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Long term effect of nitrogen addition on understory community in a Chinese boreal forest

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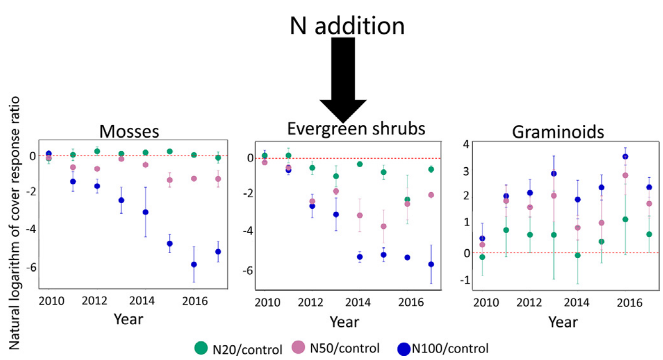
HIGHLIGHTS

- A N addition experiment was conducted in a Chinese boreal forest.
- N addition significantly and negatively affected mosses cover.
- N addition had no significant effect on vascular plants species richness but changed community composition.
- The effect of N addition varied across functional groups and shifted overtime.

GRAPHICAL ABSTRACT



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ABSTRACT

Increasing atmospheric nitrogen (N) deposition is an important driver of biodiversity change. By conducting an eight-year N addition experiment (0, 20, 50 and 100 kg N ha^{-1} yr^{-1}), we investigated the long-term effect of simulated N deposition on understory species composition and richness in a boreal forest, northeast China. We found that moss cover decreased significantly with increasing N addition. N addition had no significant effect on vascular plants species richness but changed the plant community composition. The relative coverage of evergreen shrubs decreased, while that of graminoids increased under high-level N addition (100 kg N ha^{-1} yr^{-1}). Under the high-level N treatment, *Deyeuxia angustifolia* cover increased significantly after 4 years, while that of *Vaccinium vitis-idaea* decreased significantly after 3 years and almost disappeared after 5 years. The negative effect of N addition on mosses and evergreen shrubs accumulated over time, while the positive effect on graminoids increased during the first 4 years and did not change significantly thereafter. Our results suggest that the effect of N deposition varies across functional groups and shifts over time.

1. Introduction

Biodiversity is a key driver of ecosystem productivity (Duffy et al., 2017), and most of the biodiversity in forest ecosystems is contributed by understory plants (Gilliam, 2006, Gilliam, 2007). Increasing nitrogen (N) deposition is one of the major drivers that cause biodiversity loss

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Table 1
Repeated measures ANOVA results.

Source	df	SS	MS	F	p
Vascular plants total cover					
Treatment	3	6380	2126.7	2.20	0.17
Error: plot	8	7740	967.5		
Year	7	11,090	1584.3	19.53	**<0.001**
Treatment * year	21	2344	111.6	1.38	0.17
Error: Plot * year	56	4543	81.1		
Total	95				
Moss cover					
Treatment	3	13,625	4542	5.10	**0.03**
Error: plot	8	7129	891		
Year	7	11,305	1615.1	20.62	**<0.001**
Treatment * year	21	5852	278.6	3.56	**<0.001**
Error: plot * year	56	4386	78.3		
Total	95				
Richness (species/m^2)					
Treatment	3	42.59	14.20	1.54	0.28
Error: plot	8	73.86	9.23		
Year	7	37.57	5.37	10.00	**<0.001**
Treatment * year	21	22.72	1.08	2.02	**0.02**
Error: Plot * year	56	30.06	0.54		
Total	95				

Bold values are significant at $P < 0.05$.

(Sala et al., 2000), as is consistently shown by both observational and experimental research (Suding et al., 2005; Bobbink et al., 2010; De Schrijver et al., 2011; Verheyen et al., 2012; Clark et al., 2013; Simkin et al., 2016). In China, N deposition has been dramatically increasing for decades (Liu et al., 2013), and the forests have been receiving high levels of N deposition (Du et al., 2014a). However, the long-term effects of N deposition on the plant diversity in China's forests have rarely been reported, especially regarding sensitive ecosystems such as boreal forests (Bobbink et al., 2010).

Many previous studies have revealed the impacts of N deposition on understory biodiversity in forests, but the responses of understory plants to N addition are not consistent. For example, long-term N addition caused species loss in a temperate forest (Walter et al., 2017) and a tropical forest (Lu et al., 2010), while most studies found no overall effect of N fertilization on biodiversity but rather a change of community composition (Hurd et al., 1998; He and Barclay, 2000; Strengbom et al., 2001; Ostertag and Verville, 2002; Nordin et al., 2009). These inconsistencies might be attributed to differences in background N deposition, vegetation type and experiment duration (Bobbink et al., 2010; De Schrijver et al., 2011; Hedwall et al., 2013a; Gilliam et al., 2016). The homogeneity hypothesis assumes that the dominance of nitrophilic species will increase following increasing N input, while the abundance of N efficient species will decrease, resulting in changes in community structure and decreased diversity (Gilliam, 2006; Gilliam et al., 2016).

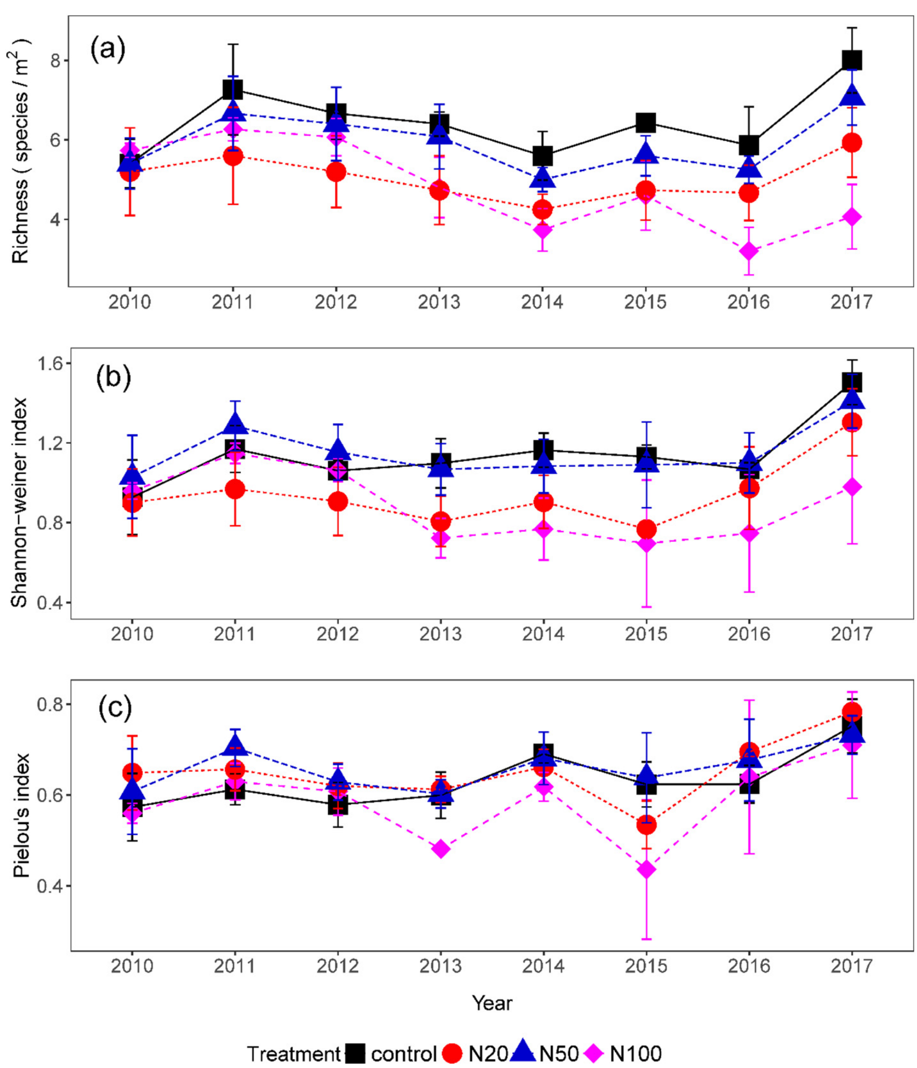

Fig. 1. Species richness and diversity in response to N addition over time (a, species richness; b, Shannon-Wiener index; and c, Pielou's index).