bengtsson
Rhithrogena semicolorata (Curtis)
Heptagenia sulphurea (Müller)
Ecdyonurus torrentis Kimmins*
Leptophlebia marginata (L.)
Paraleptophlebia cincta (Retzius)
Paraleptophlebia submarginata (Stephens)

EPEHEMEROPTERA (Mayflies) ... continued
Habrophlebia fusca (Curtis)
Ephemera danica Müller
Serratella ignita Poda
Caenis rivulorum Eaton
Caenis luctuosa group + (*C. luctosa* Burmeister, *C. macrura* Stephens, *C. pusilla* Navás)

PLECOPTERA (Stoneflies)
Brachyptera risi (Morton)
Taeniopteryx nebulosa (Linn.) (Aubert 1950)*
Amphinemura standfussi Ris
Amphinemura sulcicollis (Stephens)
Nemurella picteti Klapálek**
Nemoura avicularis Morton
Nemoura cinerea (Retzius)
Nemoura cambrica group+ (*N. cambrica* (Stephens), *N. erratica* Claassen))
Leuctra fusca (L.)
Leuctra geniculata (Stephens)
Leuctra hippopus (Kempay)
Leuctra nigra (Olivier)
Leuctra moselyi Morton *?**
Capnia bifrons (Newman) **RDB**
Isoperla grammatica (Poda)
Siphonoperla torrentium (Pictet)

ODONATA (Damselflies and dragonflies)
Pyrrhosoma nymphula (Sulzer)
Coenagrion puella group + (*C. puella* (L.), *C. pulchellum* (Van der Linden))
Calopteryx splendens (Harris)
Calopteryx virgo (L.)
Cordulegaster boltoni (Donovan)
Aeshna mixta group+ (*A. mixta* Latreille, *A. cynea* Müller)
Aeshna cyanea (Müller)*
Orthetrum coerulesens (Fabricius)*

HEMIPTERA (Water boatmen and pond skaters)
Hydrometra stagnorum (L.)
Velia (Mesovelia) caprai Tamanini
Gerris lacustris (L.)
Aquarius najas (DeGeer)
Hesperocorixa sahlbergi (Fieber)
Sigara (Subsigara) falleni (Fieber)
Sigara limitata Fieber***

COLEOPTERA (Beetles)
Laccophilus minutus (L)
Hydroporus pubescens (Gyllenhal)
Brychius elevatus Panzer
Haliplus lineatocollis (Marsham)
Haliplus flavicollis (Sturm)*
Haliplus ruficollis (DeGeer) ***
Porhydrus lineatus (Fabricius)*
Graptodytes pictus (Fabricius)
Deronectes latus (Stephens)
Nebrioporus depressus/elegans (Panzer)
Stictotarsus duodecimpustulatus (Fabricius)
Platambus maculatus (L.)
Gyrinus natator group+ (*G. natator* (L.), *G. substriatus* Stephens)
Gyrinus urinator Illiger*
Orectochilus villosus (Müller)
Hydrochus angustatus Germar
Helophorus (Trichohelophorus) brevipalpis Bedel
Helophorus flavipes Fabricius
Helophorus obscurus Mulsant
Helophorus arvernicus Mulsant*
Paracymus scutellaris (Rosenhauer)

COLEOPTERA (Beetles) ... continued
Anacaena globulus (Paykul)
Anacaena lutescens Stephens
Hydraena gracilis Germar
Hydraena riparia Kugelann
Hydraena testacea Curtis
Hydraena nigrita Germar *** **RDB**
Hydraena rufipes Curtis
Ochthebius auriculatus Rey*
Limnebius truncatellus (Thunberg)
Hydrocyphon deflexicollis (Müller)
Dryops luridus (Erichson)
Elmis aenae (Müller)
Limnius volckmari (Panzer)
Oulimnius tuberculatus (Muller)

COLLEMBOLA (Springtails)
Podura aquatica Linnaeus

LEPIDOPTERA (Moths)
Elophila nymphaeata (L.)

NEUROPTERA (Alder flies)
Sialis lutaria (L.)
Sialis fuliginosa Pictet
Sisyra fuscata (Fabricius) ***

TRICHOPTERA (Caddis flies)
Agapetus fuscipes (Curtis 1834)*
Rhyacophila dorsalis (Curtis)
Hydroptila sp.
Oxyethira sp.
Ithytrychia sp.
Lype phaeopha (Stephens)*
Lype reducta (Hagen) ***
Tinodes waeneri (L.)
Cyrnus trimaculatus (Curtis)
Plectrocnemia conspersa (Curtis)
Plectrocnemia geniculata McLachlan*
Polycentropus flavomaculatus (Pictet)
Polycentropus irroratus (Curtis)
Polycentropus kingi McLachlan
Hydropsyche angustipennis (Curtis)
Hydropsyche silalai Döhler
Hydropsyche pellucidula (Curtis)
Lepidostoma hirtum (Fabricius)
Chaetopteryx villosa (Fabricius)*
Halesus digitatus (Shrank)*
Halesus radiatus (Curtis)*
Melampophylax mucoreus (Hagen)
Anabolia nervosa (Curtis)
Glyphotaelius pellucidus (Retzius)
Limnephilus decipiens (Kolenati)
Limnephilus extricatus McLachlan
Limnephilus lunatus Curtis
Limnephilus rhombicus (L.)
Limnephilus flavicornis (Fabricius)*
Micropterna group+ (*M. sequax* McLachlan, *M. lateralis* (Stephens) *Stenophylax permistus* McLachlan, *S. vibex* (Curtis))
Potamophylax group+ (*P. rotundipennis* Brauer, *P. cingulatus* (Stephens), *P. latipennis* (Curtis), *Allogamus auricollis* Pictet, *Chaetopteryx villosa* (Fabricius))
Goera pilosa (Fabricius)
Silo nigricornis (Pictet)
Silo pallipes (Fabricius)
Berea maurus (Curtis)***
Beraeodes minutus (L.)
Notidobia ciliaris (L.)
Sericostoma personatum (Spence)