Functional diversity in a model plant community

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Intensification of agriculture has reduced the abundance and diversity of arable plants to an extent that food webs in the arable landscape are losing species and losing function. The biodiversity of arable systems is inextricably linked to their sustained functioning and productivity. If functions such as decomposition and nutrient retention are impaired, the soil-plant system will decline and ultimately collapse. Crop variety and field management can, in principle, be deployed to achieve a sustainable balance between biodiversity and crop yield. To do this needs understanding of the way plant diversity affects other important aspects of the system. However, the species as an accounting unit of diversity is arguably too coarse and hides too much variation. We therefore seek to link the functional properties of the habitat to differences between smaller units such as ecotypes or individual organisms. The approach is systematic and iterative. We define the system's properties, characterise selected individuals *ex-situ*, reconstruct 'communities' of individuals with known traits, test for expected emergent properties and validate on large scales of time and space.

Many of the salient properties of the arable crop/weed/invertebrate system have been studied. They include the architecture of the canopy, the fluxes of resource (e.g. radiation), stores of carbon and nutrients and the structure of plant and animal communities as defined by functionally based groupings (type-accumulation curves, relative abundance and spatial distribution). This phase of the work is near completion for typical crop rotations in northern GB, but function has been quantified only at the level of species. In 2002, we moved to quantify the effects of the differences that occur between ecotypes and individuals. For this we have chosen *Capsella bursa-pastoris* (shepherd's purse) as a model, partly because of its genetic synteny with *Arabidopsis thaliana* but also because it is widespread, economically important as a weed, phenotypically plastic comprising several distinct ecotypes and contributes to the arable food web. Individual accessions were taken throughout GB and phenotypically characterised in controlled environments. The ecotypes can be separated, e.g. by nitrogen content, flowering time, vegetative traits and reproductive capacity. New statistical approaches are used to quantify the life-cycle trajectory of each accession. Genotyping (SSRs) distinguishes the different ecotypes and will be developed to explore the connection between phenotypic and genotypic variation.

For the next stage, *Capsella* ecotypes, each with defined traits, were assembled at a 'patch' scale in the field during 2003 in different combinations, at different population densities and within various weed assemblages. An indicator of an emerging system-property is the total branch length of a dendrogram for plants in a 1m^2 plot based on many physiological traits. (Fig. 1 shows a dendrogram for three traits, plant height, leaf number and rosette diameter.) This preliminary estimate of functional diversity is now being related to the abundance and biomass of associated insects (herbivores, detritivores, pollinators, predators and parasitoids) caught by suction sampling. The mechanisms linking plant traits to diversity and abundance in the food web are being investigated.

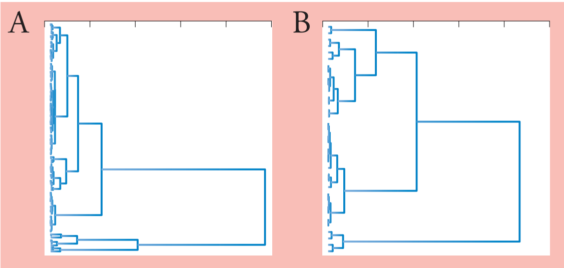

Figure 1 Cluster analysis of two populations each in 1m^{-2} of field, characterised by three physiological traits. Functional diversity is proportional to total dendrogram length. Plot A (a single ecotype) has lower dendrogram length and therefore lower diversity than plot B (a mixture of 2 ecotypes).

The effects of these fine differences between ecotypes of *Capsella* will be combined with existing coarser knowledge of the 70 or so commonest arable plant species. The effect of plant traits on the food web will then be predicted at scales of the field and over several years of cropping. Inferences will be validated by reference to large, existing data sets on arable diversity and to measurements made later in the project on a range of crop/weed communities. The final outcome of the project will be a design for a workable arable system that balances crop production and biodiversity.