

What value natural rivers?

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PRINCIPAL AIM

The principal aim of this study was to determine whether the ecosystem services provided by protected Scottish rivers are more abundant and resilient than those of unprotected rivers (Figure 1). The results strengthen the belief that near-natural river corridors, that are protected for their habitats and species, may support higher levels of provisioning, regulating, and cultural ecosystem services.

INTRODUCTION

Many near-natural landscapes that are rich in biodiversity are protected by nature conservation designations. To date, only limited research has been conducted on rivers to determine whether such protection at the landscape scale has the added benefit of offering long-term protection against the loss of ecosystem services. Even fewer studies have systematically quantified the ecosystem service potential of whole river ecosystems due to a lack of assessment tools. This is primarily because rivers and their valley floors, both at the reach and network scale, are complex ecosystems with high multi-scalar heterogeneity. A study was commissioned by NatureScot, the Scottish Government's nature agency to address the deficiencies.

METHODOLOGY

The study used the now widely accepted three-part ecosystem service classification (provisioning, regulating, cultural), and in so doing added significantly to earlier river ecosystem service assessments that did not include all three services. The key components of the study and methodology were:

(i) In consultation with key personnel from Scottish environmental organizations, to identify the ecosystem services relevant to Scottish rivers. Four provisioning services (water supply, hydroelectric power, agriculture, and timber production), three regulating (natural flood management, climate regulation, and water quality), and six cultural (aesthetic value, social relations, inspiration, education/knowledge, cultural heritage, and recreation) were identified.

(ii) The river corridor width was delineated by the boundaries of 1 in 100-year indicative flood maps. These sheets, modelled by the UK Centre for Ecology and Hydrology, are available for the whole of Scotland. Data on 20 physical habitat features and land cover types were taken from Google Earth™; the process was based upon a previously published method but was altered to take account of cultural ecosystem services. The linkages between habitat features and land cover types and the generation of provisioning and regulating services were based on an extensive scientific literature review (180 articles) and expert opinion. The level of confidence in each linkage was described as high, medium, or low.

The linkages between cultural services and the presence or absence of features and land cover were established separately to the other services. A Survey Monkey questionnaire was used based on photographs that included river features and land cover types. Respondents (N=60) were asked whether they would visit a river type for the range of cultural services represented using a five-point classification of never, rarely, sometimes, frequently, or very frequently. Only those services with a mean score equating to sometimes or frequently were included in the ecosystem service matrix and scoring.

(iii) An integer-based scoring system for each river reach, ranging from 0–100% and using a class interval of 10, was adopted for classification. A score of 0–10 meant virtually absent and 91–100 implied near maximum potential contribution. If assessing all seven provisioning and regulating services, the maximum score was 700. Reach scores for cultural services were assigned in the same way, but with a maximum score of 600 per reach. Area-weighted scores were also derived, by multiplying the area (in hectares) of valley floor of each 500 m reach by the reach score.

(iv) The methodology was applied to four sets of rivers in Scotland (Figure 1). Each pair comprised one river designated as a Special Area of Conservation (SAC) and one where nature designations were largely absent. SACs are designated to protect specific habitats and species listed in the annexes of the Habitats Directive. Twenty of Scotland's rivers are designated SACs, most notably for the protection of the freshwater pearl mussel (*Margaritifera margaritifera*) and Atlantic salmon (*Salmo salar*).

Reach-scale scores were summed to give a total score for each river. To determine the effect of statutory protected areas on ecosystem service supply, the differences between the scores for the pairs of rivers were assessed using a Mann–Whitney U test.

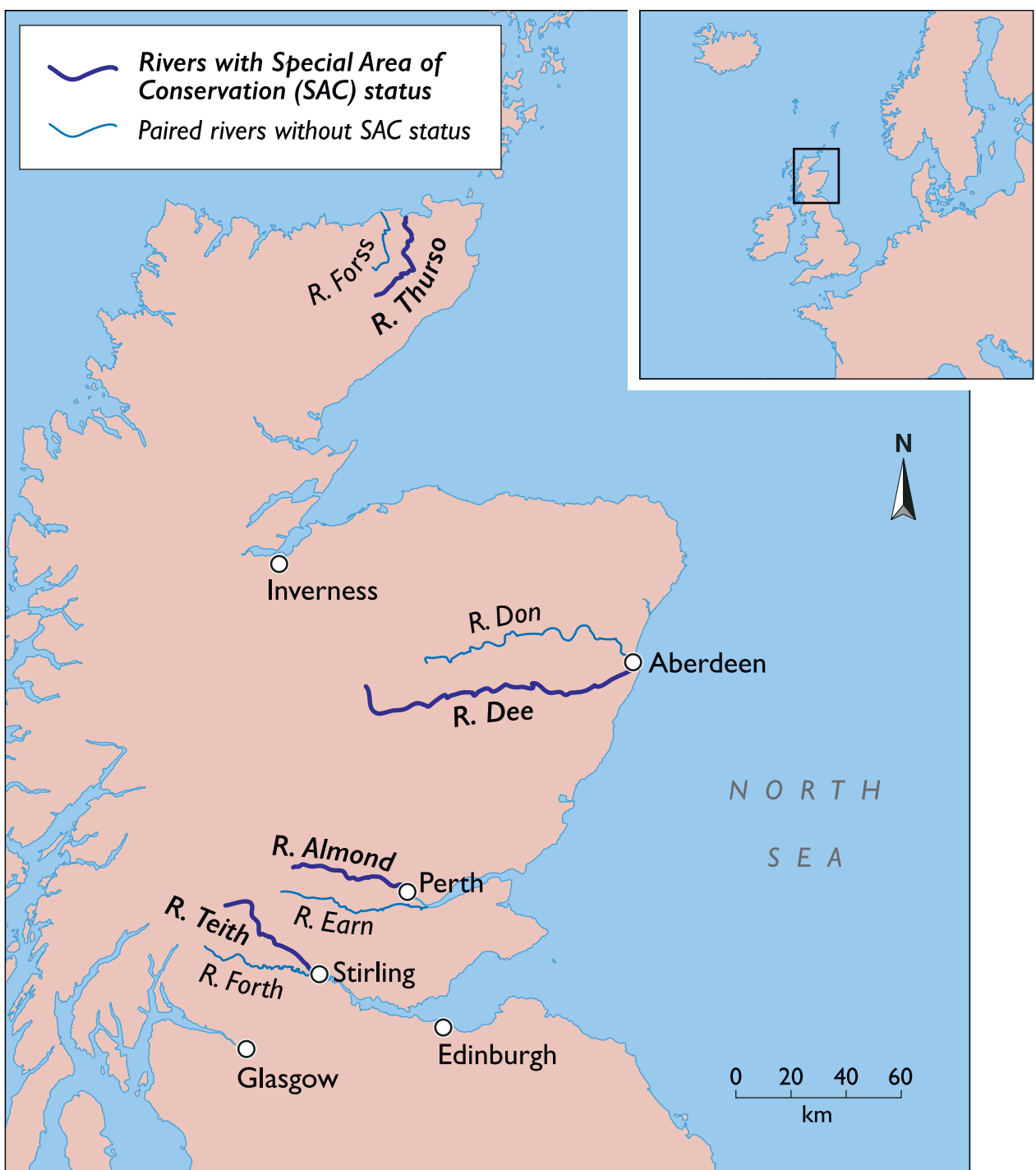


Figure 1. A map of Scotland showing the location of the eight individual rivers studied and their pairing according to levels of nature protection by statutory designations.



Figure 2. The River Grunard – a river where “natural” habitats and processes are dominant providing a number of important ecosystem services.

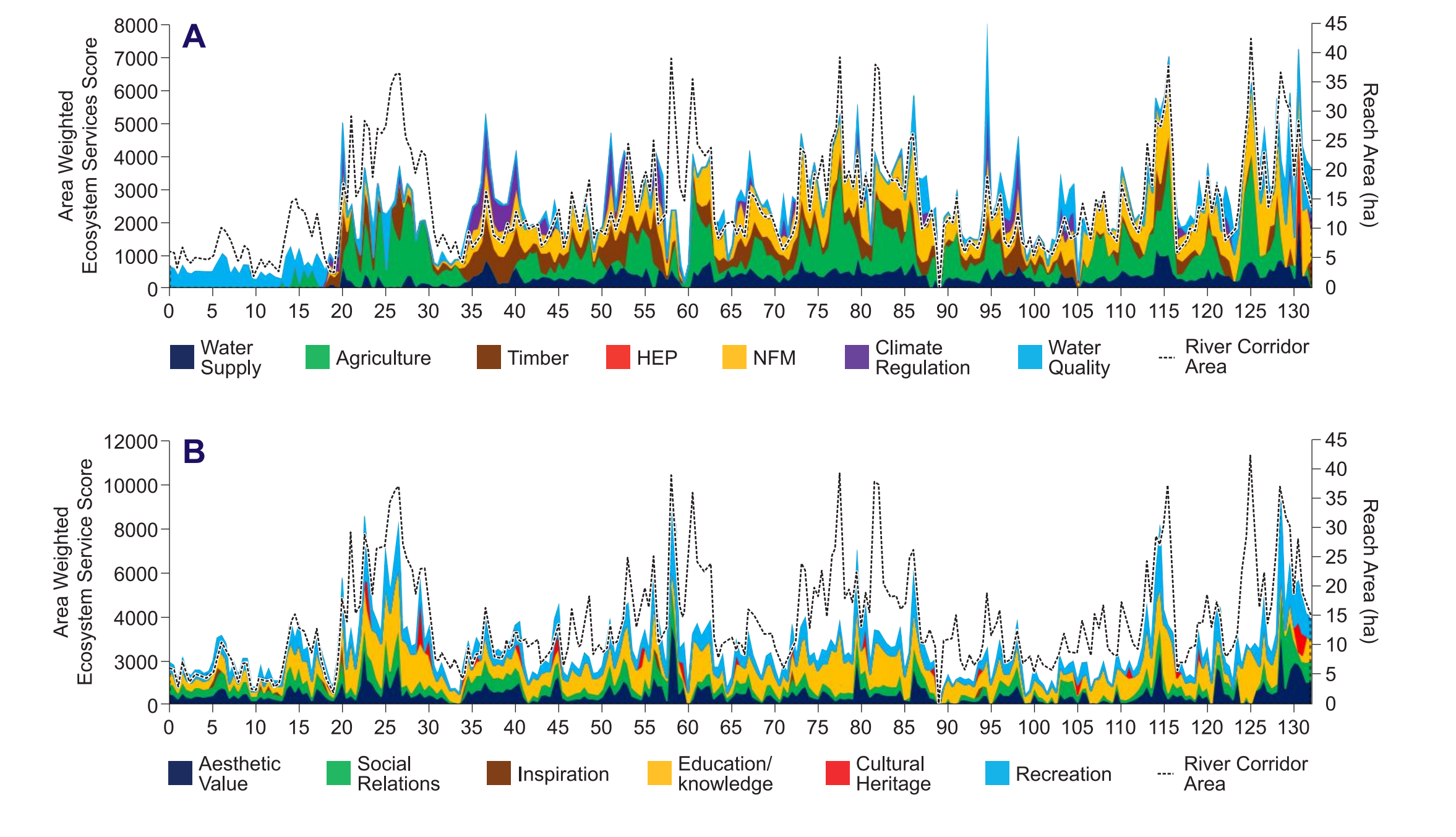


Figure 3. Downstream changes in ecosystem service scores for the River Dee together with the area of floodplain/valley floor for each 500 m reach. Long profiles for provisioning and regulating and cultural services are separated only for clarity: (A) Provisioning and regulating; (B) Cultural. The dotted lines represent the valley floor area in hectares for each 500 m reach.

River	U/P	Catchment area (km ²)	Mean annual flow (m ³ s ⁻¹)	Species justifying designation	
				Common name	Scientific name
Thurso	P	413	9.1	Atlantic Salmon	<i>Salmo salar</i>
Forss	U	130	not known		
Dee	P	2080	24.6	Freshwater pearl mussel	<i>Margaritifera margaritifera</i>
				Otter	<i>Lutra lutra</i>
				Atlantic salmon	<i>Salmo salar</i>
Don	U	1280	21.2		
Teith	P	518	24.6	Sea Lamprey	<i>Petromyzon marinus</i>
				Brook lamprey	<i>Lampetra planeri</i>
				River lamprey	<i>Lampetra fluviatilis</i>
Forth	U	1036	24.7		
Almond	P	360	6.2	Sea Lamprey	<i>Petromyzon marinus</i>
				Brook lamprey	<i>Lampetra planeri</i>
				River lamprey	<i>Lampetra fluviatilis</i>
				Atlantic Salmon	<i>Salmo salar</i>
				Otter	<i>Lutra lutra</i>
Eam	U	590	22.8		

Table 1. The eight rivers used in the study, shown as protected (P) and unprotected (U) pairs, with information on their catchment areas, mean annual flow, and the species present that justified the designation of each river.

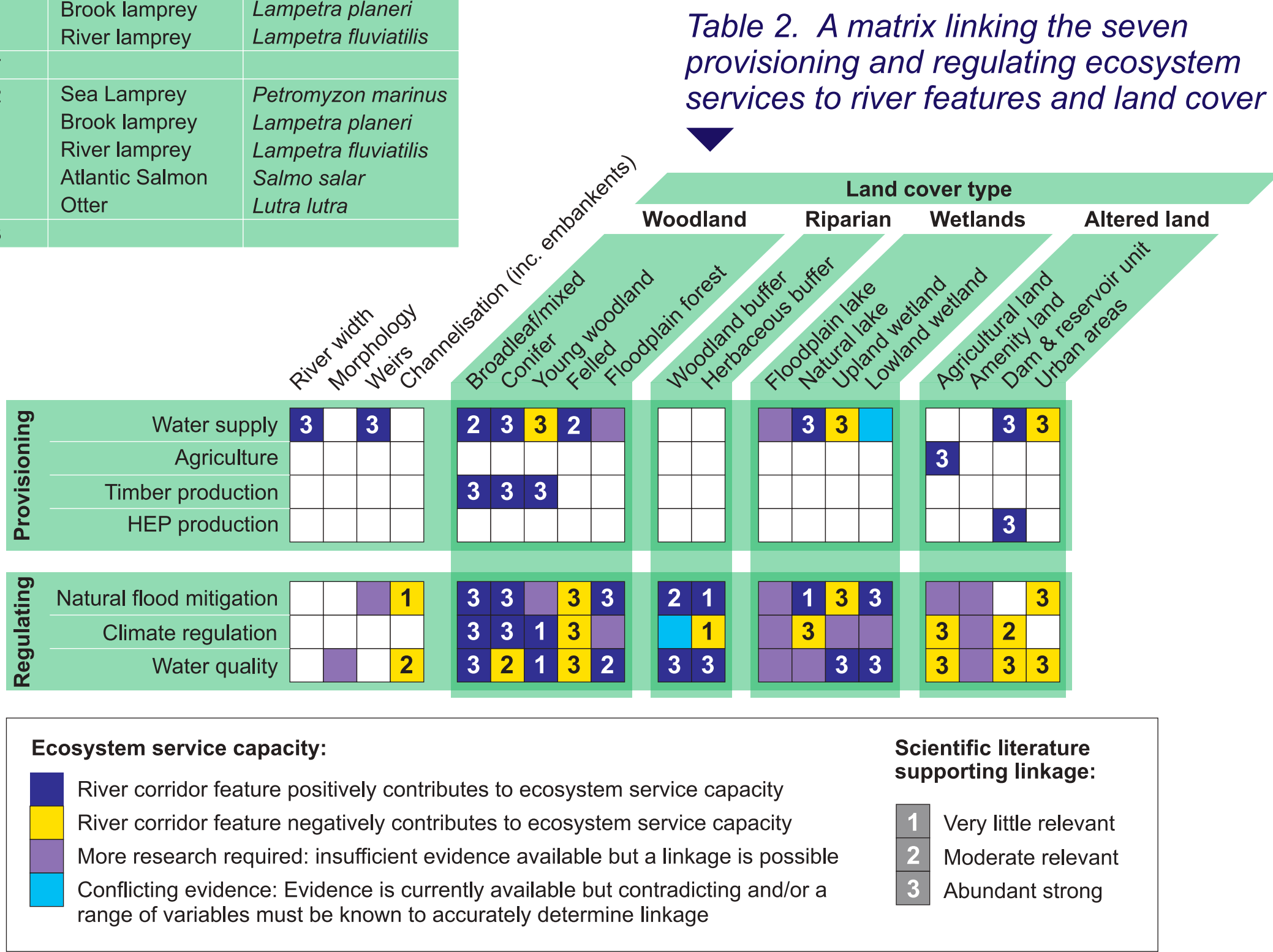


Table 2. A matrix linking the seven provisioning and regulating ecosystem services to river features and land cover

Riverscape feature/land cover	Aesthetic value	Social relations	Inspiration	Education/knowledge	Cultural heritage	Spirituality/religion	Recreation
Cultural heritage feature	2.5	2.1	1.5	1.7	2.5	0.6	2.3
Waterfalls	3.2	2.3	2.2	2.2	1.7	1.4	3.0
Land cover type							
Woodland	3.0	2.3	1.9	2.1	1.6	1.1	2.9
Felled woodland	1.6	1.0	0.9	1.7	1.2	0.5	1.8
Upland wetlands	3.0	2.0	1.8	2.0	1.7	1.2	2.9
Lowland wetlands/floodplain lake	2.2	1.7	1.3	1.8	1.5	0.8	2.4
Agricultural land	3.0	1.8	1.6	2.1	1.8	1.0	3.1
Amenity land	2.6	2.2	1.3	1.7	1.7	0.8	2.6
Natural lake/reservoir	2.4	1.8	1.4	1.8	1.7	0.8	2.5
Urban areas	1.3	1.6	0.8	1.2	1.4	0.4	1.6

Table 3. Mean perception survey participant score for the linkage between river feature and land cover, and cultural ecosystem service. Shaded boxes indicate a significant link. A score of zero denotes never and a score of four very frequently (Spirituality/religion was removed from the matrix and analysis on the basis of these data).

Riverscape feature/land cover	Aesthetic value	Social relations	Inspiration	Education/knowledge	Cultural heritage	Spirituality/religion	Recreation
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Waterfalls	3.2	2.3	2.2	2.2	1.7	1.4	3.0
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Woodland	3.0	2.3	1.9	2.1	1.6	1.1	2.9
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Upland wetlands	3.0	2.0	1.8	2.0	1.7	1.2	2.9
Lowland wetlands/floodplain lake	2.2	1.7	1.3	1.8	1.5	0.8	2.4
Agricultural land	3.0	1.8	1.6	2.1	1.8	1.0	3.1
Amenity land	2.6	2.2	1.3	1.7	1.7	0.8	2.6
Natural lake/reservoir	2.4	1.8	1.4	1.8	1.7	0.8	2.5
Urban areas	1.3	1.6	0.8	1.2	1.4	0.4	1.6

Table 5. An analysis of statistical different outcomes between the paired rivers in relation to ecosystem service provision.

Rivers	Total Ecosystem Service score	Total Provisioning score	Total Regulating score	Total Cultural score	Total Ecosystem Service score	Total Provisioning score	Total Regulating score	Total Cultural score	Total Ecosystem Service score	Total Provisioning score	Total Regulating score	Total Cultural score	Total Ecosystem Service score	Total Provisioning score	Total Regulating score	Total Cultural score
River Don																
River Dee																
River Forss																
River Thurso																
River Eam																
River Almond																
River Forth																
River Teith																
Summary of ecosystem service supply																
Unprotected rivers	1	1	1	4			1	1	1	1	2			2	2	2
Protected rivers	3	2	3	2			2	2	2	3	2	2		2	2	2

IMPLICATIONS

• The method described provides a basis for river management that not only addresses the protection of habitats and species but also ecosystem services. The method may need to be calibrated for different biogeographical regions.

• Several assumptions, albeit based on the expert knowledge of river scientists, are made about links between river landscape features and provisioning and regulating ecosystem services. These assumptions are reflected in the uncertainty scores given to individual linkages, but even where these assumptions are scientifically valid, they still might not be universally applicable. New scientific evidence may also need to be included in the methodology.

• Being able to identify ecosystem service hotspots and areas devoid of ecosystem services in river networks or across catchments is also potentially of value to catchment managers, as areas or reaches with lower levels of ecosystem service supply can be examined to determine whether this is a product of inherent river system variability, a result of the degree of legislative protection, or an indicator of environmental degradation.

• The incorporation of cultural ecosystem services using a photo-preference questionnaire survey is seen as a significant advance, but untangling the variety of ways in which cultural ecosystem service scores may be categorized remains a challenge.

• The focus of this study was on the main stem of the rivers; work to determine the level of ecosystem services provided by lower-order rivers and tributaries is needed.