
# Vegetation communities of British rivers

## a revised classification

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# Chapter 5 Physical characteristics and macrophyte communities associated with each level of the classification

## 5.1 Rivers in Groups A–D

First, TWINSPAN divides sites into broadly similar classes – Groups A, B, C and D. Briefly, sites with floral communities dominated by species that are typical of eutrophic lowland rivers are placed in Group A. Sites with floras typical of torrent rivers and oligotrophic waters are placed in Group D. Intermediate sites are placed into Groups B and C. Some species are more or less confined to one or other extreme of the spectrum, whilst many more are found in two or more groups, forming a continuum.

The original classification indicated that factors such as geology, channel gradient and altitude were strongly associated with different community types.

The distribution of Groups A–D in the new classification is also closely related to the same physical factors. This is clearly illustrated in Table 2, which summarises the geology, altitude, slope, substrate, flow type, width and depth of rivers in the four groups. Annex A gives details of site locations, physical features and macrophytes for each of the four groups.

Table 2 shows that from Group A to Group D there is a clear transition in terms of the altitude of sites surveyed and the altitudinal sources of the rivers. Around 85% of rivers in Group A rise at altitudes below 200 m, whereas for Group D only around 15% rise at this height; Group B is intermediate, but Group C sites have higher sources, as in Group D. There is a clear gradation of mean altitude of sites: Group B rivers are 50% higher than those in Group A, Group C rivers are 40% higher than those in Group B, and Group D rivers are 30% higher than those in Group C.

Geology is clearly a major factor in differentiating between the four groups. In Group A, calcareous clay (>29% of sites), chalk (>23%), non-calcareous clay, other soft limestones, alluvium and soft sandstone substrates predominate. In Group B, hard sandstone and soft sandstone (both >20% of sites) dominate, with hard limestone (>15%), non-calcareous shale and calcareous shales also prominent. For Group C, non-calcareous shales (>30%) are the most common substrate, with hard sandstones and hard limestones also exceeding 10%; however, a very wide range of other rock types also occur. For Group D, granite, base-rich and other igneous rocks, other metamorphic rocks and schists are all prevalent, occurring elsewhere only rarely in Group C.

Rivers in Group B were described in the original classification as characteristically having substrates of hard limestone and sandstone (including mudstone, coal measures and others); the same is evident in the revised system. Clear differences are also seen between the groups in terms of altitude and gradient. Low gradient rivers are most common in Group A, whilst steep gradient rivers prevail in Group D. Group B has a higher proportion of sites with shallow gradients than Group C, which has more sites with steep gradients than Group B.

Of the most commonly occurring taxa (Table 3) only four are represented in all groups: *Salix* spp., other trees, *Agrostis stolonifera* and *Filipendula ulmaria*. Apart from these ubiquitous plants, no common species of Group A has any affinity with Group D, and only the widespread *Phalaris arundinacea*, *Myosotis scorpioides* and *Mentha aquatica* have affinity with Group C. By contrast, seven species are common to both Group A and its nearest neighbour, Group B: *Veronica beccabunga*, *Solanura dulcamara*, *Epilobium hirsutum*, *Sparganium erectum*, *Elodea canadensis*, *Cladophora glomerata* and the algae *Vaucheria* spp.

Table 3 lists 16 taxa that are strongly associated only with Group A communities. They are all vascular plants, some submerged (e.g. *Sparganium emersum*, *Callitriche stagnalis*), some floating (e.g. *Lemna minor*, *Nuphar lutea*), some emergent (e.g. *Veronica anagallis-aquatica*, *Rorippa nasturtium-aquaticum*) and many bankside species (e.g. *Glyceria maxima*, *Lythrum salicaria*, *Carex riparia*). No bryophytes occur commonly in Group A, the only commonly-occurring non-vascular plants being the algae *Vaucheria* and *Cladophora*.

Of the less common species not listed in Table 3, some are more or less confined to Group A. *Sagittaria sagittifolia* and *Schoenoplectus lacustris* occur at least 50 times more often in Group A than in Group B, and *Berula erecta*, *Dipsacus fullonum* and *Phragmites australis* occur at least ten times more commonly.

In contrast, in Group B there are only four species (the alga *Hildenbrandia rivularis*, *Oenanthe crocata* and the mosses *Amblystegium riparium* and *Brachythecium rutabulum*) that are uniquely associated with this group, compared with 16 for Group A (Table 3). Species that commonly occur in both Group A and Group B are

**Table 2** Physical characteristics of sites in Groups A–D

| *Group* | *A* | *B* | *C* | *D* |
|---|---|---|---|---|
| *Number of taxa* | | | | |
| Mean | 38 | 38 | 37 | 31 |
| Minimum | 4 | 6 | 6 | 1 |
| Maximum | 67 | 63 | 70 | 66 |
| *Geology (% occurrence (>10%) at sites)* | | | | |
| Calcareous clay | 29 | | | |
| Non-calcareous clay | 13 | | | |
| Chalk | 22 | | | |
| Other soft limestone | | | | |
| Hard limestone | | 17 | 14 | 10 |
| Soft sandstone | 12 | 24 | | |
| Hard sandstone | | 23 | 17 | 16 |
| Calcareous shale | | | | |
| Non-calcareous shale | | | 30 | 10 |
| Hard rock | | | | 50 |
| *Height at source (m)* | | | | |
| Mean | 138 | 376 | 467 | 442 |
| Minimum | 10 | 30 | 20 | 10 |
| Maximum | 700 | 761 | 1,210 | 1,210 |
| *Altitude of site (m)* | | | | |
| Mean | 49 | 74 | 125 | 160 |
| Minimum | 0 | 5 | 5 | 0 |
| Maximum | 213 | 250 | 425 | 750 |
| *Slope (km per 15 m fall)* | | | | |
| Mean | 15 | 8.6 | 4.9 | 2.7 |
| Minimum | 0.3 | 0.1 | 0.2 | 0.1 |
| Maximum | 25 | 25 | 25 | 25 |
| *Substrates (% occurrence at sites)* | | | | |
| Silt/mud | 44 | 11 | 8 | 13 |
| Sand | 20 | 11 | 8 | 8 |
| Clay | 41 | 6 | 2 | 2 |
| Gravel | 52 | 27 | 21 | 19 |
| Pebbles | 17 | 47 | 42 | 36 |
| Cobbles | 4 | 52 | 63 | 60 |
| Boulders | 0.4 | 26 | 45 | 56 |
| Bedrock | 0.2 | 9 | 19 | 33 |
| *Habitats (% occurrence at sites)* | | | | |
| Pools | 5 | 9 | 5 | 13 |
| Slacks | 89 | 84 | 67 | 46 |
| Riffles | 5 | 10 | 14 | 42 |
| Runs | 40 | 68 | 71 | 49 |
| Rapids | 0.8 | 8 | 35 | 49 |
| *Width (m) (% occurrence at sites)* | | | | |
| <5 | 33 | 24 | 28 | 50 |
| 5–10 | 38 | 30 | 42 | 41 |
| >10–20 | 36 | 38 | 37 | 29 |
| >20 | 15 | 32 | 24 | 17 |
| *Depth (m) (% occurrence at sites)* | | | | |
| <0.25 | 45 | 75 | 80 | 73 |
| 0.25–0.5 | 49 | 52 | 42 | 52 |
| >0.5–1 | 29 | 8 | 9 | 24 |
| >1 | 30 | 15 | 11 | 11 |

*Veronica beccabunga, Epilobium hirsutum, Sparganium erectum*, and *Vaucheria* and *Cladophora*. Six taxa are common to both Groups B and C: the mosses *Rhynchostegium riparioides* and *Amblystegium fluviatile*, the freshwater lichens *Verrucaria* spp., the liverwort *Conocephalum conicum, Equisetum arvense* and the alga *Lemanea fluviatilis*.

Other species typical of Group B but not listed in Table 3 include other algae *Lemanea* spp., *Cladophora aegagropila*, the liverwort *Chiloscyphus polyanthos* and the mosses *Brachythecium rivulare, Fontinalis squamosa* and *Thamnobryum alopecurum*, which all occur at least ten times more often in Group B than in Group A, whilst *Myriophyllum alterniflorum* occurs at least 50 times more often.

Group B communities therefore frequently consist of a mixture of vascular and non-vascular plants, typically having some of the most widespread species of Group A present alongside the more widespread species of Group C.

Group C communities have very little affinity with those in Group A, with only the most widespread species of Group A present. Conversely, Group C often contains many species associated with the mesotrophic and upland extreme of Group B and with the low gradient sites in oligotrophic Group D.

Table 3 shows that just six taxa are uniquely associated with Group C communities. They are the liverwort *Chiloscyphus polyanthos*, the mosses *Fontinalis squamosa, Hygrohypnum ochraceum, Brachythecium rivulare* and *Schistidium alpicola* and *Angelica sylvestris* (all but the last named being bryophytes). Another six occur commonly across the Group B, C and D range, with species including the moss *Fontinalis antipyretica, Juncus effusus, Juncus acutiflorus, Glyceria fluitans* and *Caltha palustris*. Species such as the liverwort *Pellia epiphylla, Ranunculus flammula, Deschampsia cespitosa* and *Sagina procumbens* are typically found in both Groups C and D but only rarely elsewhere.

No submerged species that are typical of Group A are commonly found in Group C, but edge species such as *Phalaris arundinacea, Mentha aquatica, Filipendula ulmaria* and trees do span the range. Communities therefore reflect meso-oligotrophic conditions, with a marked prevalence of bryophytes as the main river-channel species.

Fifteen taxa are uniquely associated with Group D, compared with six taxa for Group C, four for Group B and 16 for Group A. Whilst Group A is dominated by vascular plants, including many true aquatics of eutrophic waters, Group D is dominated by bryophytes and oligotrophic moorland edge species. The most commonly occurring bryophytes in Group D are the mosses *Racomitrium aciculare, Scapania undulata, Sphagnum* spp., *Polytrichum commune* and *Bryum pseudotriquetrum*, whilst the common moorland edge species include those such as the liverwort *Nardia compressa* and *Molinia caerulea*. The most common true aquatic vascular plant is the oligotrophic indicator species *Juncus bulbosus*.

Acidophilic and oligotrophic species typify Group D communities. Species such as *Polytrichum commune, Sphagnum* spp. and *Carex nigra* occur at least ten times

**Table 3** Percentage frequency of occurrence of the 30 most common taxa in each Group (A–D)

| | Group | | | | | Group | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Taxon* | *A* | *B* | *C* | *D* | *Taxon* | *A* | *B* | *C* | *D* |
| *Apium nodiflorum* | 73 | | | | *Amblystegium fluviatile* | | 65 | 54 | |
| *Scrophularia auriculata* | 72 | | | | *Conocephalum conicum* | | 64 | 53 | |
| *Rorippa nasturtium-aquaticum* | 78 | | | | *Equisetum arvense* | | 58 | 49 | |
| *Glyceria maxima* | 64 | | | | *Lemanea fluviatilis* | | 48 | 54 | |
| *Callitriche stagnalis* | 61 | | | | *Fontinalis antipyretica* | | 87 | 80 | 46 |
| *Sparganium emersum* | 59 | | | | *Juncus acutiflorus* | | 68 | 74 | 59 |
| *Juncus inflexus* | 58 | | | | *Glyceria fluitans* | | 57 | 68 | 49 |
| *Lemna minor* | 55 | | | | *Juncus effusus* | | 55 | 71 | 83 |
| *Lythrum salicaria* | 54 | | | | Filamentous green algae | | 52 | 76 | 71 |
| *Polygonum amphibium* | 51 | | | | *Caltha palustris* | | 51 | 66 | 47 |
| *Lycopus europaeus* | 51 | | | | *Chiloscyphus polyanthos* | | | 68 | |
| *Carex riparia* | 50 | | | | *Fontinalis squamosa* | | | 57 | |
| *Veronica anagallis-aquatica* | 47 | | | | *Hygrohypnum ochraceum* | | | 56 | |
| *Symphytum officinale* | 47 | | | | *Angelica sylvestris* | | | 50 | |
| *Nuphar lutea* | 47 | | | | *Brachythecium rivulare* | | | 49 | |
| *Carex acutiformis* | 47 | | | | *Schistidium alpicola* | | | 48 | |
| *Veronica beccabunga* | 81 | 63 | | | *Pellia epiphylla* | | | 67 | 83 |
| *Solanum dulcamara* | 84 | 59 | | | *Ranunculus flammula* | | | 58 | 74 |
| *Epilobium hirsutum* | 92 | 65 | | | Ferns | | | 54 | 57 |
| *Sparganium erectum* | 91 | 77 | | | *Deschampsia cespitosa* | | | 51 | 51 |
| *Cladophora glomerata* agg. | 69 | 77 | | | *Sagina procumbens* | | | 46 | 41 |
| *Vaucheria* sp(p). | 68 | 62 | | | *Juncus bulbosus* | | | | 78 |
| *Elodea canadensis* | 54 | 47 | | | *Racomitrium aciculare* | | | | 72 |
| *Phalaris arundinacea* | 97 | 94 | 73 | | *Anthoxanthum odoratum* | | | | 70 |
| *Myosotis scorpioides* | 93 | 78 | 60 | | *Carex nigra* | | | | 60 |
| *Mentha aquatica* | 83 | 84 | 68 | | *Potentilla erecta* | | | | 59 |
| *Hildenbrandia rivularis* | | 56 | | | *Sphagnum* sp(p). | | | | 59 |
| *Oenanthe crocata* | | 53 | | | *Scapania undulata* | | | | 58 |
| *Amblystegium riparium* | | 52 | | | *Viola palustris* | | | | 57 |
| *Brachythecium rutabulum* | | 47 | | | *Molinia caerulea* | | | | 54 |
| *Agrostis stolonifera* | 96 | 98 | 95 | 59 | *Polytrichum commune* | | | | 54 |
| *Salix* sp(p). | 84 | 86 | 84 | 61 | *Nardus stricta* | | | | 47 |
| Trees | 78 | 89 | 83 | 53 | *Galium palustre* | | | | 45 |
| *Filipendula ulmaria* | 66 | 68 | 67 | 41 | *Carex demissa* | | | | 43 |
| *Rhynchostegium riparioides* | | 89 | 85 | | *Achillea ptarmica* | | | | 41 |
| *Verrucaria* sp(p). | | 80 | 71 | | *Bryum pseudotriquetrum* | | | | 38 |

more often in Group D than in Group C, whilst the liverwort *Marsupella emarginata*, the mosses *Blindia acuta* and *Dicranella palustris*, *Potentilla erecta*, *Nardus stricta* and *Potamogeton polygonifolius* occur at least five times more often.

Clearly, therefore, there is a transition of community structure from the vascular plant-dominated assemblages of Group A (which indicate eutrophic conditions) to the mixed moorland edge and bryophyte-dominated instream assemblages of Group D (which indicate oligotrophy). Of the 172 taxa listed in Table 3, over half are shown to be strongly associated with just one of the four groups. However, there is a continuum of distribution of species within the groups, so allocation of a site to a group is not clear-cut.

# 5.2 Rivers in types I–X

Types I–X are the groupings that are used most widely for the initial classification, comparison and assessment of the conservation value of a site. Table 4 summarises the new descriptions of types I–X, which should now be used in place of those in the *Guidelines for selection of biological SSSIs* (NCC 1989; rev. ed. Joint Nature Conservation Committee 1998). They are not markedly different in essence but they do reflect the more comprehensive geographical coverage provided by the most recent classification. Table 5 summarises the physical characteristics of sites in Groups A–D and Table 6 shows the 30 most common taxa in each group. The nearest neighbour (NN) for each type within the classification is shown to enable easy comparison.

## Type I Lowland, low-gradient rivers (NN type II)

Rivers of this type are characterised by the lowest mean altitude and shallowest gradient of all the ten river community types. There is also a greater prevalence of silt substrates and the highest proportion of deep, wide and slack rivers. As would be expected from these statistics, the geology is soft, predominantly clay and chalk. Such rivers are typically located in south-east England and East Anglia. The most typical rivers are the Salisbury Avon, the Colne and the lower Wissey, Lark, Nar, Wensum and Bure. Vascular plants totally dominate the communities, with *Cladophora glomerata* and *Vaucheria* sp(p). the only commonly occurring non-flowering plants. Of the commonly occurring aquatic species, *Carex riparia*, *Sparganium emersum*, *Potamogeton pectinatus* and *Sagittaria sagittifolia* are much more likely to be found in type I, whilst among the less common species *Pulicaria dysenterica*, *Berula erecta*, *Eupatorium cannabinum*, *Oenanthe fluviatilis*, *Iris pseudacorus* and *Phragmites australis* occur in at least three times as many type I as type II sites.

## Type II Lowland, clay-dominated rivers (NN type I)

Clay is the dominant geology, but, unlike in type I, soft sandstone and oolites and soft limestone are common and chalk is absent. The geographical spread of sites is much greater than in type I, the lowlands of the Cheshire Plain being the most significant outlier away from central and South-east England. A wide variety exists in terms of river widths, depths and habitats, with very gentle gradients and site altitudes invariably below 40 m, and clay is more typically a substrate than in any other type. Rivers that have the majority of their sites in this type include the Nottinghamshire river Devon and the Welland, Cherwell, Tame and Evenlode. The gross make-up of the assemblage is very similar to type I, but with greater variety, so any particular taxon is less likely to appear in type II than in type I. There are significantly more occurrences of the less common broad-leaved pondweed *Potamogeton natans* and *Juncus acutiflorus*, whilst amongst the more common taxa *Salix* sp(p)., *Cladophora glomerata* and *Vaucheria* sp(p). are slightly more prevalent.

## Type III Chalk rivers and other base-rich rivers with stable flows (NN type IV)

Only base-rich geology is represented in this type. Over 60% of rivers in this type are in chalk, more than double the proportion of chalk rivers found in type I. A stable flow regime resulting from a substantial base-flow is the most common feature shared by the vast majority of sites in type III. Gravel is significantly more prevalent in this type than in any other Group A type. Rivers that best exemplify the type are those flowing from the Chalk (e.g. Piddle, Frome, Test, Itchen, Mimram, Hull and headwaters of many East Anglian rivers) and those on

Table 4 Classification of river community types found in British rivers (revised from the version previously published in the Guidelines for selection of biological SSSIs (Nature Conservancy Council 1989; rev. ed. JNCC 1998))

| *Group* | *Type* | *General description* |
|---|---|---|
| A | I | Lowland rivers with minimal gradients. Predominantly in south and east England, but may occur wherever substrates are soft and chemistry enriched. |
| A | II | Rivers flowing in catchments dominated by clay. |
| A | III | Rivers flowing in catchments dominated by soft limestone such as chalk and oolite. |
| A | IV | Rivers with impoverished floras, usually confined to lowlands and mainly in England. |
| B | V | Rivers of sandstone, mudstone and hard limestone catchments in England and Wales, with similar features to those of type VI. |
| B | VI | Rivers predominantly in Scotland and northern England in catchments dominated by sandstone, mudstone and hard limestone; substrates usually mixed coarse gravels, sands and silts mixed with cobbles and boulders. |
| C | VII | Mesotrophic rivers where fine sediments occur with boulders and cobbles, so a mix of bryophytes and higher plants is typical: often downstream of type VIII communities. |
| C | VIII | Oligo-mesotrophic, fast-flowing rivers where boulders are common and bryophytes typify the plant assemblages; intermediate, and often found between types IX and VII. |
| D | IX | Oligotrophic rivers of mountains and moorlands where nutrient and base levels are low; bedrock, boulders and coarse substrates dominate. |
| D | X | Ultra-oligotrophic rivers in mountains, or streams flowing off acid sands; substrates similar to type IX but often more bedrock. |

**Table 5** Physical characteristics of sites in types I–X

| | Type | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *I* | *II* | *III* | *IV* | *V* | *VI* | *VII* | *VIII* | *IX* | *X* |
| *Number of taxa* | | | | | | | | | | |
| Mean | 46 | 38 | 42 | 29 | 35 | 40 | 31 | 39 | 31 | 31 |
| Minimum | 29 | 10 | 12 | 4 | 9 | 6 | 6 | 7 | 3 | 1 |
| Maximum | 67 | 61 | 60 | 50 | 63 | 60 | 55 | 70 | 62 | 66 |
| *Geology (% occurrence (>10%) at sites)* | | | | | | | | | | |
| Calcareous clay | 36 | 34 | 12 | 29 | | | | | | |
| Non-calcareous clay | 22 | 14 | | 12 | | | | | | |
| Chalk | 31 | | 62 | 10 | | | | | | |
| Other soft limestone | | 16 | 10 | | | | | | | |
| Hard limestone | | | | | 12 | 22 | 25 | 10 | 11 | |
| Soft sandstone | | 18 | | 18 | 19 | 28 | | | | |
| Hard sandstone | | | | | 34 | 11 | 20 | 16 | 16 | 16 |
| Calcareous shale | | | | | 11 | | | | | |
| Non-calcareous shale | | | | | | | 17 | 34 | | 13 |
| Hard rock | | | | | | | | | 45 | 29 |
| *Height at source (m)* | | | | | | | | | | |
| Mean | 108 | 158 | 111 | 158 | 303 | 447 | 373 | 496 | 306 | 496 |
| Minimum | 25 | 25 | 25 | 10 | 30 | 61 | 20 | 100 | 10 | 100 |
| Maximum | 229 | 640 | 229 | 700 | 655 | 761 | 810 | 1,210 | 950 | 1,210 |
| *Altitude of site (m)* | | | | | | | | | | |
| Mean | 38 | 47 | 54 | 58 | 75 | 72 | 125 | 125 | 76 | 193 |
| Minimum | 0 | 10 | 15 | 5 | 5 | 5 | 5 | 10 | 0 | 5 |
| Maximum | 200 | 200 | 168 | 213 | 244 | 250 | 725 | 425 | 725 | 750 |
| *Slope (km per 15 m fall)* | | | | | | | | | | |
| Mean | 20 | 19 | 11 | 9.8 | 6.6 | 10.5 | 6.1 | 4.5 | 4.7 | 1.9 |
| Minimum | 2.3 | 4.2 | 2.0 | 0.3 | 0.1 | 0.9 | 0.5 | 0.2 | 0.1 | 0.1 |
| Maximum | >25 | >25 | >25 | >25 | >25 | >25 | >25 | >25 | >25 | >25 |
| *Substrates (% occurrence at sites)* | | | | | | | | | | |
| Silt/mud | 54 | 39 | 48 | 39 | 11 | 11 | 26 | 2 | 39 | 2 |
| Sand | 14 | 20 | 23 | 21 | 7 | 15 | 20 | 4 | 23 | 2 |
| Clay | 49 | 57 | 18 | 28 | 9 | 4 | 5 | 0.4 | 6 | 0.4 |
| Gravel | 44 | 42 | 80 | 52 | 31 | 24 | 40 | 16 | 26 | 17 |
| Pebbles | 20 | 14 | 14 | 19 | 48 | 47 | 46 | 40 | 34 | 37 |
| Cobbles | 3 | 5 | 4 | 4 | 48 | 57 | 49 | 67 | 36 | 70 |
| Boulders | 0 | 0 | 0 | 2 | 22 | 31 | 22 | 52 | 31 | 65 |
| Bedrock | 0 | 0 | 0 | 1 | 8 | 10 | 12 | 21 | 17 | 39 |
| *Habitats (% occurrence at sites)* | | | | | | | | | | |
| Pools | 3 | 8 | 4 | 4 | 10 | 8 | 8 | 5 | 27 | 8 |
| Slacks | 94 | 93 | 90 | 77 | 86 | 83 | 57 | 70 | 62 | 40 |
| Riffles | 1 | 5 | 2 | 12 | 14 | 7 | 30 | 9 | 43 | 41 |
| Runs | 29 | 32 | 56 | 49 | 65 | 71 | 59 | 74 | 40 | 53 |
| Rapids | 1 | 0 | 1 | 2 | 8 | 9 | 9 | 43 | 26 | 58 |
| *Width (m) (% occurrence at sites)* | | | | | | | | | | |
| <5 | 7 | 24 | 27 | 71 | 36 | 13 | 41 | 24 | 50 | 50 |
| 5–10 | 13 | 51 | 46 | 33 | 37 | 23 | 38 | 43 | 34 | 43 |
| >10–20 | 56 | 42 | 39 | 8 | 37 | 38 | 26 | 40 | 31 | 28 |
| >20 | 37 | 11 | 12 | 5 | 17 | 47 | 18 | 26 | 20 | 15 |
| *Depth (m) (% occurrence at sites)* | | | | | | | | | | |
| <0.25 | 12 | 35 | 68 | 67 | 80 | 69 | 67 | 84 | 59 | 79 |
| 0.25–0.5 | 35 | 49 | 66 | 47 | 54 | 50 | 37 | 44 | 54 | 50 |
| >0.5–1 | 41 | 34 | 21 | 19 | 10 | 6 | 20 | 6 | 36 | 19 |
| >1 | 55 | 36 | 17 | 13 | 8 | 22 | 21 | 8 | 23 | 6 |

**Table 6** Percentage frequency of occurrence of the 30 most common taxa in types I–X

| | *Type* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Taxon* | *I* | *II* | *III* | *IV* | *V* | *VI* | *VII* | *VIII* | *IX* | *X* |
| *Symphytum officinale* | 70 | | | | | | | | | |
| *Potamogeton pectinatus* | 85 | 68 | | | | | | | | |
| *Sagittaria sagittifolia* | 79 | 59 | | | | | | | | |
| *Nuphar lutea* | 75 | 70 | | | | | | | | |
| *Schoenoplectus lacustris* | 69 | 60 | | | | | | | | |
| *Glyceria maxima* | 90 | 66 | 78 | | | | | | | |
| *Carex riparia* | 88 | | 64 | | | | | | | |
| *Lycopus europaeus* | 77 | | 62 | | | | | | | |
| *Iris pseudacorus* | 75 | | 78 | | | | | | | |
| *Sparganium emersum* | 91 | 69 | | 32 | | | | | | |
| *Apium nodiflorum* | 91 | 59 | 89 | 66 | | | | | | |
| *Scrophularia auriculata* | 70 | 68 | 82 | 70 | | | | | | |
| *Juncus inflexus* | 69 | | 74 | 50 | | | | | | |
| *Eupatorium cannabinum* | 75 | | 72 | 34 | | | | | | |
| *Enteromorpha* sp(p). | | 67 | | | | | | | | |
| *Rorippa amphibia* | | 59 | | | | | | | | |
| *Lythrum salicaria* | | 56 | 67 | 35 | | | | | | |
| *Alisma plantago-aquatica* | | 52 | | 30 | | | | | | |
| *Carex acutiformis* | | | 89 | | | | | | | |
| *Callitriche obtusangula* | | | 87 | | | | | | | |
| *Ranunculus penicillatus* subsp. *pseudofluitans* | | | 86 | | | | | | | |
| *Veronica anagallis-aquatica* | | | 82 | | | | | | | |
| *Berula erecta* | | | 73 | | | | | | | |
| *Elodea canadensis* | 73 | 62 | | | | 64 | | | | |
| *Lemna minor* | 72 | 66 | | 31 | | | | | | |
| *Callitriche stagnalis* | 72 | 57 | 70 | 51 | | | 54 | | | |
| *Solanum dulcamara* | 93 | 82 | 90 | 76 | 74 | | | | | |
| *Vaucheria* sp(p). | 73 | 74 | 74 | 50 | 73 | 51 | | | | |
| *Cladophora glomerata* agg. | 74 | 80 | 61 | 55 | 72 | 83 | | | | |
| *Epilobium hirsutum* | 91 | 90 | 100 | 87 | 64 | 66 | | | | |
| *Sparganium erectum* | 95 | 92 | 96 | 82 | 71 | 83 | 47 | | | |
| *Veronica beccabunga* | 90 | 74 | 88 | 79 | 57 | 69 | 47 | | | |
| *Rorippa nasturtium-aquaticum* agg. | 89 | 71 | 88 | 71 | | | 38 | | | |
| *Phalaris arundinacea* | 100 | 98 | 98 | 92 | 89 | 99 | 80 | 71 | | |
| *Mentha aquatica* | 94 | 74 | 99 | 72 | 77 | 91 | 66 | 69 | | |
| *Myosotis scorpioides* | 96 | 92 | 97 | 90 | 62 | 93 | 70 | 57 | 44 | |
| *Agrostis stolonifera* | 98 | 97 | 91 | 98 | 98 | 99 | 93 | 96 | 64 | 58 |
| *Salix* sp(p). | 83 | 87 | 88 | 76 | 88 | 84 | 78 | 86 | 58 | 62 |
| Trees | 75 | 76 | 83 | 77 | 97 | 81 | 68 | 88 | 46 | 56 |
| *Polygonum amphibium* | | 68 | | 32 | | 55 | | | | |
| *Filipendula ulmaria* | | 54 | 88 | 68 | 67 | 69 | 71 | 66 | 56 | |
| *Juncus acutiflorus* | | | | | 63 | 72 | 58 | 79 | 47 | 64 |
| *Fontinalis antipyretica* | | | 67 | | 84 | 90 | 66 | 85 | 48 | 45 |
| *Juncus effusus* | | | | 62 | 49 | 60 | 82 | 68 | 88 | 81 |
| *Glyceria fluitans* | | | | 48 | 58 | 55 | 79 | 64 | 78 | |
| *Amblystegium riparium* | | | | 45 | 65 | | | | | |
| Filamentous green algae | | | | 44 | | 63 | 58 | 81 | 58 | 77 |
| *Angelica sylvestris* | | | | 41 | | | 61 | | 54 | |
| *Equisetum arvense* | | | | 31 | 47 | 69 | | 54 | | |
| *Rhynchostegium riparioides* | | | | | 92 | 87 | 57 | 94 | | |
| *Oenanthe crocata* | | | | | 74 | | | | | |
| *Pellia endiviifolia* | | | | | 60 | | | | | |
| *Lunularia cruciata* | | | | | 55 | | | | | |
| *Brachythecium rutabulum* | | | | | 46 | | | | | |
| *Hildenbrandia rivularis* | | | | | 49 | 63 | | | | |
| *Verrucaria* sp(p). | | | | | 77 | 82 | | 84 | | |
| *Conocephalum conicum* | | | | | 74 | 54 | | 65 | | |

**Table 6** *(continued)*

| | Type | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Taxon* | *I* | *II* | *III* | *IV* | *V* | *VI* | *VII* | *VIII* | *IX* | *X* |
| *Amblystegium fluviatile* | | | | | 61 | 69 | | 64 | | |
| *Chiloscyphus polyanthos* | | | | | 53 | | | 80 | | |
| *Mimulus guttatus* | | | | | | 73 | | | | |
| *Rorippa sylvestris* | | | | | | 52 | | | | |
| *Cinclidotus fontinaloides* | | | | | | 52 | | | | |
| *Caltha palustris* | | | | | | 66 | 71 | 64 | 70 | |
| *Deschampsia cespitosa* | | | | | | | 57 | 49 | 46 | 53 |
| *Ranunculus flammula* | | | | | | | 53 | 59 | 84 | 69 |
| *Pellia epiphylla* | | | | | | | 45 | 74 | 69 | 89 |
| *Stachys palustris* | | | | | | | 43 | | | |
| *Senecio aquaticus* | | | | | | | 38 | | | |
| *Callitriche hamulata* | | | | | | | 38 | | | |
| *Equisetum fluviatile* | | | | | | | 43 | | 63 | |
| *Galium palustre* | | | | | | | 42 | | 61 | |
| *Myriophyllum alterniflorum* | | | | | | | 41 | | 59 | |
| *Sagina procumbens* | | | | | | | 40 | | | 47 |
| Ferns | | | | | | | 37 | 60 | 54 | 58 |
| *Lemanea fluviatilis* | | | | | 45 | 50 | | 69 | | |
| *Hygrohypnum ochraceum* | | | | | | | | 68 | | |
| *Fontinalis squamosa* | | | | | | | | 68 | | |
| *Schistidium alpicola* | | | | | | | | 59 | | |
| *Brachythecium rivulare* | | | | | | | | 58 | | |
| *Thamnobryum alopecurum* | | | | | | | | 54 | | |
| *Scapania undulata* | | | | | | | | 56 | | 71 |
| *Juncus bulbosus* | | | | | | | | | 84 | 75 |
| *Carex nigra* | | | | | | | | | 76 | 54 |
| *Eleocharis palustris* | | | | | | | | | 58 | |
| *Juncus articulatus* | | | | | | | | | 57 | |
| *Carex rostrata* | | | | | | | | | 53 | |
| *Potamogeton polygonifolius* | | | | | | | | | 48 | |
| *Potamogeton natans* | | | | | | | | | 48 | |
| *Viola palustris* | | | | | | | | | 58 | 57 |
| *Molinia caerulea* | | | | | | | | | 50 | 56 |
| *Sphagnum* sp(p). | | | | | | | | | 50 | 63 |
| *Anthoxanthum odoratum* | | | | | | | | | 49 | 79 |
| *Racomitrium aciculare* | | | | | | | | | | 83 |
| *Potentilla erecta* | | | | | | | | | | 66 |
| *Polytrichum commune* | | | | | | | | | | 65 |
| *Nardus stricta* | | | | | | | | | | 61 |
| *Hyocomium armoricum* | | | | | | | | | | 47 |
| *Bryum pseudotriquetrum* | | | | | | | | | | 46 |
| *Carex demissa* | | | | | | | | | | 46 |
| *Brachythecium plumosum* | | | | | | | | | | 45 |
| *Marsupella emarginata* | | | | | | | | | | 45 |
| *Achillea ptarmica* | | | | | | | | | | 41 |
| *Jungermannia atrovirens* agg. | | | | | | | | | | 40 |
| % occurrence of 30th most common taxon | 69 | 52 | 61 | 30 | 45 | 50 | 37 | 49 | 44 | 40 |

the Oolite of the Cotswolds (e.g. Coln and Windrush). Whilst the plant assemblages have many of the species found typically in type I and type II, *Carex acutiformis*, *Callitriche obtusangula*, *Ranunculus penicillatus* subsp. *pseudofluitans*, *Berula erecta* and the moss *Fontinalis antipyretica* are particularly characteristic. Of the less commonly occurring species, *Hippuris vulgaris* and *Carex paniculata* are especially characteristic, whilst *Groenlandia densa*, *Phragmites australis* and *Rumex hydrolapathum* are more common than in any other types.

## Type IV Impoverished lowland rivers (NN type III)

A wide variety of soft geology prevails with sites generally at lower altitudes than in types within Groups B–D but slightly higher than in the three other types within Group A. The prevalence of narrow rivers is greater than for any other types. The over-riding character of the majority of the sites is the degradation of the physical environment through land drainage and flood defence activities. Others suffer from depleted flows or pollution problems. Because of these key factors, mean numbers of species per site are less than 75% of other Group A types. Sites are widely distributed in the lowland areas of Great Britain but with a higher proportion found on rivers with stream order 2 (Strahler 1959). The most typical species are all emergent or marginal species, none of the common submerged aquatics of the other Group A types occurring in more than 35% of sites.

## Type V Sandstone, mudstone and hard limestone rivers of England and Wales (NN type VI)

As in type VI, the geology is predominantly sandstone and hard limestone, but the latter is much more, and the former less, important. Calcareous shales are also more likely to be found within this type too. Typical rivers include the Tamar, Torridge, Exe, Teifi, Monnow, Lugg and Dove, with few sites north of the Mersey. Substrates are dominated by pebbles and cobbles, with much less of the finer material so characteristic of types I–IV. In total contrast to these latter types, no submerged aquatics occur in more than half the type V sites, and *Sparganium erectum* is the only emergent to do so. Submerged habitats are often dominated by mosses, the most important being *Rhynchostegium riparioides*, *Fontinalis antipyretica* and *Amblystegium* sp(p). Of the common species found in both types IV and V, *Oenanthe crocata*, *Solanum dulcamara*, *Conocephalum conicum* and *Vaucheria* sp(p). are significantly more frequent in type V, whilst of the less common taxa *Apium nodiflorum*, *Eupatorium cannabinum*, *Lythrum salicaria* and *Carex remota* are more than three times more frequent.

## Type VI Sandstone, mudstone and hard limestone rivers of Scotland and northern England (NN type V)

Sandstone and hard limestone geology prevails, as in type V. The altitude of sites is similar in both types but gradient is significantly steeper in type V. Despite this, the various substrates occur in broadly similar proportions, dominated by pebbles and cobbles and with much less of the finer material so characteristic of types I–IV. Geographical location appears to be very significant, with hard limestone and sandstone catchments north of the Mersey invariably having type VI communities. Typical examples are the Ribble, Wharfe, Eden, Tweed, Lunan Water and Ythan; outliers are the Usk and Teme. Of the common species encountered in both type V and type VI, *Myosotis scorpioides*, *Mentha aquatica*, *Mimulus guttatus*, *Equisetum arvense*, *Caltha palustris*, *Elodea canadensis* and filamentous algae are much more prevalent in type VI. This also applies to less commonly occurring species such as *Myriophyllum spicatum*, *Polygonum amphibium*, the moss *Schistidium alpicola*, *Ranunculus fluitans* and *Eleocharis palustris*, which all occur at least three times more frequently in type VI than in type V.

## Type VII Mesotrophic rivers dominated by gravels, pebbles and cobbles (NN type VIII)

Shales, hard limestone and hard sandstone dominate the geology of both type VII and type VIII. However, type VII has double the proportion of sites on hard limestone and less than half the proportion on non-calcareous shales than does type VIII. Typical site altitudes are similar, but gradients are shallower in type VII, and there is a far greater proportion of fine substrates, ranging from silts to sands and gravels. Sites are well scattered around the country, most typically in catchments of more basic geology than type VIII or with relatively stable flows. Wetland edge species characterise the assemblage, with fewer bryophytes than in either Group B or in neighbouring type VIII (reflecting finer sediments). Of the common species in both type VII and type VIII, *Phalaris arudinacea* and *Myosotis scorpioides* are more common in type VII, whilst of the less common species the following are also far more prevalent in type VII: *Callitriche stagnalis*, *C. hamulata*, *Equisetum fluviatile*, *Myriophyllum alterniflorum*, *Juncus articulatus*, *Potamogeton natans* and *Rorippa nasturtium-aquaticum*.

## Type VIII Oligo-mesotrophic rivers (NN type VII)

Shales, hard limestone and hard sandstone dominate the geology, but compared with type VII, type VIII has half the proportion of sites on hard limestone and double the proportion on non-calcareous shales. Gradients are steeper in type VIII, and it has a vastly higher proportion of coarse substrates, ranging from cobbles to boulders and bedrock, than does type VII. Typically sites are downstream of high land and base- and nutrient-poor (oligotrophic), with rivers such as the lower Findhorn, Spey, Dee and Esk in Scotland and mid-reaches of rivers flowing from the Pennines (e.g. Ure), the highlands of the Lake District (e.g. Derwent) and the highlands of Wales (e.g. Conwy, Dee, Cothi) and Exmoor (e.g. Barle) exemplifying this type. The higher proportion of rocky substrate and their less base-rich nature result in a wide variety of bryophytes being typical. Species that are far more common in type VIII than in type VII include: *Rhynchostegium riparioides*, *Chiloscyphus polyanthos*, *Pellia epiphylla*, *Hygrohypnum ochraceum*, *Amblystegium fluviatile*, *Thamnobryum alopecurum*, *Scapania undulata* and *Schistidium alpicola*. Many less common bryophytes and lichens occur more than five times more frequently in type VIII than in type

VII; these include *Dermatocarpon fluviatile, Hyocomium armoricum, Dichodontium pellucidum* and *D. flavescens.*

## Type IX Oligotrophic, low-altitude rivers (NN type X)

Rivers of this type have macrophyte assemblages that indicate nutrient-poor chemistry that is usually base-poor too. They have much gentler gradients than rivers in type X and are located at much lower altitudes. These factors give rise to a much greater abundance of silts and sands as substrates and at least 50% less of cobbles, boulders and bedrock. Solid geology is broadly similar to that for rivers of type X, but the absence of sites on non-calcareous shales and the presence of hard limestone gives the type a slightly less oligotrophic nature. The contrasting gradient and substrate characteristics are reflected in the plant assemblages dominated by oligotrophic vascular plants. Because of the relative scarcity of rocks, *Fontinalis antipyretica* (typically a more lowland species) and *Sphagnum* sp(p). are the only mosses among the top 30 common species, yet the aquatic vascular plants *Juncus bulbosus, Equisetum fluviatile, Myriophyllum alterniflorum, Potamogeton polygonifolius* and *P. natans* all are much more common than in type X. No single large rivers epitomise this type, with the assemblage distributed from the English lowland acid heaths of the New Forest to the Scottish Flow Country and the Western Isles. It is on the lowlands of the Western Isles that the greatest density of the type, and most typical communities, occur.

## Type X Ultra-oligotrophic rivers (NN type IX)

Macrophyte assemblages in type X rivers indicate both oligotrophic chemistry and the common presence of rocks, which enable bryophytes to thrive. Sites with type X communities are found on rivers with steeper gradients than in type IX and that are located at much higher altitudes. These factors give rise to a much greater abundance of cobbles, boulders and bedrock. Typically, sites are found on all rivers rising at high altitudes on base-poor rock and/or where blanket bog or acid heath dominates the catchment upstream. Thus, rivers with stream order 1 or 2, such as those on, for example, Dartmoor, Exmoor, the Brecon Beacons, Plynlimon, Snowdonia, the Pennines, the North York Moors, the Cairngorms or the north-west Highlands, are all likely to be dominated by type X communities. In contrast to type IX, bryophytes are a major component of the flora and are very dominant in submerged habitats; the following species are noteworthy as common: *Pellia epiphylla, Racomitrium aciculare, Scapania undulata, Hyocomium armoricum, Bryum pseudotriquetrum, Marsupella emarginata* and *Jungermannia atrovirens.* Several of these species are at least ten times more common in type X than in type IX, as are the less frequently recorded *Nardia compressa, Hygrohypnum ochraceum* and *Schistidium alpicola.* Of 18 species that occur at least three times more commonly in type X than type IX, 16 are bryophytes.

# 5.3 Rivers in Group A: sub-types AIa–AIVc

Types I to IV in Group A are further sub-divided into 11 sub-types. Table 7 summarises the physical characteristics of sites in sub-types AIa–AIVc and Table 8 shows the 30 most common taxa in each sub-type of Group A. The nearest neighbour (NN) for each sub-type within the classification is shown to enable easy comparison.

## Type I Lowland, low-gradient rivers

### *AIa Large, lowland rivers with high base-flow (NN sub-types AIb/AIc)*

AIa sites belong to a geographically distinct sub-type that is exemplified by the lower reaches of the Dorset Stour and Hampshire Avon, where these rivers traverse a mixed geology below predominantly groundwater-fed reaches. Geology is always either clay or chalk, and sites are invariably more than 20 m wide. Sites are typically very species-rich. Many of the most commonly occurring species listed in Table 8 for sub-type AIa are also typical of AIb and AIc, but *Myriophyllum spicatum, Nuphar lutea, Potamogeton perfoliatus, Butomus umbellatus* and *Phragmites* are more prevalent. *Azolla filiculoides* and *Juncus articulatus* are more than ten times as prevalent, whilst *Bidens cernua, Galium palustre, Rorippa palustris, R. sylvestris, Oenanthe crocata, Carex hirta* and *Juncus acutiflorus* are more than three times as commonly occurring. In contrast, *Ranunculus circinatus, Rorippa amphibia* and *Potamogeton berchtoldii* are more than ten times as common in AIb and AIc than in AIa.

### *AIb Fast-flowing, coarse-bedded lowland rivers of low gradient (NN sub-type AIc)*

In sites of the AIb sub-type, geology is very similar to AIa sites, with clay and chalk dominant and sites geographically confined to south and west of Watford. Typical sites include faster-flowing reaches on the lower Hampshire Avon and Coln. Sites are often species-rich, but less so than AIa sites, and dominant and commonly occurring species have much in common with AIa and AIc. Of these taxa, *Vaucheria* sp(p). and *Elodea canadensis* are less common than in AIc, whilst *Ranunculus penicillatus* subsp. *pseudofluitans, Sagittaria sagittaria, Lemna minor* and *Salix* sp(p). and other trees are more prevalent. Of the less common taxa, *Myosoton aquaticum* is more than ten times as likely to be found in AIb than in AIc, *Bidens tripartitas* and *Lemna polyrhiza* are more than five times as common and *Impatiens capensis* more than three times as common.

### *AIc Lowland, very low-gradient rivers with fine substrates (NN sub-type AIb)*

These lowland rivers differ only slightly from sites classified as sub-type AIb, differing more in their geographical distribution than in their community assemblage. Sites are typified by fen and East Anglian rivers such as the Lark, Stour, Waveney and Wissey and other rivers with very low gradient (e.g. rivers in the Somerset Levels). Alluvium and calcareous clay dominate the geology, with fine sediments more prevalent than in other sub-types. The flora is totally dominated by vascular plants, but the algae *Vaucheria* sp(p). and *Cladophora glomerata* are also important. The low gradient, which results in fine sediments and sluggish flows, is reflected by a ten-times greater occurrence in sub-type AIc than in AIb sites of species such as *Ranunculus circinatus, Ceratophyllum demersum, Potamogeton berchtoldii, P. lucens* and *Lemna gibba*, and a three times greater occurrence of *Veronica catenata, Phragmites australis* and *Zannichellia palustris*.

## Type II Lowland, clay-dominated rivers

### *AIIa Small 'classic' clay rivers (NN sub-types AIIb/AIIc)*

This sub-type is very characteristic of classic clay rivers, where both the catchment geology and the underlying substrates are clay. Gravels and pebbles mixed with clay are therefore less common than in the AIIb and AIIc sub-stypes, and sites are typically less than 10 m wide. As for all type II rivers, vascular plants totally dominate the assemblage, and of the lower plants only the algae *Enteromorpha* spp. and *Cladophora glomerata* are important. Of the species that are common in all type II rivers, *Nuphar lutea, Sagittaria sagittifolia, Glyceria maxima, Schoenoplectus lacustris* and *Sparganium emersum* are particularly characteristic of AIIa sites. Of the less common species, *Galium palustre, Scutellaria galericulata* and *Veronica catenata* are all more than three times as prevalent in AIIa than in AIIb or AIIc, whilst the opposite is true for *Zannichellia palustris, Ranunculus penicillatus* subsp. *pseudofluitans* and *Potamogeton pectinatus*.

### *AIIb Clay rivers with diverse substrates and flow patterns (NN sub-type AIIc)*

The geology of sites of this sub-type is a mixture of soft sandstones, soft limestone and clays, with a diverse mixture of substrates also typical, with silt, sand, clay, gravel and pebbles expected in more than 25% of sites. The sub-type has, therefore, no close affinity to a single rock type or substrate category. Species that are typical of clay rivers in general predominate, with *Sparganium erectum, Sagittaria sagittifolia, Schoenoplectus lacustris* and *Ranunculus penicillatus* subsp. *pseudofluitans* more common than is typical for clay rivers in general, and trees, *Salix* sp(p). and *Nuphar lutea* particularly prevalent. As is typical for all Group A communities, vascular plants dominate, except for the algae *Cladophora glomerata, Vaucheria* sp(p). and *Enteromorpha* sp(p).; an exception is the relatively common occurrence of the moss *Amblystegium riparium*. Of the less commonly occurring species, *Eupatorium cannabinum, Lycopus europaeus, Lythrum salicaria, Symphytum officinale* and *Carex acutiformis* all occur more than three times as commonly on banks of sub-type AIIb rivers than in communities of sub-type AIIc, and the same is true for *Fontinalis antipyretica, Rhynchostegium riparioides* and *Callitriche obtusangula* in mid-stream.

**Table 7** Physical characteristics of sites in sub-types of Group A: AIa–AIVc

| | *Sub-type* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *AIa* | *AIb* | *AIc* | *AIIa* | *AIIb* | *AIIc* | *AIIIa* | *AIIIb* | *AIVa* | *AIVb* | *AIVc* |
| *Number of taxa* | | | | | | | | | | | |
| Mean | 53 | 45 | 45 | 42 | 40 | 30 | 51 | 39 | 30 | 34 | 18 |
| Minimum | 44 | 35 | 29 | 23 | 18 | 10 | 41 | 12 | 7 | 17 | 4 |
| Maximum | 67 | 53 | 60 | 58 | 61 | 47 | 60 | 57 | 43 | 50 | 32 |
| *Geology (% occurrence (>10%) at sites)* | | | | | | | | | | | |
| Alluvium | | | 12 | | | 28 | | | | | |
| Calcareous clay | | | 60 | 54 | 30 | 18 | | 16 | 35 | 18 | |
| Non-calcareous clay | 67 | 35 | | 19 | 16 | | | | 13 | 12 | |
| Chalk | 33 | 56 | 21 | | | | 95 | 54 | 14 | | |
| Other soft limestone | | | | 15 | 16 | 13 | | 13 | 15 | | |
| Hard limestone | | | | | | | | | | | 19 |
| Soft sandstone | | | | | 23 | 26 | | | 12 | 59 | |
| Hard sandstone | | | | | | | | | | | 31 |
| Calcareous shale | | | | | | | | | | | |
| Non-calcareous shale | | | | | | | | | | | |
| Hard rock | | | | | | | | | | | |
| Base-rich igneous | | | | | | | | | | | 25 |
| *Height at source (m)* | | | | | | | | | | | |
| Mean | 158 | 100 | 95 | 139 | 151 | 195 | 83 | 118 | 151 | 102 | 257 |
| Minimum | 137 | 46 | 25 | 25 | 61 | 25 | 76 | 25 | 25 | 35 | 10 |
| Maximum | 200 | 160 | 229 | 190 | 640 | 640 | 107 | 229 | 640 | 137 | 700 |
| *Altitude of site (m)* | | | | | | | | | | | |
| Mean | 77 | 45 | 24 | 64 | 48 | 23 | 33 | 60 | 62 | 23 | 67 |
| Minimum | 2 | 0 | 15 | 10 | 10 | 10 | 15 | 15 | 5 | 5 | 5 |
| Maximum | 200 | 90 | 92 | 170 | 200 | 65 | 65 | 168 | 213 | 61 | 165 |
| *Slope (km per 15 m fall)* | | | | | | | | | | | |
| Mean | 19.9 | 17.7 | 21.2 | 19.6 | 17.1 | 20.2 | 11.8 | 10.7 | 9 | 15.4 | 8.3 |
| Minimum | 11.7 | 2.3 | 9.8 | 1.5 | 4.2 | 4.3 | 5.0 | 2.0 | 0.3 | 5.0 | 1.2 |
| Maximum | 23 | >25 | >25 | >25 | >25 | >25 | >25 | >25 | >25 | >25 | 21 |
| *Substrates (% occurrence at sites)* | | | | | | | | | | | |
| Silt/mud | 39 | 44 | 62 | 35 | 39 | 41 | 32 | 52 | 40 | 24 | 56 |
| Sand | 0 | 9 | 21 | 6 | 28 | 26 | 11 | 27 | 22 | 6 | 31 |
| Clay | 83 | 30 | 45 | 87 | 41 | 44 | 21 | 17 | 29 | 47 | 6 |
| Gravel | 56 | 61 | 35 | 30 | 55 | 36 | 84 | 79 | 58 | 47 | 25 |
| Pebbles | 39 | 48 | 3 | 4 | 25 | 8 | 21 | 13 | 26 | 0 | 6 |
| Cobbles | 11 | 0 | 2 | 2 | 7 | 3 | 0 | 6 | 5 | 0 | 13 |
| Boulders | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 |
| Bedrock | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| *Habitats (% occurrence at sites)* | | | | | | | | | | | |
| Pools | 6 | 0 | 3 | 7 | 10 | 5 | 11 | 3 | 6 | 0 | 0 |
| Slacks | 94 | 83 | 98 | 98 | 89 | 95 | 95 | 89 | 79 | 82 | 63 |
| Riffles | 0 | 4 | 0 | 4 | 6 | 3 | 0 | 3 | 9 | 0 | 44 |
| Runs | 22 | 44 | 26 | 24 | 41 | 26 | 47 | 58 | 49 | 59 | 38 |
| Rapids | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 6 |
| *Width (m) (% occurrence at sites)* | | | | | | | | | | | |
| <5 | 6 | 9 | 7 | 43 | 20 | 10 | 0 | 34 | 76 | 53 | 50 |
| 5–10 | 0 | 13 | 17 | 54 | 48 | 51 | 16 | 54 | 30 | 47 | 38 |
| >10–20 | 6 | 78 | 62 | 26 | 52 | 46 | 84 | 27 | 7 | 18 | 0 |
| >20 | 94 | 30 | 22 | 2 | 11 | 21 | 37 | 6 | 5 | 0 | 19 |
| *Depth (m) (% occurrence at sites)* | | | | | | | | | | | |
| <0.25 | 0 | 4 | 19 | 33 | 39 | 36 | 53 | 72 | 71 | 59 | 44 |
| 0.25–0.5 | 17 | 70 | 28 | 50 | 51 | 41 | 63 | 66 | 50 | 41 | 44 |
| >0.5–1 | 39 | 83 | 26 | 33 | 37 | 23 | 21 | 21 | 27 | 0 | 6 |
| >1 | 83 | 26 | 57 | 33 | 32 | 44 | 21 | 16 | 8 | 24 | 31 |

Table 8 Percentage frequency of occurrence of the 30 most common taxa in sub-types of Group A: AIa–AIVc

| | *Sub-type* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Taxon* | *AIa* | *AIb* | *AIc* | *AIIa* | *AIIb* | *AIIc* | *AIIIa* | *AIIIb* | *AIVa* | *AIVb* | *AIVc* |
| *Stachys palustris* | 100 | | | | | | | | | | |
| *Butomus umbellatus* | 89 | | | | | | | | | | |
| *Schoenoplectus lacustris* | 83 | 74 | 62 | 78 | 62 | | | | | | |
| *Sagittaria sagittifolia* | 83 | 96 | 71 | 83 | 61 | | | | | | |
| *Myriophyllum spicatum* | 89 | | 74 | | 59 | 49 | | | | | |
| *Potamogeton perfoliatus* | 94 | | | | | 51 | | | | | |
| *Potamogeton pectinatus* | 94 | 87 | 81 | | 85 | 90 | | | | | |
| *Phragmites australis* | 94 | | 69 | | | | 79 | | | | |
| *Elodea canadensis* | 94 | | 79 | 65 | | 67 | 84 | | | | 31 |
| *Lycopus europaeus* | 94 | 96 | 64 | | 61 | | 100 | | | | |
| *Ranunculus penicillatus* subsp. *pseudofluitans* | 83 | 87 | | | 63 | | 100 | 82 | | | |
| *Apium nodiflorum* | 94 | 96 | 88 | 61 | 65 | 49 | 100 | 86 | 79 | | 31 |
| *Rorippa nasturtium-aquaticum* | 94 | 91 | 86 | 70 | 76 | 64 | 90 | 87 | 85 | | 50 |
| *Lemna minor* | 83 | 96 | | 70 | 61 | 67 | | | 37 | | |
| *Glyceria maxima* | 89 | 91 | 90 | 82 | 59 | 51 | 84 | 76 | 33 | | 25 |
| *Sparganium emersum* | 100 | 91 | 88 | 76 | 76 | 44 | | | | 77 | |
| *Symphytum officinale* | 100 | 91 | | | | | | 55 | | 47 | |
| *Oenanthe crocata* | 100 | | | | | | | | | 88 | |
| *Sparganium erectum* | 100 | 100 | 91 | 98 | 99 | 72 | 100 | 94 | 83 | 100 | 56 |
| *Phalaris arundinacea* | 100 | 100 | 100 | 98 | 97 | 97 | 100 | 97 | 93 | 100 | 81 |
| *Mentha aquatica* | 100 | 87 | 95 | 83 | 80 | 51 | 100 | 99 | 77 | 82 | 38 |
| *Agrostis stolonifera* | 94 | 100 | 97 | 96 | 99 | 97 | 84 | 93 | 98 | 100 | 100 |
| *Salix* sp(p). | 94 | 91 | 76 | 98 | 94 | 59 | 84 | 89 | 79 | 100 | 31 |
| *Solanum dulcamara* | 94 | 100 | 90 | 89 | 89 | 62 | 95 | 89 | 86 | 77 | |
| *Epilobium hirsutum* | 89 | 91 | 91 | 91 | 100 | 69 | 100 | 100 | 94 | 82 | 63 |
| *Myosotis scorpioides* | 94 | 100 | 95 | 100 | 93 | 80 | 100 | 96 | 93 | 77 | 88 |
| *Nuphar lutea* | 94 | 74 | 69 | 96 | 72 | | | | | 53 | |
| *Iris pseudacorus* | 89 | 96 | | | | | 90 | 75 | | 47 | 44 |
| *Veronica beccabunga* | 89 | 96 | 88 | 76 | 73 | 72 | | 92 | 87 | 47 | 69 |
| *Eupatorium cannabinum* | 89 | 71 | 71 | | | | 95 | 66 | 33 | 65 | |
| *Carex riparia* | | 96 | 95 | | | | | 63 | | | 25 |
| *Scrophularia auriculata* | | 91 | | 82 | 78 | | | 86 | 78 | 71 | 25 |
| Trees | | 87 | 69 | 83 | 94 | | | 90 | 84 | 88 | 31 |
| *Callitriche stagnalis* | | 83 | 72 | 70 | | 41 | | 73 | 52 | 71 | 38 |
| *Cladophora glomerata* | | 83 | 67 | 61 | 87 | 92 | | 59 | 69 | | |
| *Carex acutiformis* | | 70 | | | | | 100 | 86 | | | |
| *Veronica anagallis-aquatica* | | 70 | | | | | 84 | 82 | 35 | | 31 |
| *Vaucheria* sp(p). | | | 90 | | 79 | 82 | 84 | 72 | 61 | | |
| *Juncus inflexus* | | | 71 | 63 | | 41 | | 75 | 59 | | 38 |
| *Enteromorpha* sp(p). | | | 67 | 65 | 63 | 74 | | | | | |
| *Lythrum salicaria* | | | 64 | 65 | 70 | | 95 | 59 | | | |
| *Veronica catenata* | | | | 63 | | | | | | | |
| *Rorippa amphibia* | | | | 72 | 59 | 39 | | | | | |
| *Filipendula ulmaria* | | | | 76 | | | 95 | 86 | 65 | 94 | 63 |
| *Polygonum amphibium* | | | | 74 | 62 | 69 | | | | | 44 |
| *Alisma plantago-aquatica* | | | | 72 | | | | | | 65 | |
| *Amblystegium riparium* | | | | | 61 | | | | 58 | | |
| *Potamogeton crispus* | | | | | | 46 | | | | | |
| *Ranunculus sceleratus* | | | | | | 46 | | | | | |
| *Elodea nuttallii* | | | | | | 36 | | | | | |
| *Rumex hydrolapathum* | | | | | | | 95 | | | | |
| *Zannichellia palustris* | | | | | | | 84 | | | | |
| *Carex paniculata* | | | | | | | 79 | | | | |
| *Impatiens capensis* | | | | | | | 90 | | | | |
| *Fontinalis antipyretica* | | | | | | | 100 | 58 | | | |
| *Berula erecta* | | | | | | | 90 | 69 | | | |

Table 8 (continued)

| | Sub-type | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Taxon* | *AIa* | *AIb* | *AIc* | *AIIa* | *AIIb* | *AIIc* | *AIIIa* | *AIIIb* | *AIVa* | *AIVb* | *AIVc* |
| *Callitriche platycarpa* | | | | | | | 95 | | 40 | | |
| *Juncus effusus* | | | | | | 39 | | | 58 | 82 | 56 |
| *Callitriche obtusangula* | | | | | | | 100 | 83 | | 59 | |
| Filamentous green algae | | | | | | | | | 45 | | 56 |
| *Brachythecium rutabulum* | | | | | | | | | 37 | | |
| *Equisetum arvense* | | | | | | | | | 34 | | |
| *Glyceria fluitans* | | | | | | 36 | | | 43 | 47 | 69 |
| *Angelica sylvestis* | | | | | | | | | 35 | 77 | 44 |
| *Lythrum salicaria* | | | | | | | | | | 94 | |
| *Impatiens glandulifera* | | | | | | | | | | 71 | |
| *Deschampsia cespitosa* | | | | | | | | | | 53 | |
| Ferns | | | | | | | | | | 53 | |
| *Myosoton aquaticum* | | | | | | | | | | 47 | |
| *Lysimachia vulgaris* | | | | | | | | | | 47 | |
| *Caltha palustris* | | | | | | | | | | | 50 |
| *Alopecurus geniculatus* | | | | | | | | | | | 31 |
| *Rorippa sylvestris* | | | | | | | | | | | 31 |
| *Potamogeton natans* | | | | | | | | | | | 25 |
| *Eleocharis palustris* | | | | | | | | | | | 25 |
| % occurrence of the 30th most common taxon | 83 | 70 | 64 | 61 | 59 | 36 | 79 | 55 | 33 | 47 | 25 |

### *AIIc Clay-dominated rivers with impoverished flora (NN sub-type AIIb)*

Heavy management and relatively low numbers of species typify this sub-type, with more than 25% fewer species per site compared with other type II rivers. Only six species are present in more than 75% of the sites classified into the sub-type, compared with 17 and 15 in the other sub-types of type II rivers. Typical rivers are the enriched and heavily managed rivers of the Cheshire Plain (Dee, Weaver, Dane) and East Midland rivers such as the Welland or Devon. As the impoverished nature of the flora is the key distinguishing feature, there are no physical features or species that characterise the sub-type. In general a wide range of soft geological types are found, invariably at very low altitudes and where the slope is very gentle. The most commonly occurring and dominant species are those that are widespread along enriched banks (e.g. *Phalaris arundinacea, Agrostis stolonifera* and *Myosotis scorpioides*) or pollution-tolerant river plants (e.g. *Potamogeton pectinatus, Vaucheria* sp(p)., *Cladophora glomerata* and *Enteromorpha* sp(p).).

## Type III Chalk rivers and other base-rich rivers with stable flows

### *AIIIa Classic chalk rivers (NN sub-type AIIIb)*

Chalk is the only typical geology within the catchments of rivers classified into this sub-type. Typically rivers are 10–20 m wide (and never less than 5 m) and have more clay, gravel and pebble substrates and less silt and sand than rivers in sub-type AIIIb. The Itchen and the Test typify AIIIa. *Impatiens capensis, Lysimachia vulgaris, Lemna trisulca* and *Potamogeton lucens* are more than ten times as likely to be found in sub-type AIIIa than in AIIIb, whilst *Hippurus vulgaris, Oenanthe fluviatilis, Rumex hydrolapathum, Groenlandia densa* and several other species are more than three times as likely. Of the species common in both sub-types, *Ranunculus penicillatus* subsp. *pseudofluitans, Callitriche obtusangula, Fontinalis antipyretica, Berula erecta, Carex acutiformis* and *Zannichellia palustris* are all much more typical of AIIIa than AIIIb. Sites are typically very species-rich.

### *AIIIb Chalk/oolite streams and high base-flow rivers (NNI sub-type AIIa)*

In common with AIIIa, chalk is the dominant geology but calcareous clay and other soft limestone (e.g. oolite) are also important. The varied geology and the greater range of river sizes within the sub-type result in a higher proportion of finer sediments being present. Sub-type AIIIa is likely wherever Chalk or Oolite has a strong influence on river flows; thus examples stretch from the Hull in Yorkshire through the Midlands and East Anglian rivers Nar, Wissey and Wensum to the more southerly rivers of Oolite (e.g. Windrush and Coln) and Chalk (e.g. Piddle, Frome, Kennet, Mimram). The core 'chalk stream' species are well represented, but they are rarely all present at the same site, as is typical in sub-type AIIIa sites. Species that are not typical of classic chalk streams are more prevalent in AIIIb, the most characteristic being *Ranunculus sceleratus, Potamogeton pectinatus, Equisetum arvense, Juncus effusus* (more than five times as many occurrences) and *Brachythecium rutabulum* and *Glyceria fluitans* (more than three times as many occurrences). Typically, AIIIb sites support only 75–80% of the number of species found in AIIIa sites.

## Type IV Impoverished lowland rivers

### *AIVa Base-rich/neutral, impoverished rivers, normally close to source (NN sub-type AIVb)*

AIVa rivers occur in a very wide geographical range, but primarily in England. A very common feature shared by the vast majority of them is a high degree of physical manipulation or degradation because of high levels of regular management or depletion of flows. Most are narrow and shallow rivers or ditches, with a low number of species expected. For instance, the most species-rich site out of 86 had fewer species than the average number expected in more than 100 sites in AIa-AIc. The 'ditch' nature of the communities is highlighted by the total dominance of the assemblage by emergent or annual wetland species, with the commonest true aquatic macrophytes not expected to be present in more than 30% of sites. *Apium nodiflorum, Cladophora glomerata* (especially), *Rorippa nasturtium-aquaticum, Juncus inflexus, Petasites hybridus, Carex riparia* and *Zannichellia palustris* are much more typical than in AIVb, whilst *Salix* sp(p). and *Juncus effusus* are much less common. This is unremarkable as the geology is generally more calcareous than in AIVb.

This is a large sub-type with many rivers represented in it. Sites are typically on heavily managed reaches of rivers where basic rock is present within the catchment. Typical examples are the Bristol Avon and Churn, on Oolite, the Darent on the North Downs, the Lark, Brett and Bure of East Anglia, the Eau and Glen of the Lincolnshire Wolds and the Gypsey Race of the Wolds in East Yorkshire.

### *AIVb Base-poor, impoverished ditch communities (NN sub-type AIVa)*

The most significant physical difference between AIVb and AIVa is the prevalence in the former of soft sandstone geology (59% compared with 12%). Where sites are at lower altitudes and have slacker gradients, clay and gravel dominate the substrates more than in any other of the 'ditch' sub-types. The less basic nature of the geology is reflected in the assemblages, with *Impatiens glandulifera, Oenanthe crocata, Pellia epiphylla, Nuphar lutea* and several other species more than five times more likely to be found than in AIVa and *Amblystegium riparium, Rorippa nasturtium-aquaticum, Juncus inflexus, Carex riparia* and *Zannichellia palustris* usually at least five times less likely to be recorded. Sites have slightly more species than is typical for AIVa, with rivers flowing off the Hastings Beds (e.g. Beult, Teise, West Sussex and East Sussex Rother) and the New Forest (e.g. Beaulieu and Lymington) especially typical.

### *AIVc Upland rivers with impoverished floras (NN sub-types AIVa/AIVb)*

The main features that distinguish this sub-type of Group A from the other ten is the greater altitude at source and much greater likelihood of riffle habitats. Sites are usually heavily modified by river engineering works, often leading to a high proportion of sites having silty substrates. Despite this, cobbles, boulders and bedrock are more commonly present in type AIVc than in either AIVa or AIVb, whilst pebbles and gravels are less frequently present.

The more upland sources account for the much rarer occurrence (or the absence) of species found in all other lowland sub-types (AIa–AIVb) within Group A. Good examples of such species include *Sparganium erectum, Mentha aquatica, Epilobium hirsutum, Solanum dulcamara* and *Salix* spp. The community has only three truly aquatic plants typically present: *Callitriche stagnalis, Elodea canadensis* and *Potamogeton natans*, which are all tolerant of siltation. Overall the community is dominated by plant species more commonly found in Group B; this suggests that without the physical degradation that afflicts most sites, they would be classified within Group B.

Sites are most typically found in northern England (Wansbeck, Bowmont Water) and southern Scotland (Annan, Blackadder Water), where rivers which rise in uplands flow through intensively farmed landscapes in their lower reaches.

# 5.4 Rivers in Group B: sub-types BVa–BVIc

Types V and VI in Group B are further sub-divided into ten sub-types. Table 9 summarises the physical characteristics of sites in sub-types BVa–BVIc and Table 10 shows the 30 most common taxa in each sub-type of Group B. The nearest neighbour (NN) for each sub-type within the classification is shown to enable easy comparison.

## Type V Sandstone, mudstone and hard limestone rivers of England and Wales

### *BVa Mesotrophic upland hard limestone/ sandstone rivers (NN sub-types BVb/BVc)*

In common with its nearest neighbours, sites of this sub-type are commonly found on hard limestone and soft sandstone. However, the more frequent occurrence of hard limestone and calcareous shales and much less frequent occurrence of clay and soft limestone distinguish BVa sites from those of BVb and BVc. Steep slope and higher altitudes are typical; altitude at source is double that of its nearest neighbour and slope is steeper than in any other sub-type of Group B. Fine sediments are rare, and bedrock, boulders and cobbles are more prevalent than is typical for the group as a whole. Generally, sites are shallow and moderately wide.

The harder rock, steeper gradients and higher altitudes result in bryophytes being much more common in this sub-type than is typical for B sub-type communities. Also, no truly aquatic vascular plant is a common component of the community. The base-rich nature of the rock is reflected in the common occurrence of bryophytes such as *Cinclidotus fontinaloides* and *Pellia endiviifolia*. Of the 12 most common taxa, eight are bryophytes; the other four are edge grasses *Agrostis stolonifera* and *Phalaris arudinacea*, together with *Salix* sp(p). and other trees. Of the less common species, the alga *Lemanea fluviatilis* and the mosses *Brachythecium rivulare* and *Dichodontium pellucidum* occur much more commonly in sub-type BVa than in BVb or BVc, whilst species such as *Lythrum salicaria, Iris pseudacorus, Glyceria plicata, Stachys palustris, Callitriche stagnalis* and *Alopecurus geniculatus* occur much less commonly.

Sites in the BVa sub-type are rarely found outside the hard limestone areas of south and north Wales, the Derbyshire Dales, the lower Pennines, the Lake District or the North York Moors; sites are also common in the upper reaches of rivers on the sandstones of Herefordshire and Worcestershire. Typical rivers from the areas cited include the Monnow, Usk, Tawe, Neath (lower), Clywedog, Elwy, Dove, Lathkill, Wharfe, Ure, Ehen, Hodder, Esk, Rye, Arrow and Lugg.

### *BVb Small, lowland, base-rich sand rivers or winterbournes (NN sub-type BVc)*

Sites within this sub-type are very close to the mid-range character for type V rivers for attributes such as altitude and slope, with the geology typically limestone, sandstone or calcareous clay and with sites on shale and hard rock generally absent (as with sub-types BVa-BVc). Silt and sand substrates are more common than in other type V rivers; the only other difference from its nearest neighbour is the tendency for rivers to rise at slightly higher altitudes.

Of the common species, BVb communities typically contain many more algae and bryophytes than do BVc communities; examples include *Cladophora glomerata, Vaucheria sessilis, Hildenbrandia rivularis, Amblystegium riparium, A. fluviatile* and *Pellia endiviifolia*. As for BVc, but in contrast with BVa, more vascular plants are common, with *Juncus acutiflorus, Apium nodiflorum, Rorippa nasturtium-aquaticum* and *Ranunculus penicillatus* subsp. *pseudofluitans* noteworthy. The species that occur much more commonly in BVb than BVc indicate a much more calcareous and stable substrate: *Hildenbrandia rivularis* and *Ranunculus penicillatus* subsp. *pseudofluitans* occur more than ten times as commonly; *Verrucaria* sp(p)., *Symphytum officinale, Veronica anagallis-aquatica, Elodea canadensis, Glyceria plicata* and *Zannichellia palustris* are all more than five times as commonly found and many other vascular plants are more than three times as commonly found in BVb than BVc.

Sites in BVb are widely scattered in England and Wales, the sub-type most typically representing outlier sites in lowland England that are not classified into Group A. In contrast to BVc, most sites are rarely located on rivers where clay is important within the catchment. However, many sites are winterbournes (e.g. Frome, Lambourne, Moors) or the extreme upper reaches of chalk/oolite/limestone rivers (e.g. Avon, Babingly, Coln, Culm, Darent, Kit, Otter, Yarty), whilst other sites are scattered on relatively base-rich mixed geologies (often sandstones) at low altitudes (e.g. Arrow, Axe, Clwyd, Lugg, Monnow, West Sussex Rother and Trothy).

### *BVc Small, lowland, impoverished mixed sand/clay rivers (NN sub-type BVb)*

Sites within this sub-type characteristically flow mainly over hard limestone and sandstone (typically for all BVa-BVc rivers) but are usually located on rivers that rise at much lower altitudes than is typical of sites in Group B sub-types. Sites are also typically much narrower than sites on other type V rivers.

Relatively uncommon species (e.g. *Sagina procumbens* and *Carex pendula*) and the much more commonly occurring species (e.g. the liverworts *Marchantia polymorpha, Lunularia cruciata* and *Pellia epiphylla*, the vascular plants *Deschampsia cespitosa, Scrophularia auriculata* and *Callitriche stagnalis*, ferns and filamentous green algae) are far more commonly found in this sub-type than in BVb, many reflecting the strong influence of clay within the sites. Typically these species are found on steep clay banks.

Species more associated with rock or calcareous conditions (e.g. *Hildenbrandia rivularis, Amblystegium riparium, A. fluviatile, Pellia endiviifolia, Rorippa nasturtium-aquaticum* and *Ranunculus penicillatus* subsp. *pseudofluitans*) are all rare in BVc compared with BVb.

**Table 9** Physical characteristics of sites in sub-types of Group B: BVa–BVIe.

| | *Sub-type* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *BVa* | *BVb* | *BVc* | *BVd* | *BVe* | *BVIa* | *BVIb* | *BVIc* | *BVId* | *BVIe* |
| *Number of taxa* | | | | | | | | | | |
| Mean | 33 | 36 | 30 | 38 | 39 | 41 | 42 | 42 | 42 | 25 |
| Minimum | 21 | 20 | 9 | 17 | 25 | 22 | 28 | 24 | 24 | 6 |
| Maximum | 43 | 54 | 50 | 52 | 63 | 60 | 56 | 55 | 58 | 36 |
| *Geology (% occurrence (>10%) at sites)* | | | | | | | | | | |
| Alluvium | | | | | | | | | | |
| Calcareous clay | | 10 | | | | | | | | |
| Non-calcareous clay | | | 13 | | | | | | | |
| Chalk | | | | | | | | | | |
| Other soft limestone | | | | | | | | | | |
| Hard limestone | 27 | 10 | 17 | | | 13 | 24 | 32 | | 40 |
| Soft sandstone | 18 | 32 | 25 | | | 44 | 41 | 16 | 38 | |
| Hard sandstone | 18 | 17 | 21 | 65 | 81 | 13 | 14 | 12 | | 30 |
| Calcareous shale | 18 | | | 19 | 16 | 19 | | 10 | | |
| Non-calcareous shale | | | | 15 | | | 17 | 25 | | |
| Hard rock (base-rich) | | | | | | | | | 36 | 25 |
| *Height at source (m)* | | | | | | | | | | |
| Mean | 441 | 248 | 175 | 306 | 322 | 463 | 533 | 481 | 352 | 433 |
| Minimum | 183 | 30 | 35 | 107 | 198 | 335 | 76 | 61 | 61 | 160 |
| Maximum | 665 | 579 | 480 | 640 | 640 | 761 | 761 | 761 | 680 | 680 |
| *Altitude of site (m)* | | | | | | | | | | |
| Mean | 107 | 67 | 60 | 87 | 51 | 51 | 57 | 78 | 76 | 98 |
| Minimum | 15 | 5 | 15 | 15 | 15 | 15 | 12 | 15 | 10 | 5 |
| Maximum | 224 | 244 | 185 | 183 | 168 | 215 | 130 | 229 | 250 | 270 |
| *Slope (km per 15 m fall)* | | | | | | | | | | |
| Mean | 4.7 | 6.4 | 6.6 | 7.6 | 8.8 | 15.5 | 11.3 | 9.5 | 10.2 | 5.3 |
| Minimum | 0.1 | 1.5 | 2.0 | 3.1 | 1.5 | 3.0 | 4.0 | 1.5 | 1.0 | 0.9 |
| Maximum | 11 | 20 | >25 | 15 | 15 | >25 | >25 | >25 | >25 | 20 |
| *Substrates (% occurrence at sites)* | | | | | | | | | | |
| Silt/mud | 4 | 19 | 8 | 12 | 3 | 16 | 7 | 6 | 8 | 35 |
| Sand | 2 | 13 | 8 | 4 | 3 | 16 | 3 | 7 | 26 | 25 |
| Clay | 2 | 9 | 33 | 8 | 0 | 9 | 0 | 2 | 6 | 5 |
| Gravel | 13 | 41 | 63 | 35 | 7 | 38 | 10 | 12 | 40 | 20 |
| Pebbles | 36 | 58 | 42 | 73 | 29 | 47 | 28 | 53 | 55 | 30 |
| Cobbles | 76 | 32 | 25 | 42 | 65 | 28 | 69 | 74 | 47 | 55 |
| Boulders | 40 | 7 | 13 | 8 | 48 | 22 | 59 | 35 | 15 | 30 |
| Bedrock | 22 | 0 | 4 | 0 | 16 | 13 | 17 | 12 | 4 | 10 |
| *Habitats (% occurrence at sites)* | | | | | | | | | | |
| Pools | 13 | 7 | 17 | 4 | 13 | 25 | 14 | 3 | 0 | 15 |
| Slacks | 84 | 81 | 88 | 92 | 94 | 97 | 90 | 90 | 79 | 35 |
| Riffles | 0 | 22 | 29 | 8 | 10 | 0 | 0 | 0 | 0 | 70 |
| Runs | 82 | 55 | 58 | 85 | 52 | 41 | 76 | 81 | 76 | 70 |
| Rapids | 11 | 4 | 0 | 4 | 19 | 9 | 7 | 12 | 6 | 10 |
| *Width (m) (% occurrence at sites)* | | | | | | | | | | |
| <5 | 18 | 52 | 75 | 31 | 0 | 3 | 7 | 3 | 26 | 35 |
| 5–10 | 49 | 42 | 29 | 46 | 7 | 6 | 7 | 21 | 36 | 45 |
| 10–20 | 49 | 29 | 4 | 50 | 55 | 59 | 28 | 46 | 28 | 15 |
| >20 | 16 | 10 | 4 | 4 | 58 | 53 | 72 | 49 | 30 | 35 |
| *Depth (m) (% occurrence at sites)* | | | | | | | | | | |
| <0.25 | 93 | 80 | 75 | 92 | 55 | 50 | 55 | 81 | 81 | 50 |
| 0.25–0.5 | 56 | 54 | 58 | 46 | 58 | 38 | 66 | 59 | 40 | 45 |
| 0.5–1.0 | 2 | 7 | 25 | 8 | 16 | 6 | 10 | 3 | 2 | 20 |
| >1.0 | 9 | 3 | 4 | 0 | 26 | 47 | 17 | 19 | 13 | 20 |

**Table 10** Percentage frequency of occurrence of the 30 most common taxa in sub-types of Group B: BVa–BVIe

| | *Sub-type* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Taxon* | *BVa* | *BVb* | *BVc* | *BVd* | *BVe* | *BVIa* | *BVIb* | *BVIc* | *BVId* | *BVIe* |
| *Lemanea fluviatilis* | 73 | | | | | | | | | |
| *Thamnobryum alopecurum* | 51 | | | | | | | | | |
| *Marchantia polymorpha* | 56 | | 54 | | | | | | | |
| *Amblystegium riparium* | 67 | 71 | 42 | 73 | | | | | | |
| *Oenanthe crocata* | 58 | 73 | 54 | 96 | 100 | | | | | |
| *Chiloscyphus polyanthos* | 53 | | | 85 | 90 | | | | | |
| *Lunularia cruciata* | 58 | | 54 | 58 | 65 | | | | | |
| *Pellia endiviifolia* | 80 | 57 | | 58 | | | 62 | | | |
| *Vaucheria* sp(p). | 80 | 77 | | 85 | 71 | 81 | 66 | 66 | | |
| *Hildenbrandia rivularis* | 69 | 57 | | | 74 | | 97 | 84 | | |
| *Cinclidotus fontinaloides* | 51 | | | | 74 | | 86 | 74 | | |
| *Petasites hybridus* | 78 | | | | | 72 | | 63 | | |
| *Conocephalum conicum* | 82 | 70 | 58 | 69 | 87 | 59 | 66 | 71 | | |
| *Verrucaria* sp(p). | 96 | 75 | | 89 | 90 | 69 | 100 | 99 | 91 | |
| *Amblystegium fluviatile* | 87 | 54 | | | 71 | 72 | 72 | 91 | 62 | |
| *Cladophora glomerata* agg. | 84 | 84 | | | 81 | 97 | 97 | 96 | 76 | |
| *Juncus acutiflorus* | 51 | 70 | | 85 | 81 | 59 | 62 | 82 | 89 | |
| *Equisetum arvense* | 58 | | | 58 | | 66 | 83 | 66 | 89 | |
| *Deschampsia cespitosa* | 56 | | 54 | | | | | | | 40 |
| *Veronica beccabunga* | 62 | 84 | 58 | | | 78 | 79 | | 76 | 80 |
| *Myosotis scorpioides* | 62 | 86 | 54 | | | 91 | 100 | 88 | 98 | 85 |
| *Filipendula ulmaria* | 53 | 62 | 75 | 85 | 77 | | | 79 | 94 | 80 |
| *Mentha aquatica* | 78 | 86 | 67 | 62 | 77 | 88 | 83 | 99 | 98 | 65 |
| *Epilobium hirsutum* | 76 | 91 | 75 | | | 94 | 86 | 72 | | 60 |
| *Agrostis stolonifera* | 100 | 97 | 96 | 96 | 100 | 100 | 100 | 99 | 100 | 90 |
| *Rhynchostegium riparioides* | 100 | 87 | 71 | 100 | 100 | 91 | 100 | 94 | 85 | 45 |
| Trees | 96 | 96 | 96 | 100 | 100 | 91 | 83 | 82 | 79 | 65 |
| *Fontinalis antipyretica* | 91 | 78 | 63 | 92 | 94 | 88 | 97 | 97 | 93 | 55 |
| *Phalaris arundinacea* | 87 | 91 | 63 | 100 | 100 | 100 | 100 | 97 | 98 | 100 |
| *Salix* sp(p). | 84 | 83 | 88 | 96 | 97 | 97 | 66 | 94 | 81 | 60 |
| *Solanum dulcamara* | | 84 | 88 | 81 | 71 | 56 | | | | |
| *Sparganium erectum* | | 81 | 75 | 100 | 65 | 91 | 86 | 74 | 100 | 55 |
| *Ranunculus penicillatus* subsp. *pseudofluitans* | | 51 | | | | | | | | |
| *Apium nodiflorum* | | 74 | 42 | | | | | | | |
| Ferns | | | 58 | | | | | | | |
| *Pellia epiphylla* | | | 67 | 54 | | | | | | |
| *Sparganium emersum* | | | | 81 | | | | | | |
| *Callitriche hamulata* | | | | 77 | | | | | | |
| *Lythrum salicaria* | | | | 58 | 71 | | | | | |
| *Eupatorium cannabinum* | | | | 50 | 74 | | | | | |
| *Scrophularia auriculata* | | | 50 | | | 59 | | | | |
| *Fontinalis squamosa* | | | | | 77 | | | | | |
| *Impatiens glandulifera* | | | | | 58 | 75 | | 66 | | |
| *Brachythecium rutabulum* | | 51 | 50 | | | | | 60 | | |
| *Juncus effusus* | | 65 | 54 | 50 | | | | 59 | 89 | 80 |
| *Glyceria fluitans* | | 62 | 42 | 89 | 61 | | | | 70 | 65 |
| *Rorippa nasturtium-aquaticum* | | 58 | 42 | | | | | | 70 | 35 |
| *Angelica sylvestris* | | 52 | 63 | | | | | | 53 | |
| *Callitriche stagnalis* | | | 67 | | | | | | 76 | 35 |
| Filamentous green algae | | | 58 | | 61 | | | 81 | 85 | 55 |
| *Lemanea fluviatilis* | | | | 73 | 77 | | 66 | 74 | | |
| *Myriophyllum alterniflorum* | | | | 81 | 74 | | | | 68 | |
| *Ranunculus penicillatus* subsp. *penicillatus* | | | | 65 | | | | | | 40 |
| *Caltha palustris* | | | | | 58 | | 76 | 74 | 85 | 60 |
| *Symphytum officinale* | | | | | | 63 | | | | |

**Table 10** *(continued)*

| | Sub-type | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Taxon* | *BVa* | *BVb* | *BVc* | *BVd* | *BVe* | *BVIa* | *BVIb* | *BVIc* | *BVId* | *BVIe* |
| *Polygonum amphibium* | | | | | | 72 | | | 55 | 60 |
| *Rorippa palustris* | | | | | | 56 | | | | |
| *Ranunculus fluitans* | | | | | | 94 | 97 | | | |
| *Myriophyllum spicatum* | | | | | | 78 | 69 | | | |
| *Potamogeton perfoliatus* | | | | | | | 59 | | | |
| *Rorippa sylvestris* | | | | | | 75 | 83 | 60 | | 35 |
| *Elodea canadensis* | | | | | | 75 | 86 | 63 | 59 | 30 |
| *Rorippa amphibia* | | | | | | 72 | | | 55 | 60 |
| *Mimulus guttatus* | | | | | | 56 | 72 | 74 | 87 | 65 |
| *Eleocharis palustris* | | | | | | | | 59 | | |
| *Alopecurus geniculatus* | | | | | | | | | 64 | |
| *Potamogeton crispus* | | | | | | | | | 53 | |
| *Stachys palustris* | | | | | | | | | 53 | |
| *Cardamine amara* | | | | | | | | | | 65 |
| *Iris pseudacorus* | | | | | | | | | | 45 |
| *Sagina procumbens* | | | | | | | | | | 45 |
| *Juncus articulatus* | | | | | | | | | | 40 |
| *Tussilago farfara* | | | | | | | | | | 40 |
| *Equisetum palustre* | | | | | | | | | | 35 |
| % occurrence of 30th most common taxon | 51 | 51 | 42 | 50 | 58 | 56 | 59 | 59 | 53 | 30 |

Sites in BVc are widely scattered in England and Wales and, as with sub-type BVb, are most typically very isolated outlier sites in lowland England that are not classified into Group A. In contrast to BVb, most sites are located on rivers where clay is important within the catchment. Typical rivers include the Weald rivers on sand and clay, such as the Teise and East Sussex Rother, and the Fraw and Cefni on Anglesey. Whilst sites typically indicate more acidic catchment conditions than in BVb (e.g. New Forest Beaulieu and Uddens), very impoverished sites on calcareous clays (e.g. Burry Pill, Gypsey Race and Eau) are common.

## *BVd Western, stable rivers on sandstone and shales (NN sub-type BVe)*

Sub-types BVd and BVe are very characteristically found on hard sandstone and shale geology (typically calcareous shale), and are absent from hard limestone and soft sandstone. Typically, sites in sub-type BVd have finer substrates than sites in BVe, being dominated by gravel and pebbles, with minimal bedrock and boulders present. Sites also tend to be narrower (usually less than 10 m wide) and are shallow, being virtually always under 0.5 m deep.

The finer sediment means that BVd communities have a high proportion of truly aquatic vascular plants. Some of the more common species include *Sparganium emersum, Callitriche hamulata, Myriophyllum alterniflorum* and *Ranunculus penicillatus* subsp. *penicillatus*. The communities also often contain a wide variety of bank species common in Group A rivers (e.g. *Eupatorium cannabinum* and *Lythrum salicaria*), and aquatics of contrasting habitat needs (e.g. *Sparganium erectum, Rhynchostegium riparioides, Amblystegium riparium* and *Chiloscyphus polyanthos*) are all invariably present alongside each other. Relatively uncommon species within the sub-type, such as *Scrophularia auriculata, Alisma lanceolatum, Galium palustre, Alopecurus geniculatus* and *Stellaria alsine*, are far more commonly found in BVd than in BVe.

Communities of sub-type BVd are confined to western Britain, typically south-west England and south-west Wales. The Torridge and Tamar, together with their more lowland tributaries, typify the sub-type in the former region and the Teifi and Western Cleddau are typical in the latter region. All examples are on rivers where some features typical of Group A are evident (e.g. lower altitudinal sources or presence of large upland plateaux giving downstream stabilisation). However, because of the coarser substrates and the sites' extreme western distribution, the communities present do not have enough species typical of lowlands and enriched conditions to be classified into Group A.

## *BVe Lowland, large rivers in south-west England and Wales (NN sub-type BVd)*

Differences between sub-types BVe and BVd are highlighted by the much coarser substrates of the former, which is dominated much more by cobbles, bedrock and boulders. Sites also tend to be wider (usually at least 10 m wide) and deeper. Sites tend to be at lower altitudes (usually under 50 m) than is typical for most Group B communities, and the mean gradient is the slackest of any type V sub-type.

Despite the lower altitude and slacker gradients, the coarse sediment characteristics are the primary determinants of the communities. In contrast to BVd, there is a relatively low proportion of truly aquatic vascular plants present. Whilst *Myriophyllum alterniflorum, Rhynchostegium riparioides* and *Chiloscyphus polyanthos* are more-or-less as prevalent as in BVd, *Sparganium emersum, Callitriche hamulata, Ranunculus*

*penicillatus* subsp. *penicillatus* and *Amblystegium riparium* occur much more rarely. In contrast, species present on rock, such as *Hildenbrandia rivularis, Fontinalis squamosa, Cinclidotus fontinaloides, Schistidium alpicola* and *Cladophora aegagropila* occur much more commonly. Reflecting the lowland location of sites in the sub-type, bank communities commonly support species often found abundantly in Group A; typical species include *Impatiens glandulifera, Eupatorium cannabinum, Lythrum salicaria, Phalaris arudinacea* and *Agrostis stolonifera.*

Communities of sub-type BVe, like those in BVd, are more or less confined to western Britain, again most typically south-west England and south-west Wales. The lower (and much larger) reaches of the same rivers in which BVd communities exist upstream are most typical. The lower Torridge, Tamar and Teifi exemplify the sub-type, but sites on the Exe, Elwy and Welsh Dee indicate that more calcareous low-gradient rivers with moorland in their upper catchments are also represented.

## Type VI Sandstone, mudstone and hard limestone rivers of Scotland and Northern England

### *BVIa Lowland, large mesotrophic rivers on limestone or sandstone (NN sub-types BVIb/ BVIc)*

The majority of sites in this sub-type are found on soft sandstone, with a strong calcareous influence arising from their presence on limestone and calcareous shales. Sites commonly occur at low altitudes on rivers that rise at high altitudes (but not as high as in sub-types BVIb or BVc). Gradient is the most shallow for any Group B sub-type. Rivers are generally wide and it is extremely rare to find a site narrower than 10 m wide; sites are generally much deeper than is normal for Group B rivers.

The shallow gradient and low altitude (also common in sub-type BVIb) are reflected in the much higher proportions of species typical of lowland Group A rivers found in these two sub-types than in type B rivers generally. Examples include *Myriophyllum spicatum, Elodea canadensis* and *Vaucheria* sp(p)., with *Ranunculus fluitans, Symphytum officinale, Rorripa sylvestris* and *Rorippa amphibia* characteristic. The community typically contains a variety of truly aquatic vascular plants associated with fine sediments alongside a wide range of lower plants associated with gravels and shingle banks.

Typical rivers in this sub-type with communities well represented include the lower reaches of the Derbyshire Dove, Teme, Tweed, Wharfe and Usk. All rise at high altitude on moorland but then traverse basic hard rocks before becoming relatively big rivers with slack gradients in their lowlands.

### *BVIb Large, lowland reaches of meso-eutrophic rivers with upland sources (NN sub-type BVIc)*

In common with BVIa, many sites are found on soft sandstone, but others are found on non-calcareous shales as well as hard sandstone and limestone. Sites commonly occur at low altitudes on rivers that rise at high altitudes (the highest mean for all Group B sub-types. Gradient is atypically shallow for a Group B sub-type, but not as extremely shallow as in BVIa.

Rivers are generally wide, normally exceeding 20 m, but no deeper than normal for the wide rivers in sub-types BVIa-BVIc. Reflecting the shallow gradient and low altitude, much higher proportions of species typical of lowland Group A rivers are present in sub-type BVIb than in BVIc. Examples include *Potamogeton perfoliatus* (occurring more than ten times as frequently), *Enteromorpha* sp(p)., *Myriophyllum spicatum, Ranunculus penicillatus* subsp. *penicillatus, Potamogeton pectinatus* (more than five times as common) and *Ranunculus fluitans, Lemna minor* and *Zannichellia palustris* (more than three times as common). The community typically contains a variety of truly aquatic vascular plants associated with fine sediments alongside a wide range of lower plants associated with rock substrates. Common examples of the latter include *Hildenbrandia rivularis, Verrucaria* sp(p)., *Cinclidotus fontinaloides, Rhynchostegium riparioides* and *Fontinalis antipyretica.*

Relatively few rivers are classified into this sub-type, the Eden and Ribble in north-west England typifying it. Both rivers, together with outliers such as the Usk and Wharfe, are characterised by having an upland source in moorland before descending into lowlands and traversing more base-rich geological strata.

### *BVIc Middle reaches of upland rivers traversing richer strata (NN sub-type BVId)*

Sites may be located on hard limestone, soft sandstones, hard sandstone and shales. Rivers rise at high altitudes (as in sub-type BVIb), and sites are typically at higher altitudes and with a steeper gradient than is typical in the nearest-neighbour sites. In common with all sub-groups BVIa-BVIc, mixed substrates are typical, but shallower depths predominate in BVIc. The typically smaller size, higher site altitudes and steeper gradients lead to fewer aquatic vascular plants being present, unless they are species associated with more oligo-mesotrophic conditions of Group C rivers; a typical example is *Myriophyllum alterniflorum*, which occurs more than ten times as commonly in BVIc than in BVIb. Edge species such as *Equisetum palustre, Mimulus guttatus, Rorippa palustris, Tussilago farfara* and *Juncus effusus* also occur more than three times as commonly, and *Eleocharis palustris* is also more common. Many of the common algae and bryophytes of BVIb (which are much less frequent in BVIa) are also common in BVIc. Typical examples include *Hildenbrandia rivularis, Lemanea fluviatilis* and *Cinclidotus fontinaloides.*

Many more rivers are represented in this sub-type than in BVIb. Extensive middle reaches of the large rivers where BVIb is typical in the lower reaches (e.g. Eden, Ribble, Wharfe, Usk) all typically support BVIc communities. BVIc communities also occur on many smaller tributaries of these rivers (e.g. Petterill, Eamont, Hodder) and middle reaches of many larger rivers in the Pennines and Lake District (e.g. Lune, Ure, Wharfe) and where more rich geological strata are traversed by rivers below moorland (e.g. Garnock, Ithon, Tweed, Tyne).

## *BVId Small, low-gradient meso-eutrophic rivers (NN sub-type BVIe)*

In common with its nearest neighbour BVIe, these are the only sub-types within Group B where the geology is typically base-rich hard rock. In contrast to BVIe, most of the other sites in BVId are on hard sandstone. A wide range of substrates and flow types are also represented in both sub-types, with sites being much narrower than is typical for BVIa-BVIc rivers. Gradient is slack, almost half that of BVIe, with the sources of rivers in BVId being typically at lower altitudes than in other type VI sub-types. A large number of taxa occur far more frequently in BVId than in BVIe, such as the algae *Cladophora* spp., *Vaucheria* sp(p). and *Hildenbrandia rivularis*, the lichens *Collema dichotomum*, *Dermatocarpon fluviatile* and *Verrucaria* spp. (all more than ten times as frequent), the bryophytes *Amblystegium riparium*, *A. fluviatile* and *Cinclidotus fontinaloides* (all more than ten times as frequent) and the aquatic vascular plants *Potamogeton crispus*, *Myriophyllum alterniflorum* and *Glyceria maxima*.

More than 90% of sites are in Scotland, the most typical examples being on the most productive farmland associated with the lower land and richer soils of the east coast. The Bervie Water, Dean Water, Don, Eden, Lunan Water, Ugie and Ythan typify the sub-type.

## *BVIe Small, basic, upland rivers (NN sub-type BVIe)*

As in Group C, hard rock dominates sites in this sub-type of Group B, with hard limestone, hard sandstone and hard base-poor rocks typical. Sites are generally at higher altitudes than in other sub-types of type VI, with a mixture of wide and shallow rivers represented. In common with sub-type BVa only, gradient is atypically steep for Group B rivers, but silt and sand are more prevalent as substrates than in any other Group B sub-type. Many of the common species of other sub-types in Group B rarely occur in BVIe; the most typical are species which indicate eutrophic conditions, such as *Vaucheria*, *Cladophora* and *Amblystegium fluviatile*. The calcareous nature of the substrate is reflected in the more than ten times greater frequency of species such as *Ranunculus penicillatus*. subsp. *pseudofluitans*, *Apium nodiflorum*, *Carex riparia* and *Juncus inflexus*.

The sub-type has relatively few sites, typically found in the Borders (Annan, Blackadder Water, Coquet, Kale Water) and in the Lake District (Kent). Other outliers include the Yorkshire Dove and Clun. The vast majority of these rivers have basic rock geology at relatively high altitude.

# 5.5 Rivers in Group C, sub-types CVIIa–CVIIIe

Types VII and VIII in Group C are further sub-divided into ten sub-types. Table 11 summarises the physical characteristics of sites in sub-types CVIIa and CVIIIe. Table 12 shows the 30 most common taxa in each sub-type of Group C. The nearest neighbour (NN) for each sub-type within the classification is shown to enable easy comparison.

## Type VII Mesotrophic rivers dominated by gravels, pebbles and cobbles

### *CVIIa Small, shallow, high-altitude hard limestone and sandstone rivers (NN sub-type CVIIb)*

In common with nearest neighbour CVIIb, sites are invariably on hard limestone and hard sandstone with no other rock type represented by more than 10% of sites. Both CVIIa and CVIIb typically have sources at much higher altitudes than CVIIc or CVIId, with CVIIa typically occurring at much higher altitudes than other type VII river communities. Slope is also much steeper, being approximately twice that of CVIIb and four times that of CVIId. Because most CVIIa sites are in the headwaters, none is more than 20 m wide and they are typically very shallow (the narrowest and shallowest examples within Group C). However, finer sediments are more prevalent than in other Group C sub-types.

Over 25 species occur more than five times as commonly in sub-type CVIIa than in CVIIb. Many reflect the greater influence of base-rich rock in CVIIa (e.g. *Cinclidotus fontinaloides* and *Amblystegium fluviatile*), while others reflect the presence of fine sediments (e.g. *Carex vesicaria, Myriophyllum spicatum, Veronica anagallis-aquatica* and *Sparganium emersum*). Because of the stable influence of groundwater and the higher base status, several species of Groups A and B are more common in this sub-type of C than in any other. Typical examples (other than some of those mentioned above) include *Alopecurus geniculatus, Rorippa nasturtium-aquaticum* and *Veronica beccabunga*. Bryophytes are less well represented than is typical for Group C sub-types.

There are few examples in this sub-type, and sites are widely scattered in upland headwater reaches of rivers where a distinct calcareous influence to a predominantly moorland character is typical. Examples include Briggle Beck, Cowside Beck, Gordale Beck and Malham Tarn outflow in northern England and the Ythan, Wick and Loch Croispol streams in Scotland.

### *CVIIb Mesotrophic rivers with strong calcareous influence (NN sub-type CVIIc)*

The geology of sites within CVIIb is dominated, as in CVIIa, by hard limestone and hard sandstone, but physical features are different. Site altitudes are much lower and gradients are much slacker, with a great variety of widths, depths and general habitat features. Riffles, runs and rapids over cobbles, boulders and bedrock are prevalent. Bedrock and boulders are more common than in any other CVII sub-type and fine sediments are scarce.

*Marchantia polymorpha* and *Montia sibirica* are more than ten times as common in CVIIb than in CVIIa, with *Ranunculus penicillatus* subsp. *penicillatus, Conocephalum conicum* and *Phalaris arundinacea* more than three times as common. The community includes some elements indicative of base-rich conditions (but less so than in CVIIa), together with more bryophytes and other vascular plants at the margins than in CVIIa. Other typical taxa include *Cardamine amara* and *Eleocharis palustris*, with trees also much more common on the banks. Sites often have unstable channels and macrophytes are primarily confined to the margins or banks or on bedrock; consequently sites are typically unproductive and very species-poor.

Sites of this sub-type are rarely found outside northern England and southern Scotland, where more-basic rocks are exposed by rivers flowing from extensive heathy uplands. Typical examples are the Annan, Whiteadder Water, Coquet, Kent and Nevern.

### *CVIIc Lowland, mesotrophic rivers with acidic feeders (NN sub-type CVIId)*

Sites of this sub-type occur on a variety of rock types, including hard limestone, hard sandstone, soft sandstones, non-calcareous shales and base-rich hard rock. Compared with other Group C sub-types, sites of this sub-type are very typically at extremely low altitudes (i.e. under 50 m, approximately 3–5 times lower than other sub-types of CVII). Substrates vary, but silt is more common than in any other Group C sub-type. Sites in CVIIc are typically deeper than is typical for Group C and wider than is typical for type VII, reflecting the fact that they are the most lowland reaches of oligo- mesotrophic rivers.

Far more species typical of Group B occur than is typical for sub-types in Group C, reflecting the low site altitude and typically greater width and the fact that few of the rivers rise in mountains. Vascular plants, many of them truly aquatic, are more common in this sub-type than is typical for Group C sites, although bryophytes are much less common. Examples of atypically common species include *Hydrocotyle vulgaris, Impatiens glandulifera, Lythrum salicaria, Alisma plantago-aquatica, Juncus articulatus* and *Phragmites australis* (all more than ten times more frequent than in CVIId), plus *Lycopus europaeus, Apium nodiflorum, Callitriche obtusangula, Potamogeton natans, Sparganium emersum* and *Littorella uniflora*.

There are few examples of this sub-type and sites are spread throughout Great Britain, from the acid New Forest (e.g. Dockens Water and Oberwater) to Wales (e.g. Llyfni and Dysynni) and Scotland (e.g. Bladnoch and Cree).

### *CVIId Mesotrophic, upland plateau rivers (NN sub-type CVIIc)*

Rock types in CVIId differ from other type VII sub-types in that they are dominated by shales and base-rich hard

**Table 11** Physical characteristics of sites in sub-types of Group C: CVIIa–CVIIIe

| | *Sub-type* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *CVIIa* | *CVIIb* | *CVIIc* | *CVIId* | *CVIIIa* | *CVIIIb* | *CVIIIc* | *CVIIId* | *CVIIIe* |
| *Number of taxa* | | | | | | | | | |
| Mean | 36 | 22 | 30 | 37 | 27 | 40 | 36 | 49 | 42 |
| Minimum | 20 | 7 | 6 | 24 | 7 | 19 | 15 | 36 | 24 |
| Maximum | 55 | 43 | 47 | 50 | 42 | 56 | 55 | 70 | 67 |
| *Geology (% occurrence (>10%) at sites)* | | | | | | | | | |
| Alluvium | | | | | | | | | |
| Calcareous clay | | | | | | | | | |
| Non-calcareous clay | | | | | | | | | |
| Chalk | | | | | | | | | |
| Other soft limestone | | | | | | | | | |
| Hard limestone | 31 | 48 | 22 | | | | 25 | | 16 |
| Soft sandstone | | | 22 | | | | | 13 | |
| Hard sandstone | 31 | 35 | 17 | | 44 | 18 | 14 | | |
| Calcareous shale | | | | 23 | | | 18 | | |
| Non-calcareous shale | | | 11 | 46 | 17 | 58 | 21 | 28 | 29 |
| Hard rock (base-rich) | | | 22 | 27 | | | | 26 | |
| Hard rock (base-poor) | | | | | | | | 21 | 16 |
| *Height at source (m)* | | | | | | | | | |
| Mean | 435 | 417 | 263 | 379 | 302 | 464 | 503 | 598 | 589 |
| Minimum | 20 | 240 | 35 | 152 | 130 | 100 | 240 | 140 | 250 |
| Maximum | 696 | 700 | 810 | 640 | 853 | 1,210 | 853 | 1,210 | 1,210 |
| *Altitude of site (m)* | | | | | | | | | |
| Mean | 207 | 126 | 45 | 142 | 103 | 98 | 115 | 95 | 206 |
| Minimum | 20 | 18 | 5 | 10 | 30 | 15 | 15 | 15 | 10 |
| Maximum | 275 | 265 | 152 | 229 | 244 | 274 | 305 | 213 | 425 |
| *Slope (km per 15 m fall)* | | | | | | | | | |
| Mean | 2.5 | 4.3 | 5.7 | 10.6 | 3.2 | 5.7 | 3.6 | 7.3 | 2.4 |
| Minimum | 0.5 | 0.6 | 1.1 | 0.7 | 0.2 | 1.0 | 0.3 | 1.0 | 0.2 |
| Maximum | 8.1 | 21 | 15 | >25 | 8.7 | 22 | 9 | >25 | 16 |
| *Substrates (% occurrence at sites)* | | | | | | | | | |
| Silt/mud | 31 | 17 | 44 | 18 | 3 | 1 | 7 | 0 | 0 |
| Sand | 15 | 9 | 11 | 41 | 11 | 3 | 5 | 3 | 2 |
| Clay | 0 | 0 | 11 | 9 | 3 | 0 | 0 | 0 | 0 |
| Gravel | 23 | 22 | 50 | 59 | 25 | 22 | 9 | 21 | 4 |
| Pebbles | 62 | 35 | 33 | 59 | 53 | 45 | 36 | 44 | 26 |
| Cobbles | 62 | 61 | 39 | 36 | 36 | 67 | 68 | 74 | 82 |
| Boulders | 15 | 48 | 22 | 0 | 33 | 40 | 57 | 49 | 78 |
| Bedrock | 0 | 35 | 6 | 0 | 28 | 12 | 36 | 10 | 24 |
| *Habitats (% occurrence at sites)* | | | | | | | | | |
| Pools | 23 | 4 | 11 | 0 | 8 | 4 | 7 | 3 | 2 |
| Slacks | 54 | 17 | 78 | 82 | 72 | 78 | 71 | 82 | 49 |
| Riffles | 31 | 65 | 22 | 0 | 28 | 1 | 11 | 0 | 9 |
| Runs | 46 | 61 | 50 | 73 | 47 | 74 | 73 | 85 | 86 |
| Rapids | 0 | 26 | 6 | 0 | 33 | 37 | 48 | 39 | 58 |
| *Width (m) (% occurrence at sites)* | | | | | | | | | |
| <5 | 62 | 17 | 56 | 41 | 50 | 19 | 11 | 8 | 36 |
| 5–10 | 31 | 61 | 17 | 36 | 58 | 43 | 46 | 28 | 42 |
| 10–20 | 15 | 26 | 33 | 27 | 19 | 51 | 55 | 31 | 35 |
| >20 | 0 | 17 | 28 | 23 | 3 | 26 | 23 | 56 | 20 |
| *Depth (m) (% occurrence at sites)* | | | | | | | | | |
| <0.25 | 100 | 48 | 61 | 73 | 86 | 74 | 91 | 80 | 93 |
| 0.25–0.5 | 23 | 52 | 33 | 32 | 53 | 44 | 46 | 56 | 29 |
| 0.5–1.0 | 0 | 26 | 39 | 9 | 17 | 3 | 5 | 8 | 4 |
| >1.0 | 0 | 17 | 33 | 27 | 3 | 15 | 2 | 13 | 2 |

**Table 12** Percentage frequency of occurrence of the 30 most common taxa in sub-types of Group C: CVIIa–CVIIIe

| | *Sub-type* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Taxon* | *CVIIa* | *CVIIb* | *CVIIc* | *CVIId* | *CVIIIa* | *CVIIIb* | *CVIIIc* | *CVIIId* | *CVIIIe* |
| *Alopecurus geniculatus* | 77 | | | | | | | | |
| *Carex rostrata* | 46 | | | | | | | | |
| *Carex flacca* | 46 | | | | | | | | |
| *Rorippa nasturtium-aquaticum* | 77 | 30 | | | | | | | |
| *Veronica beccabunga* | 92 | 61 | | | | | | | |
| *Equisetum palustre* | 62 | 39 | | | | | | | |
| *Mimulus guttatus* agg. | 54 | 30 | | | | | | | |
| *Juncus articulatus* | 46 | 65 | | | | | | | |
| *Anthoxanthum odoratum* | 46 | 52 | | | | | | | |
| *Cardamine amara* | | 48 | | | | | | | |
| *Eleocharis palustris* | | 44 | | | | | | | |
| *Ranunculus penicillatus* subsp. *penicillatus* | | 35 | | | | | | | |
| *Brachythecium rutabulum* | | 30 | | | | | | | |
| *Stachys palustris* | | 30 | 61 | | | | | | |
| *Callitriche stagnalis* | | 35 | 72 | 64 | | | | | |
| *Equisetum fluviatile* | 54 | | 44 | 73 | | | | | |
| *Sparganium erectum* | 46 | | 50 | 86 | | | | | |
| *Alisma plantago-aquatica* | | | 61 | | | | | | |
| *Stellaria alsine* | | | 56 | | | | | | |
| *Lythrum salicaria* | | | 50 | | | | | | |
| *Apium nodiflorum* | | | 50 | | | | | | |
| *Potamogeton natans* | | | 39 | | | | | | |
| *Senecio aquaticus* | | | 61 | 59 | | | | | |
| *Galium palustre* | | | 56 | 73 | | | | | |
| *Oenanthe crocata* | | | 78 | | 72 | 71 | | | |
| Ferns | | | 61 | 55 | 78 | 56 | 57 | 87 | |
| *Callitriche hamulata* | | | 56 | 86 | | 63 | | 82 | |
| *Angelica sylvestris* | 54 | 48 | 56 | 82 | 42 | | | | |
| *Myosotis scorpioides* | 77 | 74 | 50 | 77 | | 59 | 57 | | |
| *Deschampsia cespitosa* | 62 | 48 | 72 | | 39 | | 57 | 72 | |
| *Glyceria fluitans* | 92 | 57 | 72 | 100 | 58 | 75 | | 80 | |
| *Filipendula ulmaria* | 77 | 78 | 50 | 77 | 47 | 73 | 64 | 80 | |
| *Ranunculus flammula* | 69 | | 61 | 73 | | 69 | | 97 | 75 |
| *Mentha aquatica* | 69 | 44 | 67 | 86 | | 86 | 61 | 90 | 67 |
| *Salix* sp(p). | 54 | 78 | 78 | 91 | 83 | 95 | 80 | 90 | 78 |
| *Calliergon cuspidatum* | 69 | | | | | | | | 69 |
| *Tussilago farfara* | 54 | 52 | | | | | 64 | | 71 |
| *Sagina procumbens* | 54 | 52 | | | | | 71 | | 71 |
| *Caltha palustris* | 100 | 70 | 56 | 68 | | 64 | 59 | 95 | 67 |
| *Agrostis stolonifera* | 92 | 91 | 94 | 96 | 94 | 99 | 100 | 95 | 91 |
| *Fontinalis antipyretica* | 62 | 61 | 50 | 86 | 61 | 86 | 84 | 95 | 91 |
| *Rhynchostegium riparioides* | 92 | 44 | | 86 | 89 | 95 | 98 | 90 | 98 |
| Filamentous green algae | 85 | 52 | | 68 | 61 | 78 | 75 | 90 | 96 |
| *Juncus effusus* | 77 | 74 | 83 | 91 | 42 | 74 | | 85 | 80 |
| *Carex nigra* | 54 | | | | | | | 72 | 67 |
| *Juncus acutiflorus* | 46 | | 67 | 100 | 36 | 90 | 71 | 100 | 84 |
| *Phalaris arundinacea* | | 91 | 83 | 96 | 67 | 97 | 64 | 92 | |
| Trees | | 78 | 72 | 73 | 97 | 90 | 86 | 92 | 76 |
| *Pellia epiphylla* | | 30 | 50 | 68 | 89 | 71 | 59 | 85 | 71 |
| *Myriophyllum alterniflorum* | | | | 86 | | 64 | | 92 | |
| *Chiloscyphus polyanthos* | | | | 68 | 86 | 88 | 80 | 85 | |
| *Verrucaria* sp(p). | | | | 64 | 67 | 96 | 75 | 92 | 82 |
| *Achillea ptarmica* | | | | 73 | | | | 92 | 67 |
| *Carex remota* | | | | | 56 | | | | |
| *Vaucheria* sp(p). | | | | | 44 | | | | |
| *Lunularia cruciata* | | | | | 42 | | | | |

**Table 12** (*continued*)

| | Sub-type | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Taxon* | *CVIIa* | *CVIIb* | *CVIIc* | *CVIId* | *CVIIIa* | *CVIIIb* | *CVIIIc* | *CVIIId* | *CVIIIe* |
| *Conocephalum conicum* | | | | | 75 | 69 | 89 | | |
| *Thamnobryum alopecurum* | | | | | 69 | 59 | 66 | | |
| *Dermatocarpon fluviatile* | | | | | | 60 | | | |
| *Dichodontium pellucidum* | | | | | | | 66 | | |
| *Cinclidotus fontinaloides* | | | | | | | 66 | | |
| *Hildenbrandia rivularis* | | | | | | | 55 | | |
| *Fontinalis squamosa* | | | | | 56 | 88 | | 85 | |
| *Racomitrium aciculare* | | | | | 36 | | | 74 | |
| *Equisetum arvense* | | | | 55 | | | 59 | | 75 |
| *Hygrohypnum ochraceum* | | | | 55 | 47 | 74 | | 95 | 82 |
| *Lemanea fluviatilis* | | | | | 58 | 74 | 61 | | 78 |
| *Brachythecium rivulare* | | | | | 47 | | 89 | | 84 |
| *Scapania undulata* | | | | | 47 | 51 | | 90 | 66 |
| *Amblystegium fluviatile* | | | | | 36 | 75 | 84 | | 67 |
| *Schistidium alpicola* | | | | | | | 57 | 82 | 82 |
| *Brachythecium plumosum* | | | | | | | 57 | | 69 |
| *Bryum pseudotriquetrum* | | | | | | | | 85 | 75 |
| *Jungermannia atrovirens* | | | | | | | | 74 | 67 |
| *Philonotis fontana* | | | | | | | | | 71 |
| *Hygrohypnum luridum* | | | | | | | | | 69 |
| % occurrence of 30th most common taxon | 46 | 30 | 39 | 55 | 36 | 51 | 57 | 74 | 67 |

rocks and are absent on hard limestone or sandstones. Whilst the proportion of gravel, pebbles and cobbles is typical for Group C rivers, CVIId is unique in having sites that are totally devoid of boulders and bedrock, commonly having sand as substrate. Gradient is also exceptionally shallow for Group C river types.

Because of the shallow gradient and absence of rocks, vascular plants are typically much more important than in any other Group C sub-type. Examples include: *Myriophyllum alterniflorum, Callitriche hamulata, Equisetum fluviatile* and *Sparganium erectum*. Other species that are far more prevalent in CVIId than in CVIIc are *Verrucaria* spp. and *Hygrohypnum ochraceum* (more than ten times as prevalent), *Rhynchostegium riparioides, Carex aquatilis* and *C. rostrata* (more than five times as prevalent) and liverworts *Chiloscyphus polyanthos* and *Scapania undulata*.

Sites are typically associated with mesotrophic rivers that traverse upland plateaux. The classic examples are the Spey in Scotland, as it crosses Loch Insh Marshes, and the Teifi in Wales, where it crosses Tregaron Bog. Short stretches of low-gradient mesotrophic rivers may be classified as CVIId sub-type where the altitudinal source is low (Clettwr, Grannell) or where the influence of large lakes in the upper reaches exerts a stabilising influence on the flow (Dee below Bala Lake).

## Type VIII Oligo-mesotrophic rivers

### *CVIIIa Steep-gradient, low-altitude, sand/shale rivers (NN sub-type CVIIIb)*

In common with CVIIIb, hard sandstone and non-calcareous shale are the only rock types on which sites commonly occur; in contrast to CVIIIb, hard sandstone is by far the most prevalent geology. Whilst altitudinal sources are typically low, gradient is relatively steep. A diverse range of substrates are represented, with channels usually narrower and shallower than is normal for type VIII sites.

Vegetation in CVIIIa sites is often very impoverished compared with sites in other type VIII sub-types. The community is representative for the type, but the small size and steep gradient result in species such as *Achillea ptarmica, Mimulus guttatus, Ranunculus penicillatus* subsp. *penicillatus* and *Senecio aquaticus* being present comparatively rarely; they are more than ten times as likely to occur in sub-type CVIIIb. Similarly 15 other taxa (all but two being vascular plants) have a more than threefold greater frequency of occurrence in CVIIIb than in CVIIIa; typical examples are *Mentha aquatica, Myosotis scorpioides, Ranunculus flammula, Stachys palustris, Myriophyllum alterniflorum* and *Iris pseudacorus*.

Sites are scattered throughout England and Wales but are rarely encountered in Scotland. The most typical sites are in south-west England where river reaches below moorlands (Bodmin, Exmoor or Dartmoor) become enriched; examples include the Fowey, Lyd, Okement and Torridge. The communities on the acid sand rivers of Sussex as they drop steeply from their sources (e.g. Rother) are also classified as CVIIIa.

### *CVIIIb Moderate-gradient shale/sandstone rivers below uplands (NN sub-type CVIIIa)*

In common with CVIIIa, hard sandstone and non-calcareous shale are the only rock types where sites commonly occur; in contrast to CVIIIa, non-calcareous shale is by far the most important. Sites are located at relatively low altitudes where gradient is moderate for the type. A mix of gravel, pebble, cobble and boulder bed is typical, with bedrock or fine sediments very rare.

Many species typical of type VIII occur frequently within the sub-type, but bryophytes and lichens are especially prevalent. These include *Verrucaria* spp. and *Dermatocarpon fluviatile*, with *Rhynchostegium riparioides, Fontinalis antipyretica, F. squamosa, Hygrohypnum ochraceum* and *Chiloscyphus polyanthus* especially typical. Both *Callitriche hamulata* and *Myriophyllum alterniflorum* are common, in contrast to their rare presence in CVIIIa. With a good mix of vascular and non-vascular plants commonly present, communities of CVIIIb are far more diverse than is typical for CVIIIa.

Mesotrophic rivers in the foothills of uplands in England and Wales commonly support sub-type CVIIIb communities; sites are especially typical of western England and Wales and are more rarely encountered in Scotland. Typical examples include the Barle, Exe and Fowey in south-west England, Banwy, Cledlyn, Conwy, Cothi, Dee and Dwyfach in Wales, the Derwent and Greta in the Lake District and the Spey and Ugie Water in north-east Scotland.

## *CVIIIc Base-rich, meso-oligotrophic, upland rivers (NN sub-types CVIIIa/CVIIIb)*

In contrast to the nearest neighbours, sites are not confined to non-calcareous shales and hard sandstones but are equally likely to be found on calcareous shales and hard limestone. This makes the geology atypically calcareous for a type VIII sub-type and more like that of a type VII sub-type. Sites in sub-type CVIIIc tend to be at moderate altitude with moderate slope but often occur on rivers that rise at much higher altitudes than is typical for nearest neighbour sites of sub-types CVIIIa and CVIIIb. They are also typically wider and faster-flowing than sites in these sub-types.

The base-rich nature of the rock is highlighted by the paucity of records of acidic upland mosses such as *Fontinalis squamosa, Hygrohypnum ochraceum, Scapania undulata* and *Racomitrium aciculare* and vascular plants such as *Myriophyllum alterniflorum* and *Juncus effusus*. There is also a much greater abundance of basic indicators (typical of Group B), such as *Fontinalis antipyretica, Schistidium alpicola, Cinclidotus fontinaloides, Amblystegium fluviatile* and *Hildenbrandia rivularis*.

Sites are most typically found where the underlying rock in the uplands of northern England and southern Scotland is basic, with examples in similar situations in Wales also. The Neath, Ogwen, Aber and Clwyd are typical examples in Wales. In northern England the Seven and Hodge Beck are representatives from the North York Moors and the Wharfe and Ure are examples from the Pennines. The Esk is the most typical example from south-west Scotland.

## *CVIIId Large, low-gradient, lowland reaches of upland rivers (NN sub-type CVIIIe)*

Hard rock is the dominant geology in this sub-type, although a small percentage of sites are found on soft sandstone. In common with CVIIIe, CVIIId sites tend to be found in the lower reaches of rivers that rise at atypically very high altitudes. Sites in CVIIId have very shallow gradients compared with other sub-types of type VIII and are often much wider too. Rapids, runs and slacks typify sites, with riffles and pools virtually absent.

Rivers represented in this sub-type are often unconstrained in their lower reaches, giving rise to the formation of gravel shoals and backwaters, where specialist vascular plants such as *Galium boreale* and *Littorella uniflora* occur more than ten times as frequently as in CVIIIe, and *Iris pseudacorus, Potamogeton polygonifolius, Sparganium erectum* and freshwater sponge are also more than five times as common. The more than threefold greater occurrence of species such as *Phalaris arundinacea, Equisetum fluviatile, Oenanthe crocata* and *Eleocharis palustris* indicate that many species associated with Group B rivers occur in this sub-type alongside the more oligotrophic indicators of Groups C and D. Typical common examples of the latter include *Myriophyllum alterniflorum, Callitriche hamulata, Fontinalis squamosa, Bryum pseudotriquetrum* and *Hygrohypnum ochraceum*. A wide range of habitats combined with some relatively stable substrates gives rise to very species-rich assemblages.

Classic examples of this sub-type occur in Scotland, with some outliers in Wales and the Lake District. The lower piedmont reaches of the Spey, Dee and Teith are typical examples in Scotland, and the meso-oligotrophic Brathay and Cocker in the Lake District are also good examples.

## *CVIIIe Small, oligo-mesotrophic reaches of highland rivers (NN sub-type CVIIId)*

Whilst the altitude of river sources of CVIIId and CVIIIe sub-type sites are similar, the typical gradient is three times steeper in CVIIIe than it is in CVIIId, and sites typically occur at much higher altitudes. Sites are also much narrower. Underlying rock is typically hard, and sites are occasionally on hard limestone. Bedrock and boulders dominate the substrate, with gravel very rarely encountered.

The steep gradients and coarse substrates mean that aquatic vascular plants are much rarer than in CVIIIe, with mosses such as *Hygrohypnum luridum* and *Philonotis fontana* more than five times as prevalent as in CVIIId. In contrast, the vascular plants that are typical of CVIIId are rarely present, but rich bryophyte communities are characteristic, with more than ten species occurring in more than 60% of the sites classified into the sub-type.

Many rivers have their upper reaches classified into this sub-type if there is some base-rich influence on the underlying oligotrophic moorland character. Good examples are the Don, Findhorn and Tweed in Scotland.

# 5.6 Rivers in Group D sub-types DIXa–DXe

Types IX and X in Group D are further sub-divided into eight sub-types. Table 13 summarises the physical characteristics of sites in sub-types DIXa–DXe and Table 14 shows the 30 most common taxa in each sub-type of Group D. The nearest neighbour (NN) for each sub-type within the classification is shown to enable easy comparison.

## Type IX Oligotrophic, low-altitude rivers

### *DIXa Lowland, low-gradient, oligotrophic rivers dominated by higher plants (NN sub-type DIXb/DIXc)*

Sites assigned to this sub-type have macrophyte communities that indicate oligotrophic water, but vascular plants totally dominate the communities. The reasons for this dominance are the low altitudes of the rivers at their source and the shallow gradient of sites. This gives rise to low energy regimes, enabling sand and silt to be more common substrates in type DIXa than in any other sub-type of Group D. Typically, sites are smaller and shallower than in other sub-types of Group D, and fast flows associated with runs and rapids are rare compared with other sub-types.

The fine substrates and low energy are reflected clearly in the vegetation, with only two mosses being listed amongst the 30 most commonly recorded taxa. Instead, vascular plants, especially emergent species, totally dominate the community. The greater occurrence of species such as *Hippurus vulgaris, Rorippa nasturtium-aquaticum, Apium nodiflorum* and *Callitriche stagnalis* suggests that sites are rarely base-poor. This is confirmed by the usual absence of such indicators as *Eleogiton fluitans, Callitriche hamulata, Myriophyllum alterniflorum* and *Potamogeton polygonifolius*.

Sites are widely distributed, with examples on the Scottish islands (Benbecula), Scottish mainland (Latheronwheel and Whiteadder Water), England (Coquet) and Wales (Glaslyn).

### *DIXb Hard rock, 'lowland' rivers with vascular plants dominant (NN sub-type DIXc)*

Typically, sites are on hard rock, more sites being significantly associated with base-poor rock than in any other sub-type. Rivers that support this sub-type generally rise at lower altitudes than rivers with other type D communities and the sites themselves are at lower altitudes. Slope, as in other type IX rivers, is more gentle than in type X rivers. Also, in common with other type IX rivers, silt and sand more commonly occur than in type X, with equal amounts of cobbles, boulders and bedrock. Slacker flow characterises sub-type DIXa, with pools and slacks much more common than runs and rapids.

Lower altitudes and slacker gradients over hard rocks lead to more frequent occurrence of many vascular plant aquatics indicative of clean, base-poor water than in other Group D sub-types. Typical species include *Myriophyllum alterniflorum, Menyanthes trifoliata, Juncus bulbosus, Littorella uniflora, Potamogeton polygonifolius, Potamogeton natans* and *Eleogiton fluitans*. Sites tend to have very few species and many are characteristic of moorland; this is exemplified by the common occurrence of *Molinia caerulea*.

The majority of sites within this sub-type are in Scotland, with rivers such as the Brora, Dunbeath Water, Langwell Water and Machrie Water typical.

### *DIXc Base-poor rivers with mixed communities (NN sub-type DIXb)*

Physical characteristics have great similarity with partner sub-group DIXb; river sources and site altitudes are lower than other Group D sub-types and gradients are even slacker than in DIXb. Rock types are very variable, with no single type represented in more than 25% of sites; hard rocks, including hard limestone and hard sandstone, predominate. Fine sediments are far more common than in type X, with clay present in some sites and with the lowest occurrence of boulders and bedrock than in any other Group D sub-type. Slacks and pools are more frequent than runs or rapids, and sub-type DIXc is more likely to be found on wide and deep rivers than DIXb.

Plant communities are typically much richer than in DIXb, characteristically containing a mixture of bryophytes and vascular plants. Many of the species of DIXb are well represented in DIXc, but mosses and liverworts, such as *Pellia epiphylla* and *Fontinalis antipyretica*, are more common in sub-type DIXc than in DIXb and the river margins frequently support species such as *Senecio aquaticus, Myosotis scorpioides, Mentha aquatica, Agrostis stolonifera, Equisetum fluviatile, Eleocharis palustris* and *Filipendula ulmaria*, which are not common moorland plants. Banks are also much more commonly colonised by *Salix* sp(p). and other trees.

## Type X Ultra-oligotrophic rivers

### *DXa Highland rivers with atypically shallow gradients (NN sub-type DXb)*

Sites are predominantly associated with hard rock, especially those that are base-rich, but a large proportion occur on a wide variety of other hard rock types. Altitude at source and site height are typical for type X rivers but gradient is generally very much more gentle than is typical. Substrates are similar to those in other type X rivers, but bedrock is less than a third as common as in the nearest neighbour. The preponderance of slacks and pools is greater than in other type X rivers, with runs predominant.

Bryophytes are often dominant, with many species being more common in this sub-type (or DXe) than in any other; examples include *Dichodontium pellucidum, Calliergon cuspidatum, Brachythecium plumosum, Scapania undulata, Bryum pseudotriquetrum, Hygrohypnum ochraceum, Jungermania atrovirens* and *Hyocomium armoricum*. In contrast, more vascular plant species (e.g. *Caltha palustris, Ranunculus flammula, Salix* spp.,

**Table 13** Physical characteristics of sites in sub-types of Group D: DIXa–DXe

| | *Sub-type* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *DIXa* | *DIXb* | *DIXc* | *DXa* | *DXb* | *DXc* | *DXd* | *DXe* |
| *Number of taxa* | | | | | | | | |
| Mean | 26 | 24 | 37 | 44 | 32 | 19 | 19 | 28 |
| Minimum | 3 | 7 | 23 | 23 | 16 | 1 | 8 | 13 |
| Maximum | 44 | 44 | 62 | 66 | 47 | 33 | 33 | 43 |
| *Geology (% occurrence (>10%) at sites)* | | | | | | | | |
| Alluvium | | | | | | | | |
| Calcareous clay | | | | | | | | |
| Non-calcareous clay | | | | | | | | |
| Chalk | | | | | | | | |
| Other soft limestone | | | | | | | | |
| Hard limestone | 21 | | 11 | | | 17 | 10 | |
| Soft sandstone | | | | | | | | 12 |
| Hard sandstone | 26 | | 15 | | 41 | 40 | 10 | |
| Calcareous shale | | | | | | | | |
| Non-calcareous shale | | | | | | | | 33 |
| Hard rock (base-rich) | 11 | 12 | 24 | 32 | 27 | 23 | 33 | 14 |
| Hard rock (base-poor) | 37 | 68 | 22 | 11 | | 11 | 47 | 12 |
| *Height at source (m)* | | | | | | | | |
| Mean | 191 | 294 | 361 | 465 | 449 | 594 | 481 | 481 |
| Minimum | 10 | 50 | 30 | 109 | 100 | 100 | 130 | 107 |
| Maximum | 750 | 540 | 950 | 1,210 | 780 | 890 | 890 | 1,210 |
| *Altitude of site (m)* | | | | | | | | |
| Mean | 98 | 51 | 79 | 189 | 110 | 231 | 129 | 234 |
| Minimum | 0 | 5 | 5 | 10 | 15 | 10 | 5 | 10 |
| Maximum | 725 | 300 | 335 | 490 | 575 | 750 | 645 | 474 |
| *Slope (km per 15 m fall)* | | | | | | | | |
| Mean | 6.1 | 3.6 | 4.8 | 3 | 4.6 | 1.7 | 1.5 | 1.7 |
| Minimum | 0.3 | 0.2 | 0.1 | 0.2 | 1.6 | 1.2 | 1.2 | 1.3 |
| Maximum | >25 | >25 | >25 | >25 | 5 | 5 | 6 | 10 |
| *Substrates (% occurrence at sites)* | | | | | | | | |
| Silt/mud | 58 | 36 | 33 | 3 | 5 | 0 | 3 | 0 |
| Sand | 32 | 20 | 22 | 0 | 0 | 8 | 0 | 2 |
| Clay | 0 | 0 | 11 | 1 | 0 | 0 | 0 | 0 |
| Gravel | 16 | 20 | 33 | 11 | 32 | 23 | 17 | 14 |
| Pebbles | 32 | 32 | 37 | 43 | 32 | 40 | 40 | 27 |
| Cobbles | 11 | 40 | 44 | 79 | 55 | 85 | 53 | 62 |
| Boulders | 11 | 40 | 35 | 57 | 73 | 79 | 67 | 60 |
| Bedrock | 11 | 32 | 11 | 23 | 77 | 56 | 47 | 26 |
| *Habitats (% occurrence at sites)* | | | | | | | | |
| Pools | 5 | 48 | 24 | 12 | 9 | 4 | 10 | 2 |
| Slacks | 58 | 64 | 63 | 51 | 36 | 25 | 30 | 44 |
| Riffles | 42 | 60 | 35 | 21 | 64 | 69 | 67 | 19 |
| Runs | 16 | 32 | 54 | 76 | 27 | 44 | 7 | 67 |
| Rapids | 26 | 32 | 22 | 43 | 68 | 75 | 60 | 58 |
| *Width (m) (% occurrence at sites)* | | | | | | | | |
| <5 | 74 | 52 | 39 | 41 | 23 | 42 | 70 | 71 |
| 5–10 | 16 | 48 | 35 | 36 | 68 | 50 | 53 | 31 |
| 10–20 | 11 | 28 | 41 | 35 | 50 | 35 | 13 | 12 |
| >20 | 11 | 16 | 26 | 27 | 9 | 21 | 0 | 6 |
| *Depth (m) (% occurrence at sites)* | | | | | | | | |
| <0.25 | 84 | 52 | 52 | 87 | 73 | 65 | 63 | 92 |
| 0.25–0.5 | 47 | 56 | 57 | 37 | 77 | 63 | 73 | 33 |
| 0.5–1.0 | 5 | 44 | 44 | 11 | 23 | 38 | 30 | 6 |
| >1.0 | 11 | 16 | 33 | 1 | 0 | 17 | 17 | 0 |

**Table 14** Percentage frequency of occurrence of the 30 most common taxa in sub-types of Group D: DIXa–DXe

| | *Sub-type* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Taxon* | *DIXa* | *DIXb* | *DIXc* | *DXa* | *DXb* | *DXc* | *DXd* | *DXe* |
| *Equisetum palustre* | 63 | | | | | | | |
| *Veronica beccabunga* | 42 | | | | | | | |
| *Polygonum amphibium* | 37 | | | | | | | |
| *Hippuris vulgaris* | 37 | | | | | | | |
| *Rorippa nasturtium-aquaticum* agg. | 42 | | | | | | | |
| *Apium nodiflorum* | 32 | | | | | | | |
| *Eleogiton fluitans* | | 68 | | | | | | |
| *Potamogeton natans* | | 64 | | | | | | |
| *Menyanthes trifoliata* | | 40 | | | | | | |
| *Callitriche hamulata* | | 40 | | | | | | |
| *Iris pseudacorus* | 37 | 36 | | | | | | |
| *Equisetum fluviatile* | 42 | 64 | 72 | | | | | |
| *Eleocharis palustris* | 63 | 48 | 61 | | | | | |
| *Caltha palustris* | 80 | 44 | 80 | 77 | 64 | | | |
| *Angelica sylvestris* | 37 | 40 | 70 | | 55 | | | |
| *Callitriche stagnalis* | 58 | | | | 59 | | | |
| *Juncus articulatus* | 68 | 40 | 61 | | 86 | 48 | | |
| *Carex rostrata* | | 56 | 65 | | | | | |
| *Myriophyllum alterniflorum* | | 80 | 70 | | | | 20 | |
| *Littorella uniflora* | | 68 | | | | | 23 | |
| *Potamogeton polygonifolius* | | 72 | | | | | 30 | |
| *Juncus bulbosus* | 42 | 100 | 94 | 80 | 77 | 48 | 90 | 83 |
| *Carex nigra* | 63 | 88 | 74 | 87 | 50 | | 40 | 46 |
| *Ranunculus flammula* | 58 | 88 | 94 | 87 | 91 | 42 | 70 | 62 |
| *Juncus effusus* | 74 | 84 | 96 | 91 | 86 | 73 | 57 | 85 |
| *Pellia epiphylla* | | 80 | 80 | 97 | 86 | 71 | 83 | 96 |
| Filamentous green algae | 74 | 76 | | 96 | 64 | 40 | 80 | 87 |
| *Molinia caerulea* | | 72 | 57 | | | 58 | 83 | 52 |
| *Sphagnum* sp(p). | | 72 | | | 55 | 60 | 87 | 81 |
| *Viola palustris* | | 68 | 70 | | 86 | 58 | 53 | 60 |
| Ferns | | 68 | 57 | 64 | | 48 | 67 | 62 |
| *Potentilla erecta* | | 52 | 65 | 72 | 59 | 63 | 77 | 58 |
| *Racomitrium aciculare* | | 52 | 54 | 93 | 82 | 75 | 80 | 77 |
| *Glyceria fluitans* | 95 | 48 | 87 | 64 | | | | 46 |
| *Carex demissa* | | 48 | | | 64 | 44 | 50 | |
| *Salix* sp(p). | 37 | 48 | 72 | 81 | 59 | 50 | 47 | 58 |
| *Anthoxanthum odoratum* | 42 | 44 | 54 | 96 | 68 | 71 | 47 | 85 |
| *Deschampsia cespitosa* | | | 78 | 67 | 64 | 52 | | 58 |
| *Filipendula ulmaria* | 47 | | 74 | 72 | | | | |
| *Galium palustre* | 53 | | 83 | 63 | 55 | | | |
| *Achillea ptarmica* | | | 76 | 80 | | 27 | | |
| *Juncus acutiflorus* | | | 76 | 95 | | 42 | 50 | 65 |
| *Agrostis stolonifera* | 90 | | 76 | 79 | 82 | 42 | | 60 |
| Trees | | | 70 | | 55 | 56 | 30 | 73 |
| *Mentha aquatica* | 37 | | 70 | | | | | |
| *Myosotis scorpioides* | 58 | | 59 | | 50 | | | |
| *Senecio aquaticus* | | | 57 | | 50 | | | |
| *Fontinalis antipyretica* | 53 | | 52 | 77 | 86 | 25 | | |
| *Dichodontium pellucidum* | | | | 64 | | | | |
| *Calliergon cuspidatum* | 37 | | | 64 | | | | |
| *Brachythecium plumosum* | | | | 69 | | 35 | | |
| *Sagina procumbens* | 47 | | | 68 | 77 | 54 | 23 | |
| *Nardus stricta* | | | | 71 | 68 | 54 | 53 | 54 |
| *Scapania undulata* | | | | 89 | | | 73 | 96 |
| *Bryum pseudotriquetrum* | | | | 88 | | | | 54 |
| *Hygrohypnum ochraceum* | | | | 77 | | | | 50 |
| *Jungermannia atrovirens* agg. | | | | 61 | | | | 69 |

**Table 14** *(continued)*

| | Sub-type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Taxon* | *DIXa* | *DIXb* | *DIXc* | *DXa* | *DXb* | *DXc* | *DXd* | *DXe* |
| *Hyocomium armoricum* | | | | 64 | | | | 87 |
| *Hygrohypnum luridum* | | | | | 73 | | | |
| *Marchantia polymorpha* | | | | | 64 | | | |
| *Montia fontana* | 37 | | | | 55 | 27 | | |
| *Chiloscyphus polyanthos* | | | | | 55 | | | |
| *Polytrichum commune* | | | | | | 69 | 70 | 92 |
| *Carex echinata* | | | | | | 38 | 30 | 50 |
| *Philonotis fontana* | | | | | | 38 | | |
| *Tussilago farfara* | | | | | | 27 | | |
| *Juncus squarrosus* | | | | | | 25 | | |
| *Narthecium ossifragum* | | | | | | | 57 | |
| *Blindia acuta* | | | | | | | 57 | |
| *Dicranella palustris* | | | | | | | 30 | |
| *Brachythecium rivulare* | | | | | | | 23 | |
| *Marsupella emarginata* | | | | | | | 57 | 71 |
| *Nardia compressa* | | | | | | | | 60 |
| *Fontinalis squamosa* | | | | | | | | 48 |
| % occurrence of 30th most common taxon | 32 | 44 | 52 | 61 | 55 | 27 | 20 | 46 |

*Filipendula ulmaria* and *Galium boreale*) are present in this sub-type but it lacks the species highly associated with acidic or oligotrophic waters (e.g. *Marsupella emarginata* and *Nardia compressa*). Of the less common species, *Verrucaria* spp., *Dichodontium flavescens*, *Hygrohypnum ochraceum*, *Schistidium agassizii* and *S. alpicola* have a ten times greater chance of being found in DXa than DXb. The same is true for edge species such as *Myrica gale*, *Carex panicea* and *Eleocharis palustris*, reflecting the gentler gradient.

The majority of sites within this sub-type are on the upper reaches of rivers in Scotland, with occasional isolated sites occurring elsewhere on high moorlands (e.g. Barle and Exe on Exmoor; Clwyd and Conwy on Snowdon; Derwent and Eden in the Lake District). Rivers with several sites are typically in extensive uplands and include the Carron, Dee, Findhorn, Inver, Oykel, Teith and Varrigill.

## *DXb Low-altitude bedrock rivers (NN sub-type DXa)*

Sites of this sub-type commonly occur only on hard sandstone and base-rich hard rock – more so than for any other sub-type. Whilst rivers typically have high altitude sources, sites are more likely to be at lower altitudes than in other type X sub-types. Bedrock (especially) and boulders are collectively much more common as substrates than in other sub-types. Sites therefore differ from those in sub-type DXc in being bedrock-dominated, with steep gradients, but at lower altitudes.

Fewer upland/base-poor species (e.g. *Scapania undulata*, *Hygrohypnum ochraceum* and *Hyocomium armoricum*) are recorded, and less frequently, in this sub-type than in other type X sub-types, reflecting the lower altitude, and the bedrock dominance is reflected in the more common occurrence of bryophytes such as *Hygrohypnum luridum*, *Fontinalis antipyretica* and *Chiloscyphus polyanthos*. The lower altitude also results in *Montia fontana*, *Callitriche stagnalis* and trees being common associates, with *Brachythecium rutabulum* and *Juncus articulatus* being ten times more likely to be found than in DXc.

The communities of DXb are strongly associated with Scotland, outliers occurring only on the Aeron in Wales and Knock Ore Gill on the Pennines. The community commonly occurs in the Aros, Brora, Dunbeath Water, Langwell Water and Machrie Water.

## *DXc High altitude, steep gradient rivers rarely on base-poor rocks (NN sub-type DXd)*

In common with DXb, many sites in this sub-type commonly occur on hard sandstone and base-rich hard rock; however, in contrast to DXb, sites also occur sporadically on hard limestone and base-poor hard rock. Rivers with this community typically rise at altitudes higher than in any other type X sub-type and with sites located at altitudes higher than in any sub-type other than DXe. The geology is much more base-rich in this sub-type, with 80% of sites on hard limestone, sandstone or base-rich hard rock, compared with 14% in sub-type DXe. In common only with DXd, a much higher proportion of deep water occurs than is typical for type X rivers. Unstable substrates – pebbles, cobbles and boulders – are collectively more common than is typical in type X.

Bed instability in hostile environments is almost certainly responsible for sites being typically very species-poor, with less than 20 taxa the norm. Despite the high altitudes, many typical species of the uplands are rarely found, owing to bed instability; these include *Nardia compressa*, *Marsupella emarginata*, *Scapania undulata*, *Fontinalis antipyretica* and *Hygrohypnum ochraceum*. The shingle bars which characterise the rivers are commonly colonised by such species as *Philonotis fontana*, *Juncus bulbosus*, *Sagina procumbens*, *Achillea ptarmica*, *Tussilago farfara*, *Montia fontana*, *Deschampsia cespitosa* and *Juncus articulatus*, the last five species being found more than ten times as commonly in DXc sites than in DXd sites.

Sites in this sub-type are scattered throughout Scotland and northern England. Typical examples where several sites occur on the same river include the Allport, Ashop, Derwent, Duddon, Orchy, Roy and Tarff; virtually all sites from source to mouth on the Roy and the Tarff are classified into this sub-type.

## *DXd Oligotrophic rivers of the west coast of Scotland (NN sub-typeDXc)*

The low altitude of sites in this sub-type is very characteristic, even though several rivers where such communities occur have much higher-altitude sources (in common with sites in sub-type DXb). Hard rock is more prevalent than in any other type X sub-type. In common with DXc, assemblages are typically very impoverished, with just 20 taxa frequently recorded.

Characterising the typical community is difficult, since many species with contrasting substrate needs occur relatively frequently. For example, common species typical of rock habitats include *Marsupella emarginata* and *Scapania undulata*, whilst species typical of peaty or gravel substrates include *Sphagnum* spp., *Myriophyllum alterniflorum*, *Juncus bulbosus*, *Littorella uniflora* and *Potamogeton polygonifolius*. *Littorella uniflora* and *Narthecium ossifragum* are more than ten times as common in sub-type DXc as in DXc and *Scapania undulata* and *Blindia acuta* are more than three times as common. The overriding influence on the flora appears to be base-poor, nutrient-poor conditions.

The majority of sites classified within this sub-type are found on the west coast of Scotland. Many sites are located on the short rivers surveyed on the Western Isles, together with rivers such as the Coe and Ulladale.

## *DXe Small, shallow, oligotrophic rivers (NN sub-types DXc/DXd)*

Sites supporting DXe communities are typically at higher altitudes than for most type X sub-types, although not necessarily on rivers that rise at exceptionally high altitudes. Non-calcareous shales and hard rock predominate, but there are several sites on softer sandstones. It is noteworthy that 45% of sites are on soft sandstone or shales, no other sub-type of Group D having a total exceeding 10%. Sites are typically very shallow and, in common with DXd, narrow too. Acid-tolerant species such as *Marsupella emarginata*, *Scapania undulata*, *Fontinalis squamosa*, *Hygrohypnum ochraceum*, *Sphagnum* spp. and *Nardia compressa* all have atypically high occurrences in this sub-type. Species such as *Scapania undulata*, *Fontinalis squamosa*, *Hyocomium armoricum*, *Rhynchostegium riparioides*, *Callitriche hamulata* and *Nardia compressa* all occur more than five times more frequently in DXe than in either of the nearest neighbour sub-types (DXc and DXd), with *Jungermania atrovirens*, *Bryum pseudotriquetrum*, *Hygrohypnum ochraceum* and *Lotus uliginosus* all more than ten times as common.

Sites within this sub-type are scattered throughout Great Britain, the only common factor being base-poor soils. Sites are common in England and particularly so in Wales, although they are infrequent in Scotland. Several lowland outliers occur on the acid heaths of the New Forest (e.g. Highland Water, Blackwater), with other sites in south-west England (e.g. Fowey, Lyd, Okement), Wales (e.g. Cothi, Conwy, Elan, Dysynni, Ystwyth), Lake District and northern England (e.g. Ehen, Dove, Greta) and Scotland (e.g. Machrie Water, Allt Coire Gabhail, Carron).