# Research Challenges

## 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 information relevant to one of the key aims for the review, which is the better targeting of future research activity toward identified knowledge gaps.

Each chapter within the review is structured around a series of "broad policy goals" and associated prioritised ecosystem services, and outlines key relevant research challenges for understanding the underpinning of ecosystem services by biodiversity and biophysical processes. Below we summarise these research challenges, as well as some over-arching knowledge gaps relevant to all of the policy goals examined. The key research challenges identified are:

### Low Carbon Economy

- Trees – detailed measurement and development of associated predictive models of changes in soil C (carbon) following afforestation;
- Peat – understanding the scale of impacts of management practices (e.g. heather burning, drainage) on peat formation; understanding the relationships between external drivers (e.g. N pollution) and peat production and decomposition;
- Soil formation – geographically comprehensive measurements of agricultural soil C status; quantification of the impact of cultivation practices (including reduced tillage) on soil C; understanding the biophysical/biotic processes regulating soil C fixation, particularly the role of soil organisms;
- Crop production – locating the tipping points between reduced inputs and adequate ecosystem service provision; understanding the underpinning by, and impacts on, biodiversity and biotic processes of new crops (e.g. biofuels).

### Sustaining Food Production

- Crops - understanding whether sustainable farming systems can deliver necessary levels of crop production; understanding in detail and at a landscape scale the pros and cons of land sparing versus land sharing;
- Livestock – understanding the influence of biodiversity and the complex impacts of landscape mosaic structure (e.g. trade-offs between forage availability vs. pest and disease regulation); exploring genetic potential in native breeds for improved livestock breeding;
- Pollination – assessing land management impacts to inform policy and advice for improved insect pollinator service delivery; exploring, particularly for production systems, the design of mosaic environments that promote pollinators whilst limiting pests/diseases;
- Soil formation - understanding the importance of biodiversity (e.g. soil organism diversity), including separating out "broad" from "narrow" functions, and understanding whether it is particular functional groups or diversity *per se* that is critical for their regulation.

### Halting Biodiversity Loss

- Wild species diversity - understanding which elements of the biota and levels of biodiversity (genetic, species, habitat) are important for service delivery, including cultural and supporting services; understanding how to restore ecosystem function as well as community composition.
- Disease and pest regulation – understanding disease and pest regulation in natural or semi-natural systems, and the potential consequences for biodiversity conservation; targeted studies of particular pest-disease-host relationships to understand the mediating role of biodiversity and environmental drivers (e.g. climate change); exploring the application of approaches from production systems to semi-natural/natural habitats;
- Crops – understanding adaptation of management practices in order to benefit overall biodiversity beyond simply reducing production intensity, e.g. actively promoting particular habitat types.

### Sustainable Water Management

- Organism group scale – understanding the influence of key organism groups (e.g. soil fungi) on regulatory processes; understanding the occurrence of redundancy *versus* adaptive capacity, particularly with respect to detoxification processes;
- Habitat scale - understanding the optimum spatial arrangement of key habitat types within landscapes and catchments in order to maximise service delivery; understanding the importance of connectivity between water and the habitats it flows through; addressing the issue of scaling needs, as existing knowledge is often developed in relatively small catchments;
- Catchment scale - developing management techniques that can be applied across entire catchments, especially given the dependency of service delivery in lowlands on processes in uplands.

### Over-arching Knowledge Gaps

Some knowledge gaps are common across broad policy goals, specifically:

- Framing cultural service concepts to explore their underpinning by biodiversity and biotic/biophysical processes;
- Understanding the role of genetic diversity in maintaining ecosystem function and service delivery;
- Understanding the role of functional diversity and species redundancy;
- Understanding the importance of the spatial configuration of habitats/ecosystems, including the possible occurrence of scale-dependent thresholds of function;
- Understanding whether the Ecosystem Approach *will or will not* further enable biodiversity conservation.

Although some knowledge gaps might be considered generic across broad policy goals, this does not mean that they are necessarily of greater importance than those related to specific broad policy goals. In order to genuinely enhance the application of the Ecosystem Approach and uptake of the ecosystem service concept, it will be necessary to address all of these knowledge gaps.

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