Chapter (non-refereed)

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The status of the River Dee in a national and international context

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1 Introduction

The classification of river systems has received considerable attention from freshwater scientists, and a wide variety of parameters has been proposed as the basis of different schemes of typology. Early workers used physical attributes such as flow and temperature (Ricker 1934), geological origin and substrate (Carpenter 1927; Butcher 1933) and the erosion and deposition of sediments (Moon 1938). Other workers have used biological features, such as fish (Huet 1946), invertebrates (Illies 1953) and plants (Haslam 1982), and there is often a reasonable cross-correlation among the different schemes (Pennak 1971). Many of the different schemes have been reviewed by Hawkes (1975) and recent proposals (Maitland 1979; Wright *et al.* 1984) have moved towards sophisticated multivariate analyses using both physico-chemical and biological data. Constant problems are that the characteristics of rivers change (sometimes dramatically) from source to mouth (Maitland 1966; Cummins *et al.* 1966), and that many differences in the biota (eg the fish: Maitland 1985) may be due to historical and not ecological factors.

The conservation of fresh waters has received more attention in recent years, but the attention given to running waters has lagged far behind that given to standing waters. Thus, in Project Aqua (Luther & Rzoska 1971), 'a source book of inland waters proposed for conservation', a total of 108 running waters is listed (Table 1), compared with a standing water list of 526. Within the United Kingdom, about 52 standing waters and one running water are listed for England, about 14 standing waters and no running waters for Wales, and about 15 standing waters and no running waters for Scotland. The single running water listed for the United Kingdom (Bere Stream) is actually not of particular conservation importance.

Table 1. Fresh waters listed for their conservation value

Source	Running waters	Standing waters
Luther and Rzoska (1971)		
International	108	526
Great Britain	1	81
Ratcliffe (1977)		
Great Britain	19	104

In Great Britain, the most recent and authoritative review of sites of national importance is that of Ratcliffe (1977). It gives less attention to running waters than to standing waters, but the coverage is nevertheless much better than in most comparable documents. In the index of open water sites (grades 1 and 2), there are 104 standing waters and 19 running waters. Eighteen of the standing waters and 2 of the running waters are regarded as internationally important. The Dee (Aberdeenshire/Kincardineshire) is listed as an upland running water of grade 1 national (but not international) importance.

2 The River Dee

The Dee rises as a large number of streams draining the east central highlands of Scotland, some of which form the outflows of high-altitude lochs such as Loch Etchachan and Loch Muick. The traditional source is the Springs of Dee, but the highest sources are found on the slopes of Ben Macdui within the Cairngorms National Nature Reserve (Ratcliffe 1977). Compared to the source streams of the Spey, within the Cairngorms, those of the Dee are more precipitous, and streams, such as the *Allt a' Choire Mhoir*, after rising on a gently sloping boulder field at 1220 m above OD then plunge 600 m down the 40° slopes of the Lairig Ghru. In its upper reaches, the substrate of this stream is granite gravel and stones, but on the steep slopes the stream cascades over bedrock and boulders. In both sections, most of the rock surfaces are covered in dense growths of bryophytes such as *Scapania undulata, Jungermannia cordifolia* and *Marsupella emarginata*. The maximum width here is about 3 m and the greatest depth only 20 cm. The water is low in pH (5.1) and extremely deficient in dissolved salts, the conductivity being low (12-19 μmhos), but nitrate levels are relatively high (0.24-0.25 mg l^{-1} NO_3–N). For most of the year, the flow consists largely of snowmelt and even in late summer the temperature rarely rises much above 5°C. The invertebrate fauna includes species of Oligochaeta, Plecoptera, Tricladida, Trichoptera and Diptera typical of arctic-alpine streams, with the larvae of orthoclad chironomids dominating numerically. There are no fish or aquatic angiosperms.

Lower down, these small alpine streams converge to form a small fast-flowing river, prone to heavy spating. It is characterized by clear waters and unstable shingle beds, interrupted at some points by areas of smooth flat bedrock. The water is extremely poor in nutrients but is less acid than higher up. Higher aquatic vegetation is virtually absent, and the stones are almost free of epilithic algae. The invertebrate fauna is sparse, and large areas of the bed can be virtually devoid of animals after floods. The fauna still contains an important arctic-alpine element, but also species characteristic of lower elevations, such as the caddis

Polycentropus flavomaculatus, the alderfly *Sialis fuliginosa,* the stonefly *Taeniopteryx nebulosa,* the water bug *Gerris costai* and Hydracarina.

Below the Linn of Dee, the river becomes broader and is moderate to fast flowing, with a more stable bed consisting of stones and gravel, a few boulders and a little sand. It remains similar throughout most of its length, gradually increasing in size so that at Cults it is up to 60 m wide. The dissolved nutrient content of the water also increases downstream as the river enters farmland, and at Peterculter it is mesotrophic (alkalinity 16 mg l^{-1} as $CaCO_3$) but nitrate levels are still relatively low (average 0.5 mg l^{-1} NO_3–N). In its lower reaches, the water is less clear and sometimes slightly discoloured by plankton from the Loch of Skene, which drains into the river. Macrophytic vegetation is virtually absent throughout the river, only a few clumps of bryophytes being found.

Associated with the increasing nutrient content, there is an increase in the biomass and variety of benthic invertebrates as one moves downstream. A number of montane species such as *Simulium monticola, Protonemura montana, Diura bicaudata* and *Crenobia alpina* disappear, and in the lower mesotrophic sections the fauna is augmented by *Polycelis tenuis/nigra, Gammarus pulex, Simulium reptans, Baetis pumilus, Ephemerella ignita,* a number of caddis species and a few gastropods, all of which appear in increasing numbers downstream.

3 International aspects

Conservation assessment criteria are notoriously subjective, and there have been far too few serious attempts to outline objective criteria which are quantifiable in some way, and which would serve as guidelines both for comparing one system with another and also for assessing any changes in time within one system. The initial selection of aquatic nature reserves in Great Britain was by ornithologists, and only recently have other (more fundamental) criteria been used (Ratcliffe 1977). A wide variety of such criteria must be considered in any general scheme of site selection.

Although the Dee is listed as a grade 1 site of national importance, there has been no suggestion so far that it could be important internationally. Examination of the available data seems to confirm that it is not. All physical comparisons with important international running water systems would seem to place the Dee low down, regardless of the parameter or rating system used (Table 2). The same seems to be true of biological factors, including important features like plant, invertebrate, fish and bird diversity, as well as various facets of organic production and community structure.

The importance of the Dee must be viewed in a national, rather than an international, context. Does it justify its rating (Ratcliffe 1977) as a grade 1 national site? If so, can the assessment criteria used be made more objective and quantifiable than has been the case in the past?

Table 2. Comparative data for world and British rivers (source: Lewin 1981)

River	Length (km)	Catchment area ('000 km²)	Q bar ('000 cumecs)
Amazon	6437	7050	180
Congo	4700	3457	41
Ob-Irtysh	5410	2975	15
Mackenzie	4241	1841	11
Ganges-Brahmaputra	2897	1621	38
Zambezi	3540	1330	7
Tigris-Euphrates	2740	1114	1
Danube	2850	816	7
Colombia	1950	668	7
Rhine	1320	160	2
Thames	239	10	0.06
Tay	188	5	0.15
Dee	140	2	0.04

4 National comparisons

4.1 Physical characteristics

Ward (in Lewin 1981) has ranked major British rivers in terms of length, area and mean annual discharge. The Dee is included in his list of rivers and falls 10th in length, 21st in catchment area, and 18th in terms of flow, eventually being ranked 18th in terms of these 3 characters. However, there are many other relevant river characteristics, some of them probably much more important in biological terms, which should be considered when comparing the attributes of different running water systems. Two of the most important of these are the altitude of the upper reaches and the extent of the lowland (and estuary) sections of each river.

Table 3 indicates that, according to the Water Data Unit (1982), the Dee rises higher than any other major British river (1310 m)*, closely followed by the Spey (1309 m), the Tay (1215 m) and the Ness. No other large river rises above 1000 m. As discussed below, this high-altitude section can be of considerable ecological importance. At the other end of the river, the Dee (unlike most of the other large rivers) is almost devoid of an estuary and has a relatively short lowland section.

In physical terms, therefore, it would be true to say that the Dee is one of the most highland in character of all the large British rivers. This statement is confirmed by an analysis of its flow regime which Warren (1985) describes as 'alpine' in character.

4.2 Chemical characteristics

It is difficult to obtain comparable chemical data for rivers in different areas. However, Table 4 gives a general chemical classification of series of stations

*but see Maizels (1985) who states that the Dee rises at 1220 m (Ed).

Table 3. Major British rivers ranked in terms of flow, length, catchment areas and maximum altitude

	Flow (cumecs)	Length (km)	Catchment area (km^2)	Maximum altitude (m)
Tay	152.2	188	4587	1215
Trent	82.2	149	8547	636
Ness	76.6	107	1792	1120
Tweed	73.9	140	4390	839
Wye	71.4	225	4040	752
Thames	67.4	239	9950	330
Severn	62.7	206	9983	827
Spey	55.9	137	2655	1309
Tyne	43.5	89	2176	839
Ouse	40.5	117	3315	713
Tywi	38.3	82	1088	792
Clyde	37.4	105	1903	732
Aire	36.9	114	1932	594
Dee	35.7	140	2100	1310
Ribble	31.7	94	1140	680
Eden	31.0	102	2287	950

4.3 Botanical characteristics

Morgan and Britton (in Ratcliffe 1977) give a brief description of the macroflora of the Dee, emphasizing the importance of the bryophytes in the upper reaches. In a more detailed survey, Holmes (1985) showed that several zones of vegetation could be distinguished on passing downstream and that, when compared to other large rivers in Great Britain, the Dee has a unique succession of communities, exemplifying a large oligotrophic highland river. Due to this representativeness and its naturalness, Holmes confirms the Dee as being of prime nature conservation interest.

4.4 Invertebrate characteristics

The invertebrate fauna of many Scottish rivers was studied at the same time as their water chemistry (Table 3) and comparable data are available for 1974 and 1980 (Scottish Development Department 1976, 1983). Both sets of samples were taken in the spring,

Table 4. Chemical classification of various stations on the large Scottish rivers (source: SDD 1976). The classes are: 1. unpolluted; 2. fairly good quality; 3. poor quality; 4. grossly polluted. The sampling stations on each river are listed numerically from mouth towards source, but the distance between each varies

STATIONS: MOUTH ←													SOURCE
	1	2	3	4	5	6	7	8	9	10	11	12	13
Ness	1	1	1	1	1								
Spey	1	1	1	1	1	1	1	1	1	1			
Don	4	1	1	1	1	1	1	1	1	1			
Dee	1	1	1	1	1	1	1	1	1	1	1	1	
Tay	2	1	2	2	2	2	2	2	2	1	1	1	1
Forth	2	1	1	1	1	1	1						
Tyne	2	1	1	2	1	1	1	1	1	1	1	1	1
Tweed	1	1	1	1	1	1	1	1	1	1	1	1	1
Annan	1	1	1	1	1								
Stinchar	1	1	1	1	1	1							
Clyde	4	3	3	2	2	2	1	1	1	1	1	1	1
Leven	1	1	1	1	1								

from near the mouth towards the source of 12 of the larger Scottish rivers. The chemical classification is related to pollution (Scottish Development Department 1976) and the classes are defined as follows: 1. unpolluted; 2. fairly good quality; 3. poor quality; 4. grossly polluted.

It is clear that, although several of the rivers concerned have sections where the chemical quality of the water is poor, this is not true of the Dee, which is one of the least contaminated of the larger Scottish rivers. It should follow, therefore, that its biota include mainly natural communities, relatively little influenced by man.

Pugh (1985) describes the Dee as being in pristine condition, emphasizing that its size and chemical nature set it apart from many other rivers. It is a fine example of a river which is oligotrophic from source to mouth.

but the 1974 data (Table 5) are expressed in the form of Trent indices, whereas the 1980 data are represented as biological scores (Scottish Development Department 1983). As with the chemical data, it is clear that, unlike several of the other large Scottish rivers, the Dee gives every indication of healthy, uncontaminated invertebrate communities along most of its length.

Other, more detailed, studies have been made of the invertebrate fauna of the Dee (Ratcliffe 1977; Wright *et al.* 1984; Davidson *et al.* 1985). Unfortunately, only Morgan and Britton (in Ratcliffe 1977) covered sites in the upper reaches of the river. Wright *et al.* (1984) compared the invertebrate fauna of the Dee with those of 41 other river systems in Great Britain, using an analysis of data at species level by multivariate statistical techniques. The Dee was characterized in this study as being 'upland' for most of its length, confirming the physical data discussed above. How-

Table 5. Invertebrate classification of various stations on the larger Scottish rivers (source: SDD 1976). The sampling stations on each river are listed numerically from mouth towards source, but the distance between each varies

	STATIONS: MOUTH ←									SOURCE			
	1	2	3	4	5	6	7	8	9	10	11	12	13
Ness	X	X	X	X	X								
Spey	X	IX	X	X	X	X	X	IX	X	VIII			
Don	VI	IX	X	IX	X	X	X	X	X	X			
Dee	VIII	IX	X	X	VII	VIII	IX	X	X	IX	X	VIII	
Tay	X	X	X	X	X	X	X	X	X	X	X	X	X
Forth	VI	X	IX	X	X	IX	IX						
Tyne	VI	VIII	IV	III	IV	VII	VIII	VIII	VIII	VII	VIII	IX	X
Tweed	IX	IX	IX	X	X	X	X	X	X	X	X	X	X
Annan	X	VIII	X	X	X								
Stinchar	VIII	IX	VIII	VIII	VIII	IX							
Clyde	II	III	VII	VI	VIII	IX	VIII	VIII	VIII	VIII	X	IX	VII
Leven	X	VIII	VII	X	X								

ever, as none of the stations sampled in this study were above 375 m and as the river rises above 1000 m, it is likely that the really interesting and characteristic part of this river has been missed by this and several other studies.

Davidson *et al.* (1985) found through an association analysis of invertebrate samples that sites on the main river were similar to each other and characteristic of an unpolluted highland river system.

4.5 Fish

A comparison of the species composition of the fish fauna of the larger Scottish rivers (Table 6) shows that, although the Dee is certainly truly highland in character, there is nothing especially remarkable about its fish community. Application of the criteria for the selection of important systems for freshwater fish recommended by Maitland (1985) confirms that the Dee is not especially noteworthy, as far as its fish are concerned.

5 Discussion

The problem of reaching an objective decision about the status of any ecosystem is a difficult one and has been discussed by a number of authors. Ratcliffe (1977) used the following criteria in his assessment of British ecosystems: extent, diversity, naturalness, rarity, fragility, representativeness, recorded history, position in an eco-geographical unit and potential value. In estimating the importance of the Dee, the author developed the procedure shown in Table 7 for the selection of running waters of conservation value. It follows the pattern of the successful procedure previously used for selecting waters important for fish conservation (Maitland 1985).

It is clear that the Dee is of relatively little importance internationally, except perhaps as a prime example of a west European highland river. It is of national importance in this category, and is probably the best example in the British Isles of a relatively natural highland river. Its particular characteristics include a

Table 6. The fish fauna of the larger Scottish rivers (updated from Maitland 1972)

	Sea lamprey	River lamprey	Brook lamprey	Salmon	Sea trout	Grayling	Smelt	Pike	Gudgeon	Minnow	Roach	Chub	Dace	Stone loach	Eel	Three-spined stickleback	Perch	Flounder	TOTAL
Ness	+	−	+	+	+	−	−	+	−	+	−	−	−	−	+	+	−	+	9
Spey	+	+	+	+	+	−	−	+	−	+	−	−	−	−	+	+	+	+	11
Don	+	+	+	+	+	−	−	+	+	+	−	−	−	+	+	+	+	+	13
Dee	+	+	+	+	+	−	−	+	−	+	−	−	−	−	+	+	+	+	11
Tay	+	+	+	+	+	+	+	+	−	+	+	−	−	+	+	+	+	+	15
Forth	+	+	+	+	+	−	−	+	−	+	+	−	−	+	+	+	+	+	13
Tyne	+	+	+	+	+	−	−	+	−	+	+	−	−	+	+	+	+	+	13
Tweed	+	+	+	+	+	+	−	+	+	+	+	−	+	+	+	+	+	+	16
Annan	+	+	+	+	+	+	−	+	−	+	+	+	−	+	+	+	+	+	15
Stinchar	+	+	+	+	+	−	−	−	−	+	−	−	−	+	+	+	−	+	9
Clyde	−	−	+	+	+	+	−	+	−	+	+	−	+	+	+	+	+	−	12
Leven	+	+	+	+	+	−	−	+	+	+	+	−	−	+	+	+	+	+	14

Table 7. Procedure for the selection of running waters of conservation value

1. Is sufficient information available about the system to characterize it from source to mouth?	YES NO	2 A
2. Are there any physico-chemical or biological features sufficiently outstanding to warrant international status?	YES NO	B 3
3. Are any of the physico-chemical or biological characteristics sufficiently important to warrant national recognition?	YES NO	C 4
4. Are any man-made developments likely to be having a significant effect on the river?	YES NO	D E

A. More research is required.
B. The system should be notified internationally.
C. The system should be notified nationally.
D. The conservation value of the system is reduced.
E. The conservation value of the system is increased.

greater altitudinal range than any other large British river, virtual absence of a meandering lowland section or estuary, and very little impact from man in terms of pollution, abstraction and hydro-electric or other abstractions. Its flora and fauna are typical of an uncontaminated highland system typically rather low in diversity, especially compared to lowland systems.

There were 2 main problems in making this review. The first is that there is still insufficient ecological information concerning the Dee. This is particularly true of most aspects of the extremely important (and potentially unique) upper reaches but also of some basic aspects such as the distribution and status of its fish populations (Jenkins & Bell 1985). Figure 1 emphasizes the upland character of the Dee compared to another, even larger, British river, the Trent. The distribution of stations for most types of sampling seems to be limited by accessibility from road bridges, and more research is needed in the mountainous

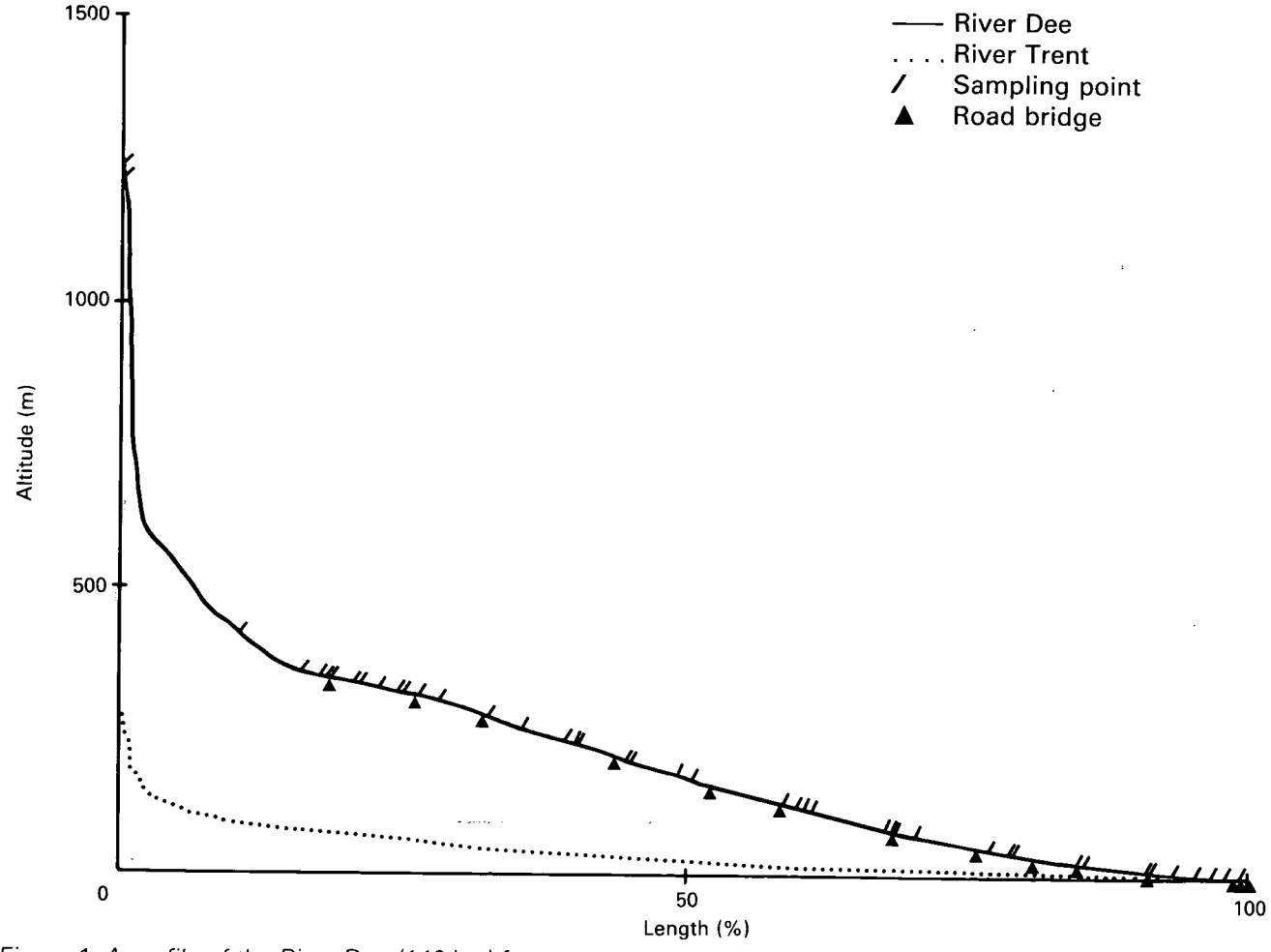

Figure 1. A profile of the River Dee (140 km) from source to mouth contrasting with the River Trent (256 km) drawn to the same percentage scale. Recent sampling points on the Dee by various organizations are shown just above the profile in relation to the main road bridges, below

upper reaches; these are, after all, one of the most important features of this river.

The second problem is that comparisons with other systems are difficult because of the absence of data and also because data are rarely available in a consistent form. For this reason, much of the information produced by the Scottish River Purification Boards and published in their Annual Reports cannot be used directly. The same is true for many data presented by local authorities and other regional organizations.

This review confirms the grade 1 national rating given to the Dee during the Nature Conservation Review (Ratcliffe 1977). However, in spite of this rating, relatively little specific action, in nature conservation terms, has been taken. The North East River Purification Board is well aware of the high quality of the river and continues its efforts to maintain this, but there remains a need for more integrated conservation plan for the whole river basin which takes into account all the various demands on the resource while keeping as its top priority the conservation of water quality and the flora and fauna of the main river. Its major features of national importance are summarized in Table 8.

Table 8. Why is the River Dee important? A summary of features of importance in a national context

1. An excellent example of a highland eroding river.
2. Its headwaters are probably the best alpine streams in Great Britain.
3. It has virtually no lowland depositing section or estuary.
4. Its waters are nutrient-poor and water quality is always high.
5. Man-made impacts are low, so the system is highly natural.
6. The plant communities show a unique succession, and are intact and representative.
7. The invertebrate communities are characteristically highland throughout most of the river.
8. The fish and other vertebrates are poor in diversity, but the salmonid fishery is important.
9. The catchment area is scenically attractive.
10. The recreational value of the river system is high.

6 Summary

The general ecological status of the Dee is reviewed. In international terms, for virtually all assessment criteria, the Dee is unimportant compared to the large rivers of the world. Its most important role is as the best example of a large natural highland river in Scotland. Its most characteristic and important features are as follows: its headwaters are among the highest of any river in the British Isles; there is virtually no lowland section (or estuary) and the substrate is eroding virtually to the river mouth; the aquatic flora and fauna are highly characteristic of this type of system and are relatively unaffected by man. In view of its national importance, strong conservation measures should be adopted to preserve its status.

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