Predicting changes in ecosystem functioning from shifts in plant traits

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Background and aim

From a perspective of ecosystem functioning, not only species diversity is important but also the functional diversity within plant communities based on functional traits of the component species. A better understanding of how functional diversity is influenced by environmental change is a prerequisite for predicting changes in ecosystem functioning and for cost-efficient management strategies. In order to link environmental changes to ecosystem functions and associated ecosystem services, we will distinguish between two aspects: on the one hand traits determine the response of the plants to environmental change and on the other hand traits are instrumental for the effect that plants impose on ecosystem functions and ecosystem services (response-to-effect framework). By using traits of known importance to ecosystem functions, shifts in trait composition within communities can be used as indicators (proxies) for changes in ecosystem functions and associated ecosystem services.

The objectives of this project are:

1. To develop a set of trait-based indicators of ecosystem functions and associated ecosystem services;
2. To link changes in habitat quality and connectivity to shifts in indicators of ecosystem functions and services.

By combining recent trait databases with the Dutch National Vegetation Database, containing over 550.000 geo-referenced site descriptions of species composition and habitat characteristics (see Schaminée et al. 2012; Bongers et al. 2013), this can be done in a way that was not previously possible. For the analysis of trait-environment relationships we have developed a new generalised linear mixed model approach (see Jamil et al. 2013). We have established collaborations with several other research groups.

Some first results

In the first phase of the project we focused on the response-side of the story. At the species level we compared the performance of specialists and generalists on both ecological and evolutionary scales (Ozinga et al. 2013, see newsletter 1). Here we report on another subproject where we analysed the effect of nitrogen deposition on the local aboveground persistence of plant species in permanent plots (Hendriks et al. 2014).
Many empirical studies have shown that there is a continuous small-scale turnover of plant species, with the net result that plant species show temporal variation in their spatial distribution patterns as 'shifting clouds in the sky'. While the direction of vegetation changes has received much attention, this is less the case for the rate of vegetation change. Local vegetation dynamics are determined by a dynamic balance between colonisation and local extinction. At the scale of small plots, the rate of local aboveground extinction can be expressed as the reciprocal of the mean or median time that a species persists in a plot. We used survival statistics (Kaplan-Meier analysis and Cox' regression) to analyse the effect of life-history traits and local abiotic conditions on local aboveground persistence.
At the species level there may be intrinsic differences in the likelihood of local aboveground persistence (survival time), due to trade-offs between investments in attributes that enhance aboveground persistence and investments in other life-history traits. Adult lifespan is hypothesised to be negatively related to dispersal ability and to seed longevity. If there is a trade-off between aboveground persistence and dispersal ability, we may also expect a relationship between aboveground survival patterns and local environmental conditions, since environmental

constraints may impose restrictions on the viable trait combinations in a given habitat. The net effect of traits on the local persistence might depend on ecosystem properties such as disturbance regime and availability of resources. Comparative data on the local aboveground persistence of plant species across habitats are, however, sparse and generally from studies based on few populations of a limited number of species. Here we focus on the effect of nitrogen deposition, which is considered to be one of the strongest drivers of changes in species composition.

We combined information on local aboveground persistence of vascular plants in 245 permanent plots in the Netherlands with estimated levels of nitrogen deposition at the time of recording. We found a positive relation between local aboveground persistence of plants and high levels of nitrogen deposition (especially ammonia deposition). This was not only the case for species with high nitrogen requirements, but also for species with low nutrient requirements. The results are a preliminary indication of the importance of lower colonisation access due to nitrogen deposition. The 'fixation' of vegetation dynamics due to the lower accessibility to newcomers poses an extra threat to species diversity, since it may lead to further additional extinction of species due to population dynamic and population genetic effects. Follow-up research is required to see to what extent this influences traits that are instrumental for the effect that plants impose on ecosystem functions and ecosystem services (i.e. the response-to-effect framework).

Figure | Long-term permanent with vegetation data are an important information source for the analysis of vegetation dynamics.

Publications

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