1

Introduction

Rivers are usually referred to by their local names (e.g. Rhin in France, Rhein in Germany, Rijn in The Netherlands but (English) Rhine in general terms). Prefixes (R (river), F (Fiumi) etc.) and suffixes (Aa, Ach, etc.) are usually omitted since their use is not consistent in the EEC countries.

The River Maps in Chapters 10, 11, 12 and 28, the descriptive notes for which are in Fig. 12.2, p. 220 (and Table 12.2, p. 222) are, for convenience of printing, presented at two different scales (see p. 220). Those at the smaller scale are: Figs. 11.2, 11.3, 12.4, 12.6, 12.8, 12.9, 12.11, 12.12, 12.15, 12.16, 12.18, 12.28, 12.29, 12.30, 12.33, 12.34, 12.36, 12.42, 12.43, 12.46, 12.47, 12.49, 12.53, 12.54, 12.57, 12.58, 28.5, 28.8, 28.11, 28.15, 28.19, 28.21.

The largest cities may be given their anglicised names (Copenhagen for København, Milan for Milan), but smaller ones are referred to by their local names.

This book is about the rivers and other watercourses of the countries of the European Economic Community (EEC): Belgium, Britain, Denmark, France, Germany (Federal Republic), Ireland (Eire and Northern Ireland), Italy, Luxembourg and The Netherlands (see Preface). A small part of south Norway is included to demonstrate a different and more northern region. The area ranges from 37° to 60° north and from 10° west to 18° east (see Fig. 1.1). The climate varies from cool temperate to Mediterranean, and from Atlantic to Continental. The landscape varies from high mountain ranges to coastal plains. Rivers pass over and across the EEC. They form passages of aquatic life that traverse countries and regions, passages which connect in one direction only, downstream. Connections for the plants between river systems or with separate water bodies are only by e.g. bird transport (unless e.g. navigation waterways have been constructed). These passages form aquatic habitats containing a wide range of plant and animal life. Aquatic plants tend to be more widespread and cosmopolitan than land ones, as the special features of the aquatic habitat somewhat lessen the effect of the overall climatic factors. The river vegetation varies less than the terrestrial vegetation over the EEC.

Physiography and river environments

Fig. 1.2 shows some of the principal rivers of the EEC. The study of river vegetation in fact concentrates on the smaller streams, streams which are tributaries of, or lie between the largest rivers. Rivers such as the Rhône and the Rhein have little macrophytic vegetation along most of their length, partly because macrophytes are excluded from their centres by the deep water, and partly because they are often excluded from the sides by cultural changes caused by e.g. pollution, boat-wash and re-channelling (the latter removes shallow water at the edges). The river pattern shown in Fig. 1.2 can be examined in conjunction with the landscape pattern. The EEC has five main mountain ranges, the Pyrenees (on the French–Spanish border), the Massif Central (in SW France), the west German mountains, the Alps (in the border regions joining Germany, Italy and France) and the Appenines (down the spine of Italy). Mountainous regions smaller in altitude or area are north Britain, the Vosges, Corsica, Sardinia and Sicily. Yet smaller regions occur in e.g. the perimeter of Ireland, the Belgian and Luxembourg Ardennes and parts of France

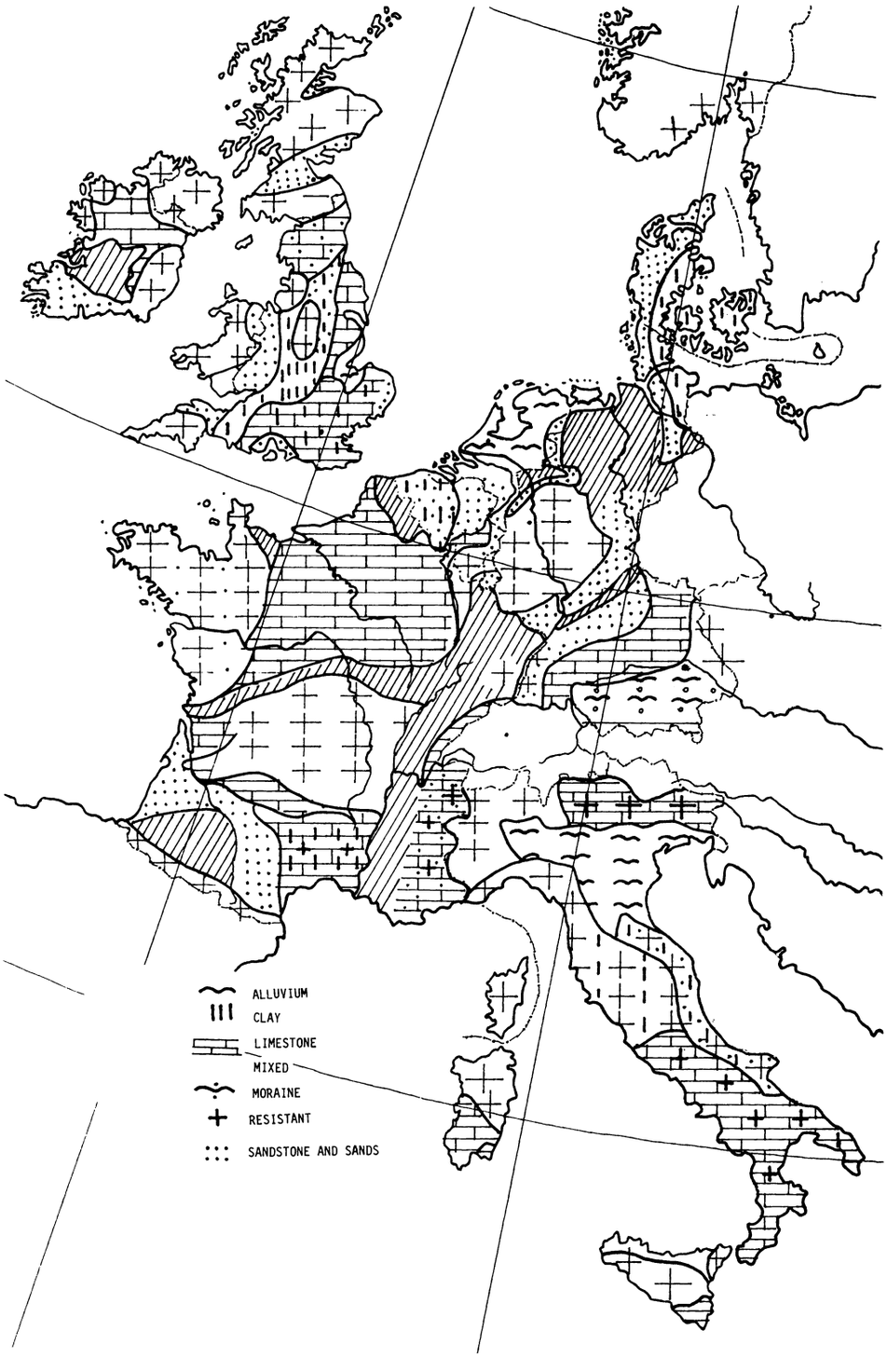
and Germany. The river Po flows between the Alps and the Appenines in Italy, the Rhein between the Alps and the west German and Vosges mountains, and the Rhône in the Alps and by the Massif Central. Other major rivers are associated with lesser hills, e.g. the Donau with the German Schwarzwald, the Moselle with lowlands and the west German hills and the Severn with the Welsh hills. Yet others pass entirely through lowlands, e.g. the Seine flows to the north-west French coast through Paris, the Thames flows through London to the English coast and the Guden flows to the north-east Danish coast. Rivers rising furthest from the sea are the most likely to have long and large tributary rivers. This leads to some confusion in the definition of a river, since some streams entering the sea are very short, while some tributaries of major rivers extend over many tens of kilometres, and the two are not comparable for vegetation. Technically, a river is a large stream of water flowing in a channel towards the sea, a lake or another stream. Consequently, for macrophytic vegetation,

Fig. 1.2. Map of the EEC showing the principal rivers and landscape types (for greater detail consult the maps in Chapters 13–23). Height of symbol indicates height of hill; straight lines indicate plain. Country borders also shown.

rivers are best defined as unified ecological systems, though the scale of what constitutes such an ecological unit will vary with the relevant investigation.

Although in the long term the valleys are carved out by rivers or glaciers, in the short term the position of a mountain river is determined mainly by the landscape. The river lies in or near the lowest point of the valley. The position of lowland streams is much less fixed by landscape, as in the lowlands valleys are usually wider and Man's activities greater. The position of a river may have varied, over the centuries, both because of natural processes and because of alterations for flood protection, navigation, farming, etc. Alluvial plains were formerly marshes or water bodies, and though they still have channels carrying water derived from higher ground, e.g. the Maas and Rijn in The Netherlands, and the Great Ouse and Brue in Britain, most of their channels are now man-made and placed more by farming preferences than by the position of the original marsh watercourses. Canals are likewise placed by man's

Fig. 1.3. Map of the EEC showing the principal rock types (for greater detail consult the maps in Chapters 13–23). Compare with Fig. 1.2 to ascertain the topography of the major areas.



choice and cross the continent to form arterial waterways joining appropriate major rivers (e.g. the Moselle and the Donau), thus forming a network suitable for commercial navigation. Belgium, France, Germany and The Netherlands are connected in this way, with further connections to Eastern Europe. Britain has a minor network of canals, which are now used mainly by pleasure craft, and other countries have even less.

The primary controlling variables for river navigation are:

Water force, a flow factor related to landscape and precipitation
Rock type
Upstream–downstream variation
Man's activities

The steeper and more mountainous the landscape, the greater, in general, is the river flow. In general terms, the comparative flow of the major rivers can be deduced from Figs. 1.1 and 1.2. Streams of any size in lowlands have relatively slow-moving water and storm flows of low force. In steeper landscapes the water movement is much hastened, and the water force much increased, by the slopes over which the water flows, and the force of storm flows and snow-melt flows becomes particularly great.

Within the environment set by the landscape and flow, rock type is an important controlling factor. The main rock types of the EEC are shown in Fig. 1.3 and comprise limestones, semi-limestones (e.g. Muschelkalk and calcareous moraine), sandstones, clays (including the variant of Coal Measures, composed mainly of hard clay), the recent deposits of e.g. loess, alluvium and moraines, and the Resistant rocks. The term 'Resistant' rock is applied to those hard rocks which, unlike sandstones and Coal Measures are resistant to erosion and, unlike limestones, are resistant to solution. They therefore include most of the igneous and metamorphic rocks such as slates, granites, schists and andesites. While river vegetation does differ on different types of Resistant rocks, these differences are less than those occurring on different types of sandstones. They are also usually more due to differences in landscape and only seldom to chemical variations in rock types. Landscape differences are primarily due to differences in erodability of the rocks, e.g. slates often form steeper, and granites gentler, hills.

The third controlling factor is the variation from source to mouth, the upstream–downstream variation. Typically, on passing downstream, channel width increases, water depth increases, the force of flow decreases (although this need not apply to the velocity of flow) and the size of the particles on the bed decreases.

Man's activities are, and have been, many and varied. The uses of waterways include:

Drainage of land, particularly for farming (and settlements)
Irrigation of farmland
Navigation
Power (formerly, water was the main source of power, e.g. for mills)
Drinking and cleansing
Effluent disposal
Amenity and recreation

Human interference is not confined to direct effects on the water or its channel. Land use has an important influence. Forests, grassland, arable land and bogs affect streams in different ways. Forests, for instance, shade many smaller streams, provide leaf fall which contributes organic matter of a specific chemical composition to the stream, break the force of rainfall and decrease run-off. Arable land often requires lower groundwater than grassland, and hence has more drainage and more alteration of channels; it is thus more likely to influence the chemical composition of streams, especially when given much fertiliser and biocide. Built-up areas have rapid run-off and so more flash floods, and, typically, more pollution.

Pollution is the final aspect of rivers to be discussed in this book (Chapters 28–30), since its pervasive action cannot be fully explored until the nature of clean vegetation is understood. However, as it is so relevant to so many aspects of river vegetation, an introduction is provided here.

Pollution is defined by Descy (1976e) as that phenomenon which gives rise to changes, of varying degrees according to the intensity of the pollution, in the structure or nature of a plant community. Plant communities can be used to estimate the degree of deterioration of the environment. In this book, as in Haslam & Wolseley (1981), anything which reduces the quality of the plant community is termed damage. Damage may come from physical or chemical causes and chemical damage is here termed pollution. The most widespread type of pollution in the EEC comes from effluents from sewage works and untreated domestic, farm or industrial wastes. Effluents vary in quality and quantity both within and between countries. Some indication of the relative pollution due to effluents in the different EEC countries is given in Table 1.1. Turbidity and temperature changes are, however, also classed as pollution. If there is deterioration and there is no normal physical cause for this, pollution is present.

The main towns of the EEC are shown in Fig. 1.1. This provides some indication of areas where total population, industry and the necessity of protecting towns from flooding and of providing for recreation combine to put great pressure on the waterways.

For the plant communities, Ireland has the cleanest rivers, followed by Denmark. The next cleanest rivers are those of Britain, Germany and The Netherlands, followed by France (and Luxembourg, though this country is really too small to classify with the others). Italy ranks above Belgium in that the population density is lower so that there are more streams sited away from centres of population, but in both countries rivers in populated areas are usually severely polluted. In each EEC country, however, both clean and grossly-polluted waters can be found.

The biotic responses to pollution are the same for macrophytes as for other groups of organisms, e.g. invertebrates. A polluted community exhibits at least

one of the following:

(1) A decrease in diversity.
(2) A decrease in abundance of species not favoured by pollution. For macrophytes, abundance is here measured as cover (biomass is unsuitable as measurement is both destructive and time-consuming, and because biomass varies more than cover with e.g. storms and water temperature).
(3) An alteration in species composition to increase the proportion of species present which are tolerant to the incident pollution and decrease the proportion of sensitive species.
(4) An increase in species favoured by the pollution.

As well as sewage etc. pollution, EEC watercourses are also polluted by eutrophication, fish farms, gravel extraction and quarrying, rice paddy fields and many more minor causes including heavy metals and wash-houses. Heavy metals are an important source of damage to animals, but are of less importance to macrophytes. Macrophytes are particularly sensitive to the toxicity of organic pollutants.

As stated by Tonolli (1976), water may be considered to be the framework and site for a series of phenomena caused by many, often interacting, variables. These variables include both natural phenomena and human interference. At any one place, any one of these variables may be overriding in its effects. In overall terms, however, river vegetation is most affected by landscape (i.e. flow parameters), then by rock type, then by upstream–downstream variation and lastly by Man's activities.

EEC macrophytes

Water plants have received much less attention than land plants, and indeed it is still commonly thought that river vegetation is comparable to a single unit of land vegetation, e.g. a *Fagus* wood, rather than to a whole complex of woodland communities. This lack of attention has occurred mainly because only a few ecologists have been interested in the subject, but also because the total number of species is small, so that the significance of different combinations of these species can easily be missed. The importance and interest of water plants was first brought to general notice by Arber (1920) and Gessner (e.g. 1955, 1959). Butcher (1927, 1933) pioneered the study of river vegetation, and Tansley (1949) summarised the then-known aquatic ecology of Britain. Sculthorpe (1971) provided a compendious account of the biology of aquatic macrophytes.

Table 1.1. *Pollution due to sewage in the different EEC countries (Water Research Centre, 1977)*

	% of population with sewerage[a]	Effluent discharge mainly to
Belgium	30	Rivers
Britain	94[b]	Rivers
Denmark	84	Lakes, rivers
France	44	Rivers
Germany	79	Rivers
Ireland	61	Sea (rivers)
Italy	58	Rivers (sea)
Luxembourg	70	Rivers
The Netherlands	92	Drains, etc.

[a]Untreated sewage is more toxic than treated material.
[b]The quality of British effluent is lower than the high percentage of sewerage quoted would seem to indicate.

The first modern study of British river ecology was that of Westlake (1968b). This has been followed by many more investigations, particularly in Germany (e.g. by Kohler, Weber-Oldecop and their colleagues), The Netherlands (e.g. by van Donselaar, de Lange, van Zon and their colleagues) and Britain (e.g. by Dawson, Haslam, Holmes, Westlake, Whitton and their colleagues). Dawson and Westlake have concentrated on plant growth and production in relation to habitat, and Kohler on the effects of pollutants in both specific and general terms.

Verneaux (1976) notes that the ultimate objective of human activity in the fields of conservation, management and utilisation of aquatic resources is the preservation of as ample a biological structure as possible in terms of abundance and diversity. Macrophytes help to provide conditions suitable for other groups of organisms (epiphytes, invertebrates and fish), and hence the state of macrophytic vegetation is often a better guide to the status of these other groups than is the state of these other groups to the status of macrophytes. While each group should be studied separately, as each has different responses to the various habitats, macrophytes are a general indicator of the whole habitat and its potential biotic structure.

As river macrophytes are affected by a wide variety of habitat factors, from e.g. land use to stream width, if the vegetation of a site is known, much can be deduced from this about the habitat, often in the past as well as the present. When some but not all the ecological factors are known, the vegetation can be used to assess the remaining factors, e.g. pollution.

There are only about a hundred common river macrophytes in the EEC. Of these, *c.* 70 are listed in Table 1.2. They include the most common species (or aggregates) throughout the EEC, a selection of widespread but less common species and a selection of those species which are common or significant in part of the EEC only. If these species are known, any frequent and species-rich community can be identified and assessed. In Table 1.2 they have been divided into groups by nutrient status (see Chapter 7 for details), and subdivided according to habitat. The habits are: (a) water-supported species – submerged low-growing, submerged higher-growing, submerged with floating or emerged parts, floating rooted, or floating non-rooted; (b) emerged – tall monocotyledons, Fringing herbs (short semi-emerged dicotyledons of mesotrophic habitat band) or others. However, some species, e.g. *Scirpus lacustris*, can be placed in more than one category.

Determinants of vegetation in the wide geographic region of the EEC

South Norway

South Norway, although not part of the EEC, has been included to give a more northern region for com-

Table 1.2. *Significant watercourse species of the EEC (and south Norway)*

The species listed comprise an arbitrary selection from common and diagnostic communities. Most communities can be identified by reference to these species.

The species have been placed in six groups. The first five are in order of the nutrient regimes in which the species most frequently occur and the last group contains species it is less easy to classify in this way. As is discussed especially in Chapters 7 and 9, species vary in the nutrient regimes in which they occur, and these chapters should be consulted for details.

Within each group, the species have been subdivided by habit. Species may have more than one habit (e.g. *Butomus umbellatus*, *Polygonum amphibium*, *Ranunculous flammula*), but each species is listed only once, under the more ecologically significant or the more frequent habitats. (Some habit groups have none of these selected species).

Water-supported species	Short emergents	Tall monocotyledons	Others
1 Species characteristic of nutrient-poor habitats			
Callitriche hamulata	(*Sphagnum* spp)	*Carex rostrata*	
Eleocharis acicularis		*Juncus articulatus*	
Eleogiton fluitans (= *Scirpus fluitans*)		*Luzula sylvatica*	
Glyceria fluitans, long leaves			
Juncus bulbosus			
Myriophyllum alterniflorum			
Potamogeton polygonifolius			
Ranunculus flammula			
2 Species characteristic of less nutrient-poor habitats			
Potamogeton gramineus	*Bidens cernua*		
Mosses[a]	*Caltha palustris*		
	Eleocharis palustris		
	Equisetum fluviatilis		
	Equisetum palustre		
	Oenanthe crocata		
	Petasites hybridus		
3 Species characteristic of nutrient-medium habitats[b]			
Callitriche spp. (*Callitriche cophocarpa*, *C. obtusangula*, *C. platycarpa* and *C. stagnalis*)	*Apium nodiflorum*	*Iris pseudacorus*	
	Berula erecta	*Sparganium erectum*	
Hydrocharis morsus-ranae	*Mentha aquatica*		
Lemna polyrhiza (= *Spirodela polyrhiza*)	*Mimulus guttatus*		
	Myosotis scorpioides		
Lemna trisulca	*Rorippa nasturtium-aquaticum* agg. (*R. nasturtium-aquaticum*, *R. microphylla* and hybrid (= *Nasturtium officinale*, *N. microphylla* and hybrid)		
Nymphoides peltata			
Potamogeton natans			
Ranunculus spp., comprising the Batrachian *Ranunculus* spp.[c]			
	Veronica anagallis-aquatica agg. (*V. anagallis-aquatica* and *V. catenata*)		
	Veronica beccabunga		
4 Species characteristic of more nearly eutrophic habitats			
Ceratophyllum demersum	*Alisma plantago-aquatica*	*Carex acutiformis* agg. (*C. acutiformis* and *C. riparia*)	*Epilobium hirsutum*
Elodea canadensis[d]	*Polygonum hydropiper* agg. (*P. hydropiper* and *P. persicaria*)[f]		
Myriophyllum spicatum		*Glyceria maxima*	
Polygonum amphibium[e]		*Phragmites communis*	
Zannichellia palustris		*Typha latifolia*	
Blanket weed: filamentous algae in noticeable quantities, mainly *Cladophora* sp.			
5 Species characteristic of nutrient-rich habitats			
Nuphar lutea	*Rorippa amphibia*	*Butomus umbellatus*	*Rumex hydrolapathum*
Potamogeton crispus		*Scirpus lacustris* (= *Schoenoplectus lacustris*)	
Potamogeton pectinatus			
Sagittaria sagittifolia			
Sparganium emersum			
Enteromorpha sp.			
6 Species not placed in the preceding groups			
Lemna minor agg. (*L. minor* and *L. gibba*, particularly when the thalli of the latter are not strongly gibbous)	*Agrostis stolonifera*	*Arundo donax*	*Osmunda regalis*
	Glyceria spp., short leaves (*G. fluitans* with short leaves, *G. plicata* and some *G. declinata*)[e]	*Cyperus bardii*	
		Juncus effusus	
		Scirpus maritimus	
		Phalaris arundinacea	

parison. Its rock type is Resistant and poor in nutrients, although overlying patches of drift and alluvium are rather more fertile. The country is mountainous inland and basically low in nutrients, with much forest and boggy marsh. Intermittent farmland occurs, mainly on the richer soils. Here the unfavourable factors of wet bog, oligotrophic leaf fall, etc. have been removed. The smaller watercourses have been altered to an extreme degree. Flow regimes include those of mountains; those of streams rising in the lowlands, where the force of water, and so the vegetation, is very different; and those of e.g. ditches in alluvial plains, where again there is a difference in vegetation. With respect of macrophytic vegetation, the region has more nutrient-poor habitats, and so species assemblages, than any EEC country, though other countries may have some communities which are equally of a nutrient-poor type. The species assemblages are composed of different combinations of species (e.g. *Alisma plantago-aquatica* occurring in rather oligotrophic habitats where other species are characteristic of these habitats) and different combinations of habit groups (e.g. no common Fringing herbs) to those occurring elsewhere. The communities are related to flow (i.e. landscape) and nutrient regimes (e.g. rock type, drift and land use). Stream size is relevant to all countries, and will not be mentioned further.

Denmark

Although next to Norway, this country is entirely lowland, with little older rock outcropping through the recent sands (mainly in the west) and clays (mainly in the east). Early settlement and farming and higher populations are characteristic of the east, particularly of Sjaelland. Sjaelland is the most polluted region, and the region where abstraction of ground water has most lowered river discharges. Denmark has much-managed and distinctive drainage patterns. The water table, however, remains high (especially in Jutland), and wetlands are still found within the farmlands. The Common Agricultural Policy of the EEC is, however, decreasing the water levels and wetlands, so even in Denmark there is cause for concern. Overall, the river vegetation is the cleanest of the lowland mainland EEC countries. The plant communities are determined by rock type, modified by management and land use patterns, and are mainly mesotrophic or somewhat eutrophic in nutrient status.

The Netherlands

The Netherlands consist mainly of alluvial plains, which are made up of, variously, clays, sands and peats, with somewhat higher-lying Terrace sands (and a little chalk) to the south. The plains watercourses are almost all man-made or, even for the Maas and Rijn, man-influenced, and many streams on the higher ground have been canalised. The pattern, size and density of the watercourses are determined by the relative ground level and also by the dates of settlement and conversion to farmland. The vegetation is determined not just by subsoil type, but also by the mosaics of groundwater below. These form different patterns to those of the subsoil, and so lead to complexities of vegetation pattern which do not occur to this extent in simpler alluvial ecosystems. The larger channels have, in general, the least vegetation, since these include the arterial waterways that are used for both navigation and effluent disposal. Excellent vegetation is widespread, particularly in the smaller channels. The communities reflect, of course, the dyke rather than running stream flow regimes, but within this overall influence, show variation.

Belgium

The alluvial plains continue south from the Dutch coast into Flanders, though with a sharp change in watercourse vegetation. Lowland Belgium has many industrial villages and small towns and a lack of effluent control, so is severely polluted. Particularly in the centre of the country, this pollution is the main influence on the stream vegetation, although towards the perimeter there are better-defined communities on e.g. acid sands and clays. In the Ardennes hills to the east, where population and industry are less, there is good hill vegetation. On the gentler slopes there is a high-cover, fairly species-rich and *Ranunculus*-based vegetation. Much, though not all, of the Ardennes is fertile land. Where not overridden by pollution, landscape and rock type determine the stream vegetation.

Luxembourg

The Ardennes hills extend into the north, but here industry pollutes stream vegetation more than in Belgium. The southern lowland rivers, however, though polluted from the industrial and other settlements, can still bear a considerable amount of vegetation. Luxembourg is also characterised by its wooded gorges, where both scour and shade often prevent much river vegetation from developing (except where frequent controls keep flow slow). The vegetation is *Ranunculus*-based in the hills and pollution-based in the south, being mainly influenced by landscape, rock type and pollution.

Notes to Table 1.2

[a] Species preferences vary widely. In this book the mosses are usually considered as a single aggregate.
[b] The species listed as Short emergents comprise the group referred to in this book as the Fringing herbs.
[c] Although separate species can often be identified, the genetic status of the group is very complex (e.g. C. D. K. Cook, S. Roberts, personal communication). Leaf length, however, typically increases downstream (except for *R. trichophyllus*), and relative leaf lengths are often ecologically diagnostic.
[d] Unless otherwise specified, includes *E. canadensis*, *E. nuttallii* and pollution forms of *E. canadensis*, which can be morphologically identical to *E. nuttalli*.
[e] Recorded as a river plant only when in the floating form or emerged in drying channels in the far south.
[f] In Italy (Po Plain) *P. hydropiper* is common as submerged clumps or carpets. Elsewhere, these are usually emerged.

Britain

This is the largest EEC island, and also has the greatest variation in stream vegetation of any EEC country. France has an almost equal variation, but is several times the size, with more variation in climate and altitude. The alluvial plains of the continental coast reappear in eastern England with smaller regions elsewhere. The dyke vegetation patterns are simpler than those of The Netherlands, as alluvial type and groundwater type normally correspond. The south and east of Britain are composed of lowland limestones, clays and sandstones, usually with fairly good river vegetation, though this is altered and decreased by pollution, particularly in industrial areas. The north and west are composed more of Resistant rock than of other rock types, and include many hills and mountains. The river vegetation pattern is simple, and is determined by landscape and rock type except where modified by e.g. land use. Blanket bog developed over much of the flatter ground in the north and west during wetter times, and the stream vegetation varies greatly with its status now: present, dried, removed or partly removed. The water table is lower than in any other EEC country, and is being lowered further. The smaller streams, in consequence, differ in important respects from those of other countries.

Ireland

This island is the most western, and, for lowlands, the wettest part of the EEC. The title of 'The Emerald Isle' refers to the abundant green grassland. That of the 'Irish bog', an equally well-known description, is now less apt, as much of the marshy ground has been drained and converted to grassland, and the main bog areas are now being dug for fuel (as was done in The Netherlands), leaving bog primarily on the hills of the perimeter, where it has the same effect as in Britain. The lowland centre is mainly hard limestone (harder than chalk) and so is more easily covered by peat and marsh. Ireland is less managed than other farming countries, with shallow, winding, much-vegetated lowland streams representing an earlier historical phase. Recent massive drainage schemes are making parts of Ireland more like other EEC countries, with water tables more suitable for arable use and with straightened, high-banked, less-vegetated streams. The major communities are *Ranunculus*-based, varying in detail with rock type, and becoming depauperate in the hills. Ireland has perhaps the lowest pollution of any lowland EEC country, but this results from a low population, with most large towns on the coast, rather than from efficient effluent control.

Germany

Although Germany has a more continental climate, it is the country most similar to Britain in its stream vegetation. The landscapes are, roughly, mountain to the west and south, and lowland to the north and east. The main mountain regions include Westerwald, Hunsruck, Eifel, Pfalzer, Schwarzwald, Alps and Schwaben. However, in the rest of the country areas such as Ober Franken, Teutoburgerwald and Frankische Schweiz are upland, or low mountain with gorges. The overall pollution status is similar to that in Britain, but the pattern differs in that more of the smaller streams are clean, and more larger ones are seriously damaged.

Sands in the north have typical sandstone communities, with more dyke influence in Schleswig Holstein. Muschelkalk streams are badly polluted but have a lime-influenced vegetation (appropriate to the lime content of the rock). The limestone streams of Frankische Schweiz, like those of the even more mountainous Schwaben, have vegetation very similar to that on lowland British chalk. On lowland patches of Resistant rock, there is, in equivalent habitats, less vegetation (more wash-out) than on other rock types. The man-made drainage pattern is of great importance, and has a locally overriding influence on the stream vegetation. The Alps are so steep that the streams have little vegetation. The western mountains are dissected plateaux, with lowland farming above. The mountain slopes are wooded, and the more prosperous, and picturesque towns are in the valleys, on the rivers. In the third phase, the rivers flow through wide farming valleys towards their mouths. On the slopes the vegetation is characteristic of mountains, but there is more vegetation on sandstone and Muschelkalk than on Resistant rock, and this difference increases below the plateaux, where water force decreases. The communities, of course, vary likewise. These plateau-mountain streams may therefore rise as lowland streams, become mountainous and then become more lowland below. However, the exact flow pattern varies greatly not just with slope, but also with the frequency of man-made controls, which hold up water and so make the flow more lowland in type.

Among the large rivers, the Rhein and Moselle have much damage from boats and pollution. The Main is less damaged, with some semi-eutrophic vegetation. Near the source, the Donau is somewhat polluted but has considerable vegetation (limestone-mixed rock type); it becomes more polluted downstream.

The north-west coastal plains fringe the Wadden Sea of the Frisian peoples and have man-made dykes. Those in Ost Friesland have the most drainage damage and depauperate vegetation. The differences in the present watercourse vegetation patterns can be largely ascribed to cultural differences between the present countries within the nation of Frisia. A similar pattern is repeated southwards, with the Flemish alluvial plains stretching from The Netherlands, through Belgium to north France. In these two (contiguous) areas, the greatest amount of drainage and arableisation is in France and Ost Friesland, and the least amount is in (Dutch) Friesland and the north.

France (mainland)

France is the largest EEC country. The main mountain areas are the Vosges (the smallest, and very steep), the Alps (the largest, with more foothills and larger, gentler landscapes), the Massif Central and the steep and jagged Pyrenees. The Massif Central is a plateau, on which streams can bear considerable (some-

what oligotrophic) vegetation in a lowland–upland landscape. Where rivers run down the mountains, the vegetation decreases, becoming mountainous in character, and this influence persists downstream. Areas of lower hills occur as foothills to the mountain, and as upland areas in or near the lowlands (e.g. Brittany).

The chalk of the north has, unusually, a *Callitriche*-based rather than a *Ranunculus*-based stream community. In the area there is loess overlying the chalk. The chalk is as much drained as in Britain, with as much channel alteration as in Denmark. The region, therefore, is exceptional for the intensity of human interference. Otherwise, lowland France has a generally higher water level and winding streams, with less overall interference with drainage than occurs in Germany. The (Jurassic) limestone has typical limestone vegetation. Various types of sandstones occur, the less fertile ones having different combinations of nutrient-poor species (Brittany, Gironde, central). The most fertile sands also have considerable and distinctive vegetation, though the intermediate lowland ones, which are the most widespread, may be rather depauperate. In France both lowland sandstone and lowland Resistant rock stream substrates are easily eroded, and have low vegetation. The clay, as usual, has a nutrient-rich-requiring community, and the Muschelkalk is intermediate between limestone and clay.

In the lowland south-west peninsula, the (Miocene) rock types are very diverse, but this is almost irrelevant to stream vegetation as the region is almost as polluted as Belgium. France has population and industrial pollution, equivalent to those of Germany, but with a different pattern. The characteristically worst streams are the small tributaries and ditches leading from villages and farms. These then greatly improve with dilution and downstream purification in the larger streams. France has more scattered rural farms and dwellings than Germany, where there are fewer polluted small streams and more polluted large rivers.

The Mediterranean coastal streams are influenced by the southern climate, and the xerotic influence is particularly strong in the south-west. Southern species enter, and may become frequent, and more streams dry up in summer.

Corsica

Corsica is often discussed separately in this book, as it lies entirely within the xerotic Mediterranean influence. It has high and steep Resistant rock mountains that give water forces as great as in the Pyrenees, and little vegetation in many main rivers. The small coastal plains have good stream vegetation. There is very little human interference, and little pollution even in the coastal plains. Consequently, small streams without much water force have much more vegetation than those of equivalent Alps and Pyrenees habitats. In the plains, similarly, there are more macrophytes in large rivers near the mountains than occur in other regions with more channel alterations. The vascular species extending into the highest force rivers are, unlike the rest of the EEC, *Osmunda regalis* and *Salix eleagnos*.

Sardinia

Sardinia is hilly, on Resistant rock, and with a strong xerotic influence. However, in contrast to Corsica, the hills form a central plateau, with low-force rivers acquiring higher water force only when running down the hill sides. There has been very little human interference, so the rivers have not been changed and the vegetation is considerable in the non-uniform and medium water force habitat. There is a remarkably wide species assemblage, which differs from that in Corsica in the dominant species. The only somewhat-polluted region is on lowland limestone, where farming and settlement has occurred inland. The river tree is *Tamarix gallica* not *Salix eleagnos*. With low human interference and water force, there is usually a wide band of fringing vegetation forming part of the river habitat. The assemblages range from water-supported to terrestrial species.

Sicily

This third, large, Mediterranean island has limestone-capped hills which have been settled and farmed since early times, causing most rivers to be seriously polluted from their sources. Gravel extraction adds to this extreme pollution. On the positive side, because there has been little channel alteration, edge fringes (as in Sardinia) are frequent even when the river centre is polluted and empty. (Fringes have lower water force. Pollution decreases anchorage, so at certain pollution levels, macrophytes can grow in edge fringes but not channel centres.) Southern species are more frequent than anywhere else in the EEC. (*Tamarix gallica* occurs as in Sardinia.)

Italy (mainland)

Italy contains two of the large European mountain ranges, the Alps and the Appenines. The Alps are in the north. These are composed of hard rocks which are difficult to erode and which have formed steep landscapes. Channels may be empty in high force streams in the main mountains. There is more vegetation in the foothills and this has a lime character where the rock is calcareous.

The Appenines run down the spine of Italy. The rock types are less hard and the landscape less steep than in the Alps, with more wide, gentle slopes. In the north, the hills merge into the Alps with partly harder rocks. There are more towns on the tops of hills, particularly in the south. The rivers erode to form wide, stony and gravelly beds, which, as in Sicily, are used for gravel extraction, especially in the South. This causes much pollution. These gravelly beds, coupled with the Mediterranean dry summers, and snow-melt floods in spring, produce a very unstable and unsatisfactory habitat for macrophytes, and empty channels are widespread. A little vegetation occurs in the most stable streams in the north (where erosion and summer-drying are less), more occurs in the centre and south, where catchments with gentle slopes can be found, and in the far south, as in Sicily, edge fringes increase.

Fringes of emergent species, most often of tall monocotyledons which can best tolerate Mediterranean

conditions, occur in the flood plains and coastal lowlands of the south. There is a remarkable lack of water-supported species. These can and do, however, develop well in clean streams rising in low ground, which are stable, with perennial or near-perennial water, showing that the absence of water-supported species is not due to climatic factors but to factors such as stability, pollution, etc.

The alluvial plains are similar to those of the Wadden Sea in their man-made drainage watercourses and their vegetation. *Phragmites communis*- (and other tall monocotyledon-) filled dykes are common, as is usual along Mediterranean coasts. The larger channels are navigable in the greater plains (Veneto), and, more widely, are useful as fisheries. In the greater part of the Po plain there is a complex irrigation–drainage system of flowing-water channels which takes water from calcareous (Alpine) streams north of the Po and from non-calcareous (Appenines) streams to the south. These, particularly the former, have abundant and distinctive (lime) vegetation.

2

River development

Summary

The geological history and the mountain structure of the EEC are described, and the origin and position of the main drainage basins are shown. Great alterations to the river course pattern occurred during the Quaternary period, including those due to glaciations and glacial deposits.

The settlement of river valleys and the use of rivers are traced from Palaeolithic through to Roman times. The development of navigation and water power is briefly described. Flood prevention schemes are also outlined. Drainage reclamation and irrigation schemes were also early developments in the use of water and wetlands, and the unique contribution made by the Dutch is described.

Introduction

River systems are as ancient or as young as the land surface across which they travel. Given a uniform land mass of hard rock, water arriving on its surface will gather into streams and then rivers, and, cutting channels in a dendritic pattern, will take the shortest route to the sea. In doing this it will erode the upland area and fill in the hollows and the sea. The European land surface, however, is not uniform, the rocks vary in their erodability, in their geological age and in the effect of movements of the earth's crust, and in addition the surface varies with the effects of Man's activities over the past 6000 years. The effect of the climate on present river systems has also varied. Succeeding Quaternary glaciations have altered routes and channels, and so have the more recent variations in climate. Thus the present distance that a river travels and its drainage pattern must be interpreted as a result of more ancient continental land masses, earth movements and climates. The Severn, Britain's longest river, rises on Plynlimon only 20 km from the Irish sea, but travels 416 km inland to the Bristol Channel. On the continent many of the larger rivers travel much greater distances, and have far larger catchment areas: the Loire travels 1000 km to the Atlantic, and at Montjean has a catchment area of 110000 km^2; the Rhône travels 808 km from the Alps to the Mediterranean, and has a catchment area of 95590 km^2 at Beaucaire; the Rhine travels 1360 km from the Alps to the North Sea, and at Rees has a catchment area of 159680 km^2; the Donau, Europe's largest river,