Biodiversity and Ecosystem Services: Arguments for our Future Environment

BESAFE
the value of biodiversity and ecosystem services

SEVENTH FRAMEWORK PROGRAMME

How have we advanced our understanding of the links between biodiversity, ecosystem functions and ecosystem services?

The issue

The concept of ecosystem services requires an understanding of the contribution of ecosystems and the services they deliver to long-term human well-being, as well as the human demand for those services. Ecosystems provide different types of service, including provisioning (e.g. food), regulating (e.g. flood protection and carbon sequestration), and cultural (e.g. recreation). However, it is not clear exactly what components of biodiversity are needed for the ecological processes or functions that deliver each of these services. Although ecosystem services are generated from myriad interactions occurring in complex systems, we need to understand at least some of the key relationships to manage the delivery of services effectively. Furthermore, improving understanding of the relationships between biodiversity and service provision will help guide effective arguments for biodiversity conservation.

Advances in understanding the links between biodiversity and ecosystem services

Several studies have furthered knowledge of the role of biodiversity in ecosystem functioning and the supply of ecosystem services. Relationships have been examined for a large number of biodiversity attributes including:

- Populations of a species;
- Groups of species (communities);
- Genetic make of an individual and species;
- Groups of species that perform similar functions in the ecosystem (functional groups);
- Traits as a characteristic of an organism (functional traits are specific properties of species which define their role in an ecosystem); and
- Functional diversity (the range, actual values and relative abundance of functional traits in the community).

However, studies are often limited to specific elements of biodiversity, particular ecosystem services and can vary greatly by geographical or ecosystem context. The BESAFE project undertook a comprehensive review to pull together this diverse literature on linkages between components of biodiversity and 11 ecosystem services. The review focused on the key attributes and traits of biodiversity that influence the delivery of these 11 services, as well as exploring the direction of this influence (positive or negative).

The 11 ecosystem services included in the review were:

- Provisioning services (Potable water, Timber production and Freshwater fishing);
- Regulating services (Water quality regulation, Water quantity regulation (flood protection), Mass flow regulation (erosion protection), Climate regulation (carbon sequestration), Pollination and Pest & disease control);
- Cultural services (Recreation and landscape aesthetics).

The key findings were:

1) Ecosystem services tended to be linked to certain ecosystem service providers (defined as the populations, functional groups or communities that contribute to service provision; Table 1). For example, the community scale was important for potable water, water quality, flood protection, erosion protection, carbon sequestration and landscape aesthetics, i.e. an entire forest, grassland or hay meadow. Most provisioning services, however, were provided by two or more specific species populations, e.g. Scots pine and silver birch for timber production. Regulating services were associated with a broad range of ecosystem service providers, with a particular functional group often providing the services of pollination (e.g. flower visiting insects) and pest control (e.g. parasitoids).

Table 1: Number of papers (out of 50) with evidence of links between ecosystem service providers and particular ecosystem services. SP = specific population; FG = functional group; DC = dominant community; CH = community/habitat).

	SP1	SP2+	FG1	FG2+	DC	CH1	CH2+
Potable water (quantity)	1	4	0	0	0	21	24
Timber production	0	28	0	7	0	0	0
Freshwater fishing	12	31	0	0	0	2	0
Water quality regulation	3	6	0	1	0	26	14
Water flow regulation (flood protection)	4	10	0	0	2	25	9
Mass flow regulation (erosion protection)	2	5	1	5	0	23	14
Atmospheric regulation (carbon sequestration)	3	2	1	2	0	28	14
Pollination	3	8	35	3	0	0	1
Pest & disease control (biological control)	10	6	15	7	0	10	2
Recreation activities	15	33	0	0	0	2	0
Landscape aesthetics	0	0	0	0	0	42	8

2) A large range of biodiversity attributes (over 20) were found to be important within the broad categories of ecosystem service providers. All the biodiversity attributes were found to impact on the delivery of one or more of the ecosystem services (Figure 1). The most common were community or habitat area (cited in 33% of articles) and structure (28%), species abundance (37%) and species richness (34%). Following these were species size or weight (18%) and community or habitat age (13%).

3) Often the biodiversity attributes and ecosystem service provider categories were linked in how they influenced ecosystem service delivery. Overall the most common links were between two or more specific species and species abundance and richness; two or more communities and habitat area; and an entire community and habitat area and structure.

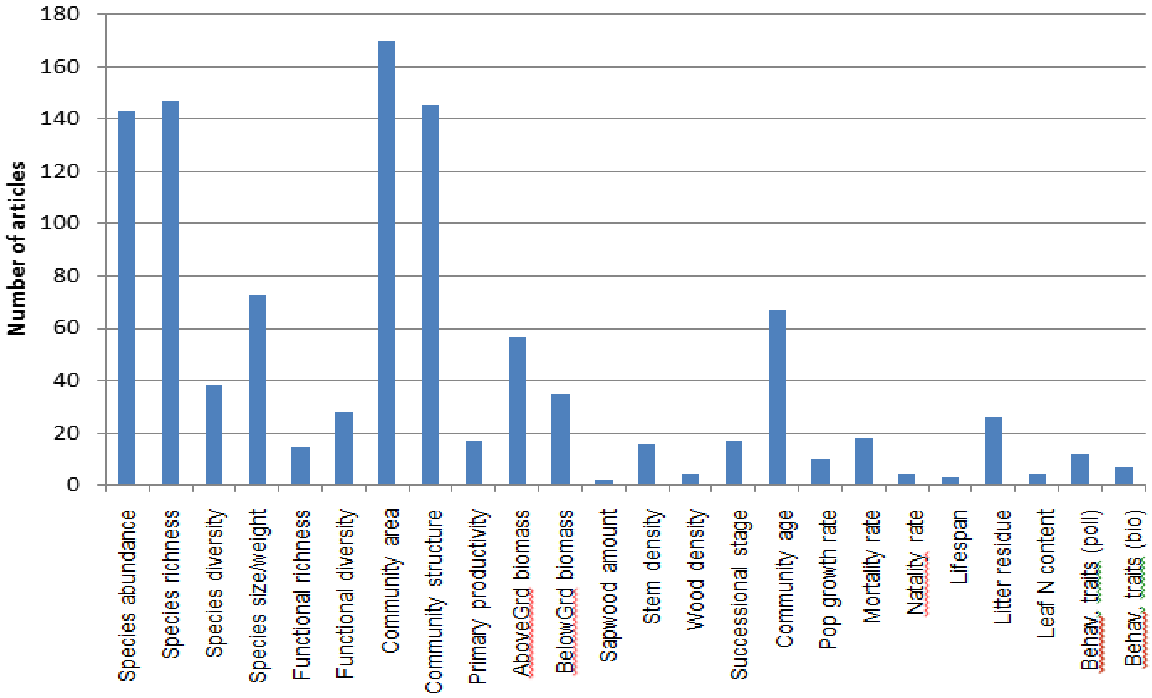

Figure 1: The importance of the different biodiversity attributes for ecosystem service delivery.

4) Usually only a few biodiversity attributes were of high importance to each ecosystem service. Network diagrams were produced for each ecosystem service highlighting these linkages (shown by the thickness of the lines connecting the biodiversity attributes to the service; Figure 2 shows an example for the service of carbon sequestration).

5) The majority of relationships between biodiversity and ecosystem services were predominantly positive (e.g. Figure 2). For example, the services of flood protection, erosion control, aesthetic value and water quality regulation were improved by increases in community and habitat area. Functional traits, such as richness and diversity, also displayed a predominantly positive relationship across the services, most commonly discussed for carbon sequestration, pest control and pollination. A number of entries also discussed a positive correlation with stand age, particularly carbon sequestration. Species level traits, such as abundance, were found to benefit a number of ecosystem services (recreation, pollination and pest control). Species richness was particularly important for timber production and freshwater fishing, where polycultures were found to be more productive than monocultures. The size and weight of species was another trait which positively affected services, including freshwater fishing, carbon sequestration and recreation.

6) Instances of biodiversity negatively affecting the examined ecosystem services were also present in the literature although these were few in number for all ecosystem services, except potable water. Many of the examples cited involved invasive species.

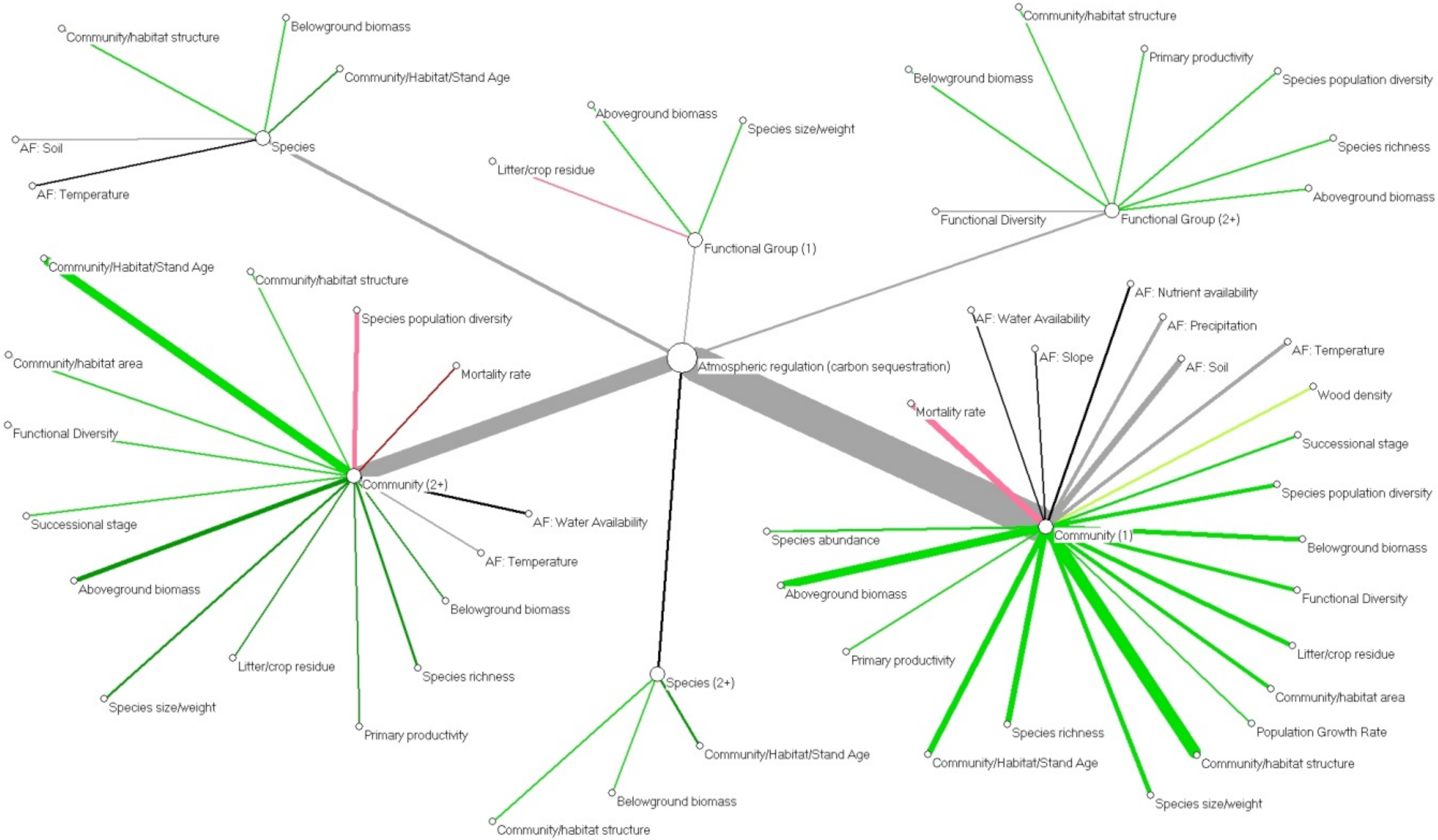

Figure 2: Network diagram for the links between biodiversity and carbon sequestration via various Ecosystem Service Providers (ESP). The width of the lines reflects the number of records showing that linkage. The colour of the lines between the ESP and their attributes reflects the direction of the evidence, with green lines for predominantly positive relationships and red lines for predominantly negative ones; grey is used for relationships that are classified as neither or both (and are hence marked as "neutral"). The depth of the colour is used to differentiate the strength of the evidence with lighter shades of green, red and grey reflecting weaker positive, negative and neutral relationships and darker shades reflecting stronger ones.

The review also found that environmental factors, such as temperature and precipitation can influence ecosystem services and their effect was most pronounced for atmospheric regulation, pest control, erosion protection and water quality regulation. In addition to climate, numerous studies cited soil properties, such as porosity, water availability and water quality, as affecting service delivery, with the latter benefitting ecosystem services in all case studies where it was mentioned.

Further work planned

The review has been completed, but we are still analysing the extensive databases that have been produced for each ecosystem service. We plan to combine the network diagrams created for each individual ecosystem service (as shown in Figure 2) to examine general trends (see preliminary attempt at this in Figure 3). This will include identifying biodiversity attributes which most commonly impact service provision and assessing the dependence of ecosystem services on different biotic and abiotic factors.

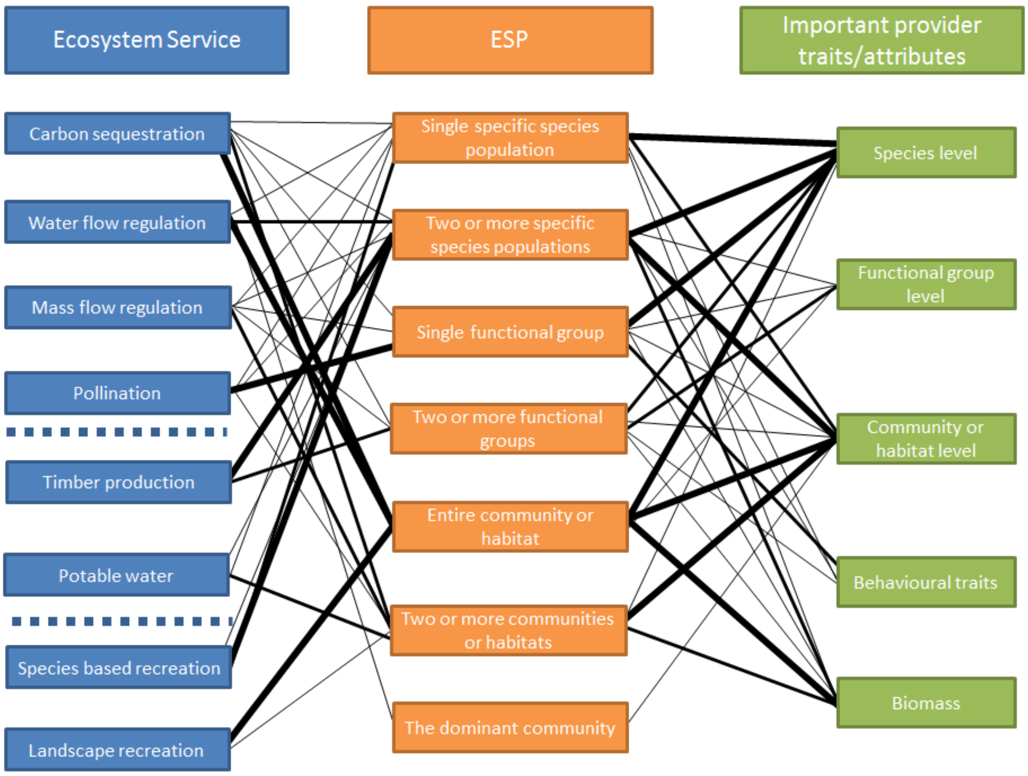

Figure 3: Preliminary analysis across all ecosystem services.

Knowledge constraints on more informed decision-making

Knowledge of the links between biodiversity and particular ecosystem services is increasing and this review has identified many of the specific links important to 11 ecosystem services. This knowledge can enhance decision-making as it provides greater understanding of the biodiversity attributes that are important in the delivery of those services and that could be targeted to enhance service delivery. Our knowledge of the quantity of a particular attribute needed, such as habitat area or species abundance, is more limited. The review also strengthens the scientific knowledge base necessary to promote the use of ecosystem services arguments in the conservation of biodiversity.