A new system for plant experiments on biodiversity or multi-species competition

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Keywords: multiple species, competition, biodiversity, experiment design, statistical models

Introduction Considerable discussion in recent years has focused on the design of competition and biodiversity experiments (Connolly *et al*., 2001a; Allison, 1999). Few agronomic experiments with >2 plant species have been conducted in greenhouse conditions (Gibson *et al*, 1999) or in the field (Connolly *et al*., 2001b). In many experiments the effects of density and initial species size have been confounded. The effects of species richness and evenness also are confounded frequently. The proposed system provides a framework of design and analysis, in which to address questions of function at community level and of structure and competition at the level of species. It provides a set of statistical models that allow the separate assessment of initial overall abundance, species richness, species evenness and environment.

Materials and methods ***Experimental designs:*** The proposed experimental designs are based on the simplex (Cornell, 1990) at each of at least 2 overall densities. For *s* species, each experimental community will consist of up to s species and can be represented as a point in an *s-1* dimensional simplex. For 3 species (Figure 1), the simplex vertices represent monocultures of each species and the central point a mixture in which the initial abundance of all species is equal. A design consists of stands defined by 2 simplexes, each at a different levels of total initial abundance The simplex methodology provides a simple framework for selecting communities. The design selected will depend on *s*, the number of species, on whether one is primarily interested in questions of function or structure, the complexity of the models to be fitted and considerations of design power. Designs for large number of species can be constructed which are not excessively large in number of experimental stands required.

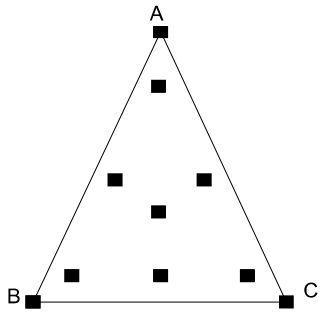

Figure 1 Simplex design for 3 species

Statistical Models: Some statistical models are proposed for the analysis of data from these experiments. For functional responses, such as yield, the models contain terms that assess the effects of species identity, overall initial abundance, environment, species richness and evenness. The richness terms are interpretable as synergistic and antagonistic interspecific relationships whose impact on the response depends on stand evenness. For structural responses, the RGRD (relative growth rate difference) models, proposed by Connolly and Wayne (2005), allow assessment of the effects of species identity, initial species abundance and environment as determinants of change in community biomass composition.

Examples Data from a 4-species experiment, using 2 grass and 2 legume species and an experiment with 5 weed species common in pastures in Switzerland, illustrate these models.

Results and conclusions The analyses of stand yield and resistance to unsown species in the 4-species experiment show strong identity effects and synergistic interaction between species, but a weak effect of overall initial abundance. The analysis of the 5-species experiment shows strong effects of species identity and environment but weak effects of initial species abundance on change in community composition. The design and models proved to be a flexible framework to address questions in multispecies experiments.

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