

# Trait variations of ground flora species disentangle the effects of global change and altered land-use in Swedish forests during 20 years

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DOI:

10.1111/gcb.13329

## Abstract

Northern forest ecosystems are exposed to a range of anthropogenic processes including global warming, atmospheric deposition, and changing land-use. The vegetation of northern forests is composed of species with several functional traits related to these processes, whose effects may be difficult to disentangle. Here, we combined analyses of spatio-temporal dynamics and functional traits of ground flora species, including morphological characteristics, responses to macro- and microclimate, soil conditions, and disturbance. Based on data from the Swedish National Forest Inventory, we compared changes in occurrence of a large number of ground flora species during a 20-year period (1994–2013) in boreal and temperate Sweden respectively. Our results show that a majority of the common ground flora species have changed their overall frequency. Comparisons of functional traits between increasing and declining species, and of trends in mean trait values of sample plots, indicate that current floristic changes are caused by combined effects of climate warming, nitrogen deposition and changing land-use. Changes and their relations with plant traits were generally larger in temperate southern Sweden. Nutrient-demanding species with mesotrophic morphology were favored by ongoing eutrophication due to nitrogen deposition in the temperate zone, while dwarf shrubs with low demands on nitrogen decreased in frequency. An increase of species with less northern and less eastern distribution limits was also restricted to temperate Sweden, and indicates effects of a moister and milder macroclimate. A trend toward dense plantation forests is mirrored by a decrease of light-demanding species in both vegetation zones, and a decrease of grassland species in the temperate zone. Although denser tree canopies may buffer effects of a warmer climate and of nitrogen deposition to some extent, traits related to these processes were weakly correlated in the group of species with changing frequency. Hence, our results indicate specific effects of these often confounded anthropogenic processes.

## Keywords

Ecological indicator values; Global warming; Herbaceous layer; Life-history traits; Long-term understory vegetation dynamics; Nitrogen deposition; Northern temperate and boreal forests; Permanent plot resurvey