Understanding critical processes and functions

How do we define and quantify relationships between biodiversity, ecosystem function and services at spatial and temporal scales that are relevant to ecosystem processes and management? Tools: manipulative experiments, examine stability, resilience and their impacts on elemental cycling, time-series data and observatories.

A1	1) What are the important characteristics (eg. variability, trajectories) of ecological change that takes place over longer timescales than those normally represented by observations, and what are the drivers?
A2	2) What are the critical dynamical characteristics that lead to nonlinear changes (eg. resilience, thresholds, irreversible), and how can they be simulated to produce realistic scenarios over decadal timescales?
A3	1) What are the key ecological processes within a landscape that contribute to a specified ecosystem service and what land uses affect these processes (either negatively or positively)? Can an integrated ecosystems approach be derived that considers a range of ecosystem services arising from a landscape and trade offs between them?
A4	3) Are ecological networks, wildlife corridors or other ecological connectivity approaches more effective ways of maintaining biodiversity and ecosystem services within landscapes than existing conservation tools of static reserves and agri-environment measures?
A5	1. [Can we] achieve a significantly better understanding of the relationship between anthropogenic pressures and the response of aquatic and wetland ecology, with sufficient precision to improve the management/protection of these systems.
A6	2) Are there key pathways/processes/interactions that are essential for ecosystem sustainability? At what level of organisation do they occur (micro, macro, mega)? How do key processes change with latitude or depth? Should we be concerned with genetic or functional diversity? Are there commonalities between types of system?
A7	2. What physical processes underpin marine biodiversity? Background: let's get away from just measuring easy scalars like temperature, and deal with the rate processes (e.g. turbulent supply of nutrients, fluctuating light regimes) that drive the ecosystems. Not so much a stand-alone question, more a plea to include these considerations in larger biodiversity questions.
A8	Is there functional redundancy in ecosystems (in time and space) with respect to environmental change? Does biodiversity matter, and at what level?
A9	Are communities adapted to their local environment, and if so, can they cope with the predicted perturbation that is likely to occur in the next 100 years? What will happen to biodiversity and ecosystem functioning in the poles?
A10	1) How will ecosystem processing of carbon in the UK be influenced by climate change, and by changes in the acidity and nitrogen content of soils?
A11	3) Does biodiversity matter: is functional capacity and stability more important than variety?
A12	2. Is functional redundancy a valid concept; how important are non-utilitarian components of the ecosystem? Reconciling the ecosystem service philosophy with traditional conservation approaches.
A13	1. How to deliver biodiversity-rich, functioning, freshwater ecosystems in the lowlands. Freshwater ecosystems form an important component of the landscape mosaic. Standing waters can contribute to obvious biodiversity (e.g. Odonata) and also less obvious (e.g. Diptera as food for songbirds). Most standing waters and almost 100% of running waters are degraded by eutrophication. The causes of this are individual farms and household septic tanks, multiplied many times over. Ecosystem processes which might mitigate eutrophication have been lost by drainage.
A14	1. How is diversity responding to environmental change? What lies behind this question is to judge whether we have in place an adequate environmental and biodiversity monitoring programme covering a full taxonomic range and range of levels, genetic to habitat.
A15	4 What is the relationship between ESS delivery and underlying marine ecosystem functions?

Understanding trends and implications

What are the consequences of variation in these relationships in the face of change at different scales (climate change, ecosystem use and management strategies)? Tools would include analysis of different large and small scale gradients, use observatories; hindcast and forecast models

B1	To what extent does biodiversity confer resilience to climate change in marine ecosystems? Sub-question: Does biodiversity play a greater role in driving the resilience WITHIN ecosystems than among ecosystems? It's likely that comparisons among marine systems would place emphasis on the type of species being important rather than biodiversity per se. However, we have good reason to believe that biodiversity is a key driver within ecosystems. I would advocate translating the outcome of a particular level of resilience into the delivery of ecosystem services.
B2	1) How will predicted climate change (e.g. nutrient supply, temperature, pH, salinity in coastal waters) impact the long-term sustainability of marine ecosystems. 'Testing' predictions arising from small-scale experiments, mesocosm studies and modelling. Suite of ecosystems e.g. deep sea, high latitude, temperate coastal. Scope for adaptation at an ecosystem level; what genetic diversity within an ecosystem might accommodate adaptation (within and between species)?
B3	3) (overlaps with 2) Is there a minimum degree of trophic redundancy required to confer sustainability in a marine ecosystem? How is this affected by changes in latitude or depth - are there commonalities? What potential is there that climate change or human impacts (fishing) will disrupt trophic redundancy?
B4	1) Spatial and temporal patterns in the biodiversity of open ocean systems, surface to seafloor, shelf to abyss. How will these systems change, and how will this affect their role in carbon fluxes etc? The obvious choice for a study area is the Celtic Sea and extending to the Porcupine Abyssal Plain, given the existing datasets for this area.
B5	2) Spatial and temporal patterns in the biodiversity of coastal systems, catchment to coast. How will changes in temperature, rainfall and land use affect marine systems, and the services they provide. The West coast of Scotland provides a range of marine study sites and land uses from agriculture to urban, and good existing datasets on the biology and physical environment.
B6	3) Migration, dispersal and connectivity in marine populations. How can we expect species and communities to be affected by climate change? What can we do to maximise the survival of species (by controlling invasive species, transplanting others, and providing reserves and suitable habitats for organisms to migrate or disperse to)?
B7	1) Understanding natural variability of biological communities (and how it effects communities, ecosystem functioning and resilience) across range of scales within the water landscape.
B8	2) How do we differentiate and measure the impacts of anthropogenic pressures on freshwater communities and functioning from the inherent natural variability.
B9	1. How sensitive are marine boundaries (e.g. properties at fronts, shelf edges) and their biodiversity to a drifting climate? Background to this: these boundaries can have high biodiversity, are regions of marked (potentially very sensitive) gradients in biodiversity, and (for coastal/ shelf seas) are usually associated with high bioresource exploitation.

B10	3. How can we model the emergent response of biodiversity to drifting climate? Background: I'm talking of a new modelling approach that allows multi-species (multi = 100s - 1000s) to compete within a realistic physical framework. The idea is viewed with some excitement at the new Hartree Computing Centre (Daresbury) where they are looking for applications to throw at several 10s of thousands of processors. I would encourage such an activity to be strongly supported by a parallel observational campaign
B11	What role does genetic diversity play in ecosystem resilience?
B12	1) How can we practically increase the resilience of ecosystems to environmental change, a) increased patch size and buffering, or b) re-linking landscapes, c) management to bring ecosystems into optimal condition?
B13	2) How important is functional diversity and trophic structure in controlling ecosystem resilience?
B14	3) How do the key drivers of environmental change interact to affect ecosystem functions at a range of scales?
B15	2) Are predictions from single local-scale experiments relevant at the landscape scale?
B16	3. What is the appropriate scale to study and manage different components of the ecosystem to maintain sustainable ecosystem function? Quantifying the importance of movement at different scales on gene flow, population structure and adaptability.
B17	3) Can we detect early warning of loss of ecosystem function in sensitive systems? Close monitoring of ecosystems (including managed) that are at risk from env change, eg peatland from drying out and loss of grazing, woodland with changing pathogens, herbivores
B18	2. To what extent is adaptation of component populations essential for an ecosystem to be resistant and resilient in the face of environmental change?
B19	3. What are the primary factors that prevent species from expanding or moving their ranges?
B20	1) How do biogeochemical cycles influence biodiversity across environmental gradients and how will changing biogeochemical cycles affect biodiversity? Would link microbial diversity/function with biodiversity of macro-organisms to address ecosystem connectivity and stability, perhaps incorporating watershed systems as platforms for study and uniting metagenomics, metabolomics and proteomics with taxonomy and biodiversity.
B21	2) How will environmental change alter organismal interactions and how will this influence sustainability? Would address whether environmental change promotes: a) differential responses of interacting organisms, and; b) new cross-ecosystem linkages (e.g. novel pathogens, competitors, predators) to create new patterns of biodiversity at the landscape level.
B22	2 In instances where we only have an aggregate measure of the benefit provided by a partcular ESS how can we better apportion this aggregate to individual landscape types?
B23	How is biodiversity maintained in an ecosystem? The number of species in an ecosystem is dependent on a huge range of variables, and will change over space time in response to climate and other forcing factors. Observatory networks, coordinated sampling strategies and quality taxonomic methods will be key to understanding these changes.
B24	3) What are the key tipping points in the function our wilder ecosystems, with respect to climate change, air pollution and land use change, and where are we now relative to them?

Developing management solutions

What are the relevant spatial and temporal scales at which management should be focussed to ensure sustainability of ecosystems, their functioning and delivery of services? Tools: development of coupled ecosystem-bio-economic models that underpin decision support systems within incorporating quantification and valuation of changes in BEF-Services and show consequences of alternative pathways, develop management strategies and operating plans

C1	3) What are the baseline, pre-impact or resilient ecosystem characteristics that could provide goals for ecosystem management/restoration?"
C2	2) Can large scale ecological restoration of landscapes recreate the ecological processes previously occurring within those landscapes or will they fundamentally differ when the original ecological assets have been lost? Can ecological restoration increase the 'resilience' of ecological processes within landscapes to impacts such as climate change?
C3	2. [Can we] achieve a significantly better understanding of the response of aquatic & wetland ecosystems to specific measures designed to restore, protect or improve these systems e.g. river restoration, reductions in pollutant or flow pressures, landscape restoration.
C4	3)How do we use this knowledge to design and undertake sustainable management and restoration measures for catchments
C5	1) Do we, and if not should we, manage connectivity at a landscape scale to enbale biodiversity and associated ecosystem functions to respond to climate and land-use change?
C6	1. What is the impact of habitat management on intra-specific diversity and what are the implications for pest management and ecosystem services (within species functional complementarily)? Hypothesis: an increasingly homogenous landscape is leading to a reduction in genetic diversity and less potential for species to adapt to new conditions.
C7	1) How can we ensure that ecosystem services will be delivered from managed land / landscapes during a period of climate and socio-economic change?
C8	2) How do we integrate the outcomes of land management decisions with regional and global environmental processes?