# New Understanding

## Biotic and Biophysical Underpinning of Ecosystem Services in the Scottish Context: A Review

This review has been undertaken as part of the Ecosystem Services Theme of the Scottish Government Strategic Research Programme: Environmental Change. Its aim is to help deliver the request from Scottish Government for:

> *Increased understanding of the linkages between the primary ecological and evolutionary processes, ecosystem function and ecosystem services, to inform assessment of the consequences of environmental change for the wide range of ecosystem services. (RD 1.1.2).*

The overall scope, approach and conclusions of the review are described in the main report and accompanying Executive Summary. This note concentrates on summarising some of the key take-home messages and new understanding that has arisen from the review.

### Take-home messages

The following messages are considered to be of particular importance throughout the review:

- The role of biological processes is constrained by the abiotic physical environment, which provides limits (e.g. regulation of productivity) within which biological systems operate;
- Although biological and biophysical processes clearly underpin the vast majority of ecosystem services, the role of biodiversity *per se* is unclear: in many cases it is the occurrence of particular species, functional groups or habitats that seems critical for service delivery;
- In some cases service delivery is strongly and directly regulated by the physical environment, whereas in others it is mediated by interactions between biotic and physical processes;
- Ecosystem services, and the components of biological and physical systems that underpin or regulate them, can interact in many different ways. These interactions occur both within and across a range of scales, and can be both synergistic and antagonistic;
- Handling the complexity of these interactions is at the heart of the uptake and dissemination of the Ecosystem Approach in environmental decision-making. Effectively it is the lack of recognition of these interactions (i.e. of how the delivery of one good or service impacts on the long-term capacity of ecosystems to deliver other services) that can lead to the degradation of natural capital and overall service delivery;
- Differences in the physical properties of upland and lowland systems in Scotland have profound implications for the biotic processes that are possible, and hence the potential for uncoupling the delivery of an ecosystem service from any biotic/biophysical process that underpins it.

### New understanding

The interactions between services, and the links between biotic and biophysical processes and service delivery, are complex. Despite this we can construct a simple model (Figure 1) that helps to clarify these interactions and the strength of biodiversity/biophysical process–ecosystem service–'goods' relationships. This model and its accompanying rationale indicate that:

- In general, in Scottish upland habitats maintenance of the existing environment in a healthy state is essential for service delivery, because the link between system function and service delivery is tight and direct. Sustainability of service delivery can readily be equated with conservation of biodiversity. The direct link between natural systems and the delivery of goods and services means that goods and services are likely to be good indicators of overall ecosystem health;
- In Scottish lowland systems, service delivery may be highly detached from the natural environment. Such situations represent perhaps the greatest risk for unrecognised

degradation of natural capital, especially as processes implemented to replace the decline in natural function may degrade natural capital still further (for example the impact of intensive farming practice on soil structure and function);

- Both upland and lowland situations should be the focus of intensive monitoring to ensure natural capital is not being eroded. But lowland systems in particular should not be monitored simply using indices of the flow of ecosystem services as these might be detached from the status of the underlying natural capital.
- Where there is a substantial disconnect of service delivery from underlying biodiversity and biophysical processes, service delivery would be promoted by increasing the strength of this link. This will also provide greater long-term system resilience and reduce dependency on external inputs. A move toward increased sustainability is therefore a choice to actively strengthen the link between system function and service delivery.

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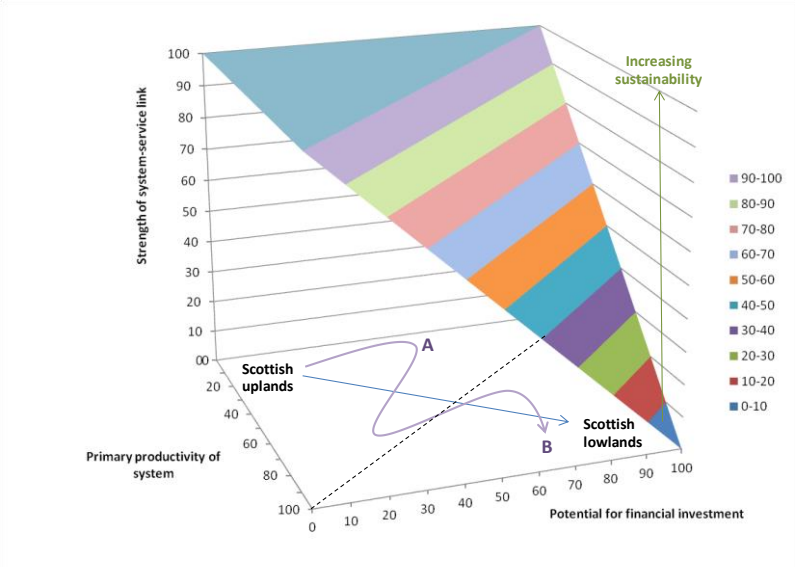
***Figure 1*** *Simple graphical model for the extent to which ecosystem service delivery can be detached from underlying biodiversity and biophysical processes. The two underlying drivers are primary productivity of the system, and potential for financial investment in land management. These drivers are shown in arbitrary units from 0 (Low) to 100 (High) but are not independent. Low primary (biotic) productivity reduces income and the potential for investment in management. However, there is not always a direct positive correlation: high primary productivity does not necessarily mean high income generation – this is dependent on whether the potential income is realised. Consequently, at low primary productivity investment in management interventions is constrained, and the delivery of services is directly dependent on biodiversity and biophysical processes (there is a strong link between natural systems and service delivery).*




*As primary productivity increases, potential income streams increase and consequently the strength of the link between natural systems and service delivery is reduced (shown in the response surface by a reduction in the strength of the system-service link). It is important to recognise though that the response surface represents the hypothetical potential maximum decline in the strength of this link:*

*this will only be realised if services are exploited and resulting income invested in artificial processes that replace natural ones. The model does not indicate whether the relationship will be positive or negative, simply whether in general it is likely to be strong or weak. The green arrow shows the hypothetical change needed to re-establish the link between natural systems and service delivery, and increase system sustainability. The purple arrow shows the movement of a service such as water supply across the response surface, with the final dependency on natural systems of that service being the mean value across the length of the path.*