The **RUBICODE** Project

Rationalising Biodiversity Conservation in Dynamic Ecosystems

Newsletter N°3, February 2008

Introduction

This edition of the RUBICODE newsletter looks at the task of Workpackage (WP) 5 which is to develop a framework that uses the functional traits (defined below) of organisms, rather than species identity, to predict the impacts of various pressures on biodiversity and its ability to provide ecosystem services.

The RUBICODE framework

First it is worth re-iterating one of the concepts underlying the RUBICODE approach. The Service-Providing Unit (SPU) defines a population or community directly in terms of service provision rather than in the usual geographic, demographic or genetic terms. Thus an SPU is:

`*The total collection of organisms required to deliver a given ecosystem service at the level needed by service beneficiaries*'.

The SPU must be quantified in terms of metrics such as abundance, seasonality and distribution. It is important to view the SPU from a stakeholder perspective and to define the level of service required. If it is simply `the more the merrier' it is impossible to define an SPU - there needs to be a level of service that is considered the minimum adequate, and the SPU must provide that and a safety margin. Where there is a threshold relationship between biodiversity and service level, defining an SPU is easier than where the service increases in proportion to the providers.

What is a functional trait?

A functional trait is a feature of an organism which has demonstrable links to the organism's function (ecosystem role) or functioning (performance). As such, functional traits determine the organism's effects on ecosystem processes or services (effect traits) and/ or its response to pressures (response traits). Functional traits reflect adaptations to variation in the physical and biotic environments and trade-offs among different functions within an organism. In plants, functional traits include aspects of morphology, physiology, biochemistry, regeneration and, at the population level, demography. In animals, these traits are combined with life-history and behavioural traits. The value / state of a functional trait is known as a trait attribute. It may be categorical (e.g. C3 vs C4 for plant photosynthetic pathway) or quantitative.

Why do we need a traits-based approach?

Most ecosystem services can be provided by more than one type of organism (species, or genotype within species) and the identity of suitable organisms (ecosystem service providers; ESPs) varies in time and space. Therefore it is useful to consider ESPs in terms of their traits, rather than their taxonomy. For example, a range of wild bee species may be suitable for pollinating a particular crop, but the species composition of wild bees will vary from year to year and place to place. Only bees that are, for example, attracted to that crop's colour or scent, and have tongues of suitable length for reaching the nectar will be suitable. Thus, growers will need to know the availability of bees with these traits (their abundance, seasonality and distribution) rather than the availability of wild bees in general.

How do traits fit into the SPU concept?

Functional diversity is the part of biodiversity that provides the service of interest because of a particular trait attribute composition.

Consequently WP5 considers SPUs as:

`The collection of trait attributes required to deliver a given ecosystem service at the level needed by service beneficiaries'.

This is proposed as a generic definition of SPUs. Within species there will be genetic variation, so this definition can still apply to the case of a service provided by a single species. Even a monoculture is only a special and simplified case. SPUs may therefore be quantified by metrics of functional diversity, by a specific syndrome of traits, or by a combination of otherwise independent trait attributes.

The relationship between traits and ecosystem service provision

Very little is known about how measures of the diversity of functional traits relate to service provision. The literature linking functional traits to ecosystem service delivery was therefore reviewed as a step towards using measures of functional diversity to predict ecosystem service levels, and towards using links between these effect traits and the response traits (determining responses to change), to predict the impact of pressures on service delivery. The objective of this first WP5 review was to answer three questions:

1) What evidence is there that links functional traits to ecosystem service delivery?

2) How is this knowledge spread across taxa, habitats and categories of service?

3) Are certain combinations of traits linked to certain combinations of services?

Nearly 250 references which showed an effect of traits on ecosystem services, or on ecosystem processes with a clear link to services, were reviewed. The similarity among ecosystem processes / services in terms of the traits that provide them was analysed.

Half the studies focussed on vascular plants and almost a quarter on soil macrofauna, with other groups poorly represented. In descending order of frequency, studies examined grassland, soil, freshwater, forest, shrubland, agricultural and wetland ecosystems. Most services examined were in the `regulating' or `supporting' categories of the Millennium Ecosystem Assessment. The processes most often studied in terms of traits were decomposition / mineralisation, productivity, nutrient retention / sedimentation, evapotranspiration and herbivory.

Effect traits were most frequently reported at the level of functional groups and the dominant traits in a community. These traits referred mostly to the morphological and chemical structure of plants, and to feeding habit and substrate type for animals and microbes. The involvement of a given trait in multiple service delivery and the dependence of each service on a range of traits resulted in clumps of associated traits and services (Figure 1). In particular, the analysis discriminated services mediated by plant and soil organisms (top left cluster of Figure 1), from those mediated by aquatic organisms (bottom left) and by other insects (centre right). Particularly close associations were found among those traits that underlie nutrient economy, herbivory, and fodder and fibre production (provided mostly by different plant traits) and among the services related to water flow and soil formation (provided mostly by soil invertebrate traits).

The review shows that functional traits are key constituents of biodiversity underlying a range of ecosystem services across different trophic levels and habitats. It shows the combined effect of various traits on bundles of ecosystem services and their underlying processes. The same trait contributes simultaneously to the control of different processes, whilst given processes are controlled by a range of traits.

This review has involved studies examining single trophic levels. Given that ecosystem processes and services rely on organisms from different trophic levels, the match between traits and services will benefit from consideration of interactions among different trophic levels, i.e. top down and bottom up effects. This will be the topic of a conceptual paper.

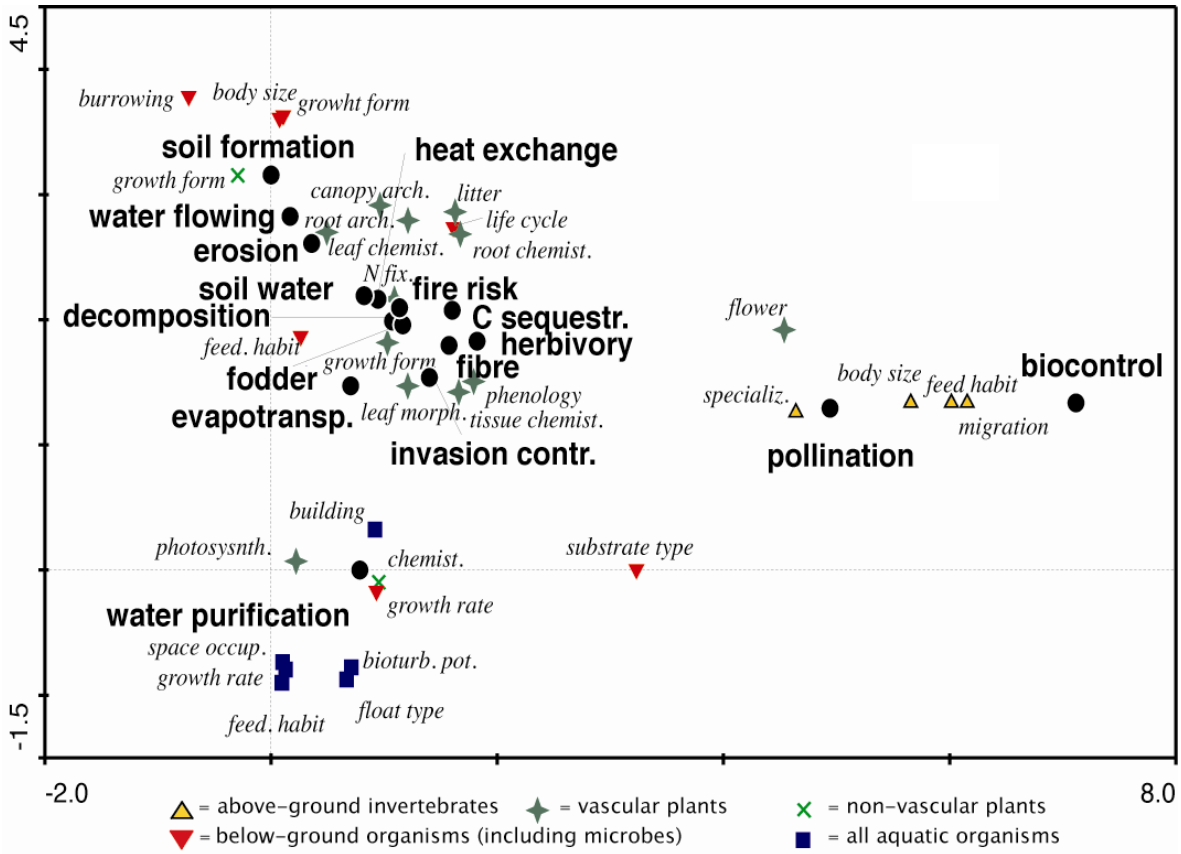


Figure 1. Association between traits and ecosystem processes. The analysis shows the similarity among ecosystem processes (black circles) in terms of the traits (different symbols for different organisms) that predict them (distance between two points reflects the level of similarity). Only those processes with more than ten entries in the literature were considered.

Framework for determining impacts of change on services dependent on more than one trophic level

The framework describes the traits determining the responses of biodiversity to a pressure, the traits determining the effects of biodiversity on service provision, the linkages between these response and effect traits, and the dependencies between traits at different trophic levels. This allows development of a predictive, mechanistic approach to determining how pressures will affect ecosystem services that depend on multitrophic interactions.

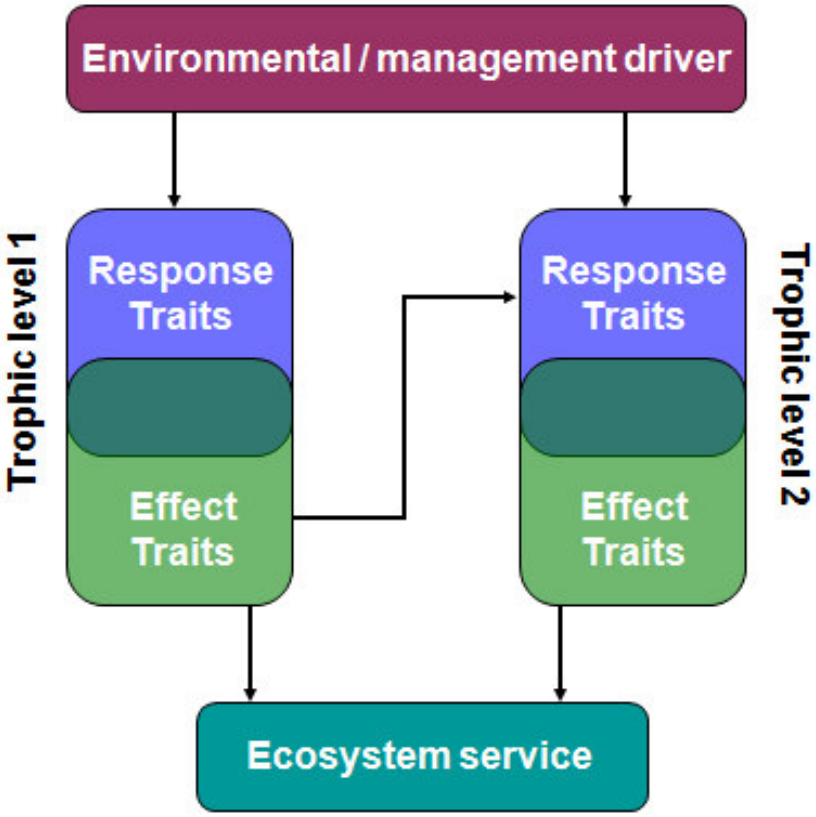
There are two types of linkage:

1) Effects of one compartment on another (arrows in schema below). One objective will be to emphasise the cascading effects from plants to higher trophic levels, to ecosystem properties and services.

2) Overlaps, meaning both identity (response traits that are also effect traits; same ecosystem property influenced both by plant and invertebrate traits) and correlation / co-occurrence (response traits that are correlated with effect traits for physiological or evolutionary reasons; or are correlated or otherwise linked with ecosystem properties).

The state of the art on these different linkages will be reviewed. The final step will be to bring in the scenarios of pressures and work through the framework for the services of interest.

The framework was recently presented and discussed by RUBICODE participants and other invited experts at a workshop in Helsingborg, Sweden. Strengths and weaknesses were highlighted and the points raised will greatly help development of the conceptual paper.



Other project activities

The project has produced a series of review papers which can be downloaded from http://www.rubicode.net/rubicode/outputs.html on:

- Frameworks and concepts for the quantification of services in dynamic terrestrial and freshwater ecosystems.
- Valuation of ecosystem services.
- Socio-economic and environmental drivers of biodiversity change.
- Indicators and indication approaches for biodiversity and ecosystem services.
- A framework for linking ecosystem service provision to biological traits.
- Habitat management strategies for conservation in dynamic ecosystems.

The RUBICODE international workshop on "Ecosystem Services and Drivers of Biodiversity Change" has just been held in Helsingborg, Sweden on 25-28 February 2008. The workshop brought together around 100 scientific experts from a wide range of backgrounds and disciplines to discuss different aspects of the RUBICODE approach. Results from this workshop will be reported in the next edition of the RUBICODE newsletter.

We are now organising our next stakeholder workshop on "Habitat Management and Conservation Policy: Strategies for a new dynamic approach focussed on ecosystem service provision" which has official endorsement by the Slovenian Presidency of the EU and will be held in Kranjska Gora, Slovenia on 29-30 April 2008.

Further information on the project, can be obtained from www.rubicode.net or the Project Co-ordinator: Paula Harrison (paharriso@aol.com). Further information on the traits workpackage can be obtained from: Richard Harrington (Richard.Harrington@bbsrc.ac.uk) and Sandra Lavorel (Sandra.Lavorel@ujf-grenoble.fr).

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