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LINKS BETWEEN NATURAL CAPITAL AND ECOSYSTEM SERVICES

KEY MESSAGES

- The delivery of ecosystem services depends on five groups of natural capital attributes:
  - A. Amount of vegetation (biomass per hectare)
  - B. Presence of supporting habitat for key species that provide services (e.g. pollinators)
  - C. Presence of species with particular characteristics
  - D. Biological and physical diversity
  - E. Abiotic factors e.g. temperature, rainfall, soil type, slope
- Different bundles of services require different combinations of these natural capital attributes – for example, a bundle of five regulating services (flood and erosion protection, air and water quality regulation, carbon storage) depends mainly on the amount of vegetation (A) but pollination depends more on B, C and D.
- More biologically and structurally diverse habitats tend to provide a higher level of most services, and are more resilient to environmental change.
- Provisioning services (e.g. food crops) often result in conversion of ecosystems to producing a small range of high-value species (C). This often leads to a reduction in the total amount of vegetation (A), the supporting habitat (B) and the biodiversity (D), which leads to trade-offs with many regulating and cultural services.
- Sustainable ecosystem management is essential in order to maximise synergies between services, minimise trade-offs, and maintain diverse, healthy ecosystems that can continue to deliver a wide range of services in the long-term. Natural capital attributes can be used as indicators to guide management strategies, including for monitoring ecosystem condition.

NATURAL CAPITAL UNDER THREAT

Natural capital – including plants, animals, air, water, soil and rocks – provides a flow of ecosystem services that are essential for human survival. Yet this capital is being depleted by over-exploitation of resources, leading to pollution, climate change, habitat loss and species loss. Decision-makers in policy, practice and business understand the need to manage natural capital sustainably, but they need evidence to guide their management strategies. In particular, they need to know how the delivery of different ecosystem services will be affected by changes in natural capital attributes, such as ecosystem type or condition.

To develop this evidence base, we systematically searched the scientific literature to find studies that examined how different natural capital attributes affected the delivery of 13 ecosystem services. We looked at both biotic attributes (such as habitat type, presence of a particular species, or biological diversity) and abiotic attributes (such as temperature and soil type). We reviewed 780 papers (60 for each service), recording whether each attribute had a positive, negative, mixed or unclear impact on delivery of the service.

A CLASSIFICATION OF NATURAL CAPITAL ATTRIBUTES

Five main groups of natural capital attributes influence the delivery of ecosystem services, and 'bundles' of services are governed by different attribute groups. The groups are broadly related to the type of habitat, the presence of particular species, and the diversity of species present (Figure 1).

A. Amount of vegetation

A bundle of five air, soil and water regulating services — flood protection, erosion protection, air quality regulation, water quality regulation and carbon storage — depends mainly on the physical amount of vegetation within an ecosystem. Forests generally perform best for these services – especially dense forests with older and larger trees. For the service of water supply, however, the amount of vegetation may have a negative impact. For example, plantations of fast-growing timber species such as pine or eucalyptus extract a lot of water from the ground, which can reduce stream flow and cause water scarcity problems in arid regions.

B. Provision of supporting habitat

Services proved by particular animal species, such as pollination, depend on the existence of suitable habitats to provide food, shelter and breeding sites for those species. Pollinators and pest predators need natural or semi-natural habitats close to crops, and fish require aquatic habitats with the right ecological, hydrological and climatic conditions to support all stages of their life cycle.

C. Presence of species with particular characteristics

Particular species are important for most services, especially fish, timber and food crop provision, which depend on desirable characteristics such as palatability (for food) or straight growth (for timber). Species-specific attributes can also be important, such as species size for fishing and species-based recreation (e.g. nature-watching); and species behaviour for pollination and pest regulation.

D. Biological and physical diversity

Biological diversity attributes include species richness (number of species present in an area), functional diversity (the mix of characteristics within a community) and genetic diversity. Growing mixtures of species tends to boost timber, food and fish production because a mix of species with different characteristics such as size or root depth can use resources such as light, water and nutrients more efficiently – this is called resource-use complementarity. Similarly, a mix of pollinating insects with different characteristics (e.g. size, shape, flight patterns) can provide a more efficient service. Biological diversity is particularly important in providing resistance to pests, diseases and changing climatic conditions. Physical diversity also improves many services. For example, structurally diverse habitats provide better water regulation, more carbon storage, and more shelter and breeding sites for pollinators and pest predators. More diverse landscapes also have a higher aesthetic value.

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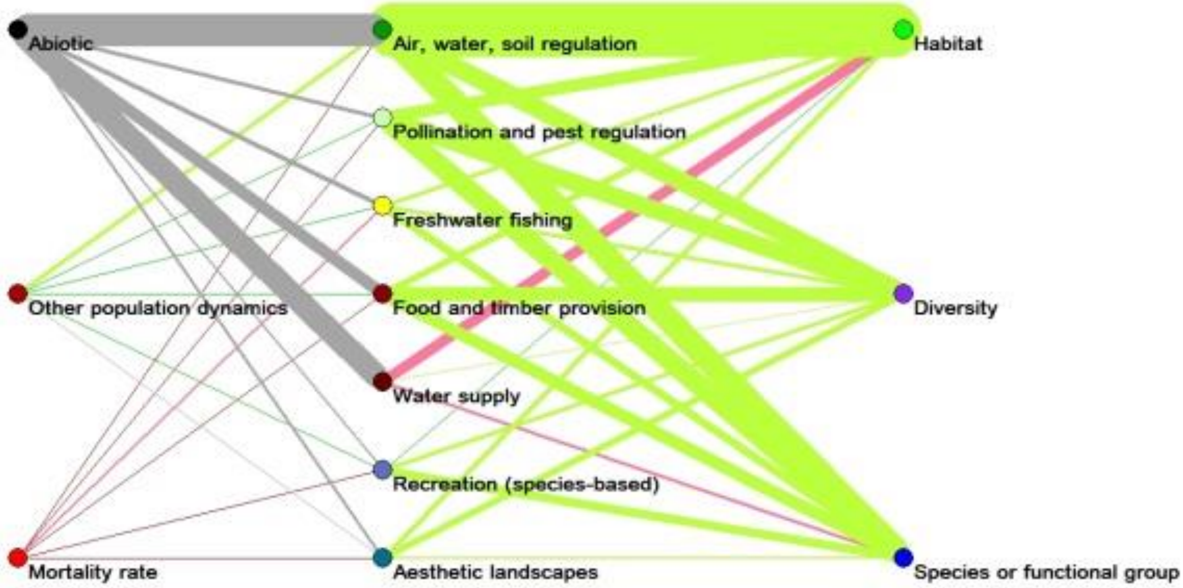

Figure 1 Summary of the evidence on how groups of natural capital attributes (related to habitat, diversity or particular species) influence bundles of ecosystem services. Line thickness is proportional to the number of studies supporting each link, and line colour indicates the predominant direction of the link. For abiotic factors all links are shown as grey lines because the direction of influence depends strongly on the context.

E. Abiotic factors

Abiotic factors such as temperature, precipitation and soil type can affect the service directly, such as when heavy rainfall causes flooding, and also indirectly through their impact on species population dynamics (e.g. growth rate and mortality), which in turn affect all the other attributes. For example, food and timber production is optimised within a certain range of climatic conditions, and yield will fall if temperature and rainfall is either too high or too low. Similarly, unfavourable abiotic conditions can reduce vegetation cover, which affects many regulating and cultural services. Over-exploitation of services, e.g. unsustainable levels of irrigation and fertiliser use in intensive agriculture, can also affect abiotic factors such as water availability and water quality and thus have a knock-on effect on other services.

This simple classification system enables natural capital attributes to be used to estimate the potential of an ecosystem to deliver different services, and to indicate how ecosystem condition affects service delivery.

CAN ECOSYSTEMS DELIVER MULTIPLE SERVICES?

Ecosystems can often deliver multiple services at the same time, but sometimes there are trade-offs. Figure 2 shows the positive and negative links between different services. For example, there are strong synergies between the five regulating services that depend mainly on the amount of vegetation (flood and erosion protection, air and water quality regulation and carbon storage), because these can all be delivered simultaneously by forest habitats. There are also strong links between air quality and aesthetic landscapes, because urban forests and street trees deliver both these services. Food crop production has strong synergies with pollination and pest regulation, and fishing has synergies with species-based recreation (recreational fishing).

Trade-offs exist between water supply and timber production, due to the high water use of some timber plantations as mentioned above. There are also many trade-offs between the provisioning services and the regulating and cultural services. For example, arable land used for crop production has a low amount of vegetation (A), little supporting habitat for beneficial species (B) and low biological and physical diversity (D), so it tends to deliver very low levels of most other services.

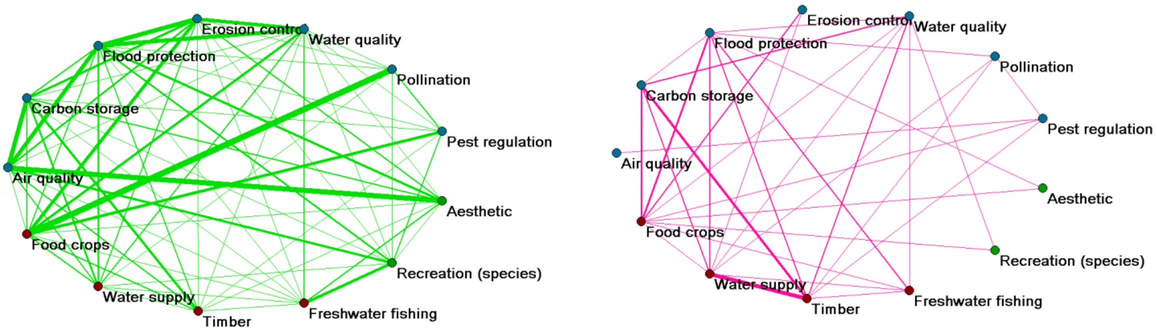

Figure 2 Positive (left) and negative (right) interactions between different ecosystem services. Line thickness is proportional to the number of papers in the review that support each link. Blue circles = regulating services; green circles = cultural services; brown circles = provisioning services.

Lessons for sustainable ecosystem management

- Physical and biological diversity enhance not only the delivery of regulating and cultural services, but also provisioning of food, timber and fish. More diverse systems often provide higher yields in the short-term, as well as greater yield stability in the long-term. Diversity can enhance resistance to pests and diseases and reduce the need for agro-chemical inputs, which brings further ecosystem benefits.
- Despite the beneficial role of diversity, there are some conflicts and trade-offs between ecosystem service provision and conservation objectives:
    - Over-exploitation of provisioning services, and sometimes cultural services (e.g. tourism), often has negative impacts on other services and on biological and physical diversity.
    - Species richness may reach a plateau beyond which service delivery does not increase, e.g. for managed plantations with three or four timber species, so there may be no incentive to restore or protect the richest ecosystems.
    - Some services may be delivered adequately by relatively common species or by non-native species such as managed honeybees.
    - Over-emphasis on protecting forests, which deliver the highest levels of many regulating and cultural services, could lead to loss of other ecosystems such as heathland, natural grasslands or sparsely vegetated land.
- Sustainable ecosystem management aims to maintain diverse, resilient ecosystems that can deliver a wide range of ecosystem services in the long-term, avoiding short-term over-exploitation of specific services. If applied correctly, the ecosystem services approach can provide motivation to conserve ecosystems in a healthy condition, simultaneously delivering services for people and habitat for wildlife.
- Indicators for managing ecosystems and monitoring their condition can be based on the different natural capital attributes that determine the delivery of different bundles of ecosystem services. These indicators can also be used (together with local expert knowledge) to help develop simple land-use scoring systems for quickly mapping the relative contribution of different habitats to different ecosystem services.

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