

## Chapter 26

# Biodiversity of Acid Grasslands in the Atlantic Regions of Europe: The Impact of Nitrogen Deposition

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**Abstract** Reduction in the species richness of acid grasslands along a gradient of atmospheric nitrogen (N) deposition has previously been demonstrated in the UK (Stevens, Dise, Mountford, Gowing, *Science* 303:1876–1879, 2004). Further surveys of acid grasslands in the UK confirm this relationship. This chapter reports an examination of the relationship across the Atlantic region of Europe. Examining the cover of functional groups across this gradient reveals that forb cover is strongly reduced along the gradient of N deposition.

**Keywords** Atmospheric nitrogen deposition • Functional group cover • Grass: forb ratio • Plant species richness • *Violin caninae* grassland

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**Table 26.1** Location of grasslands surveyed

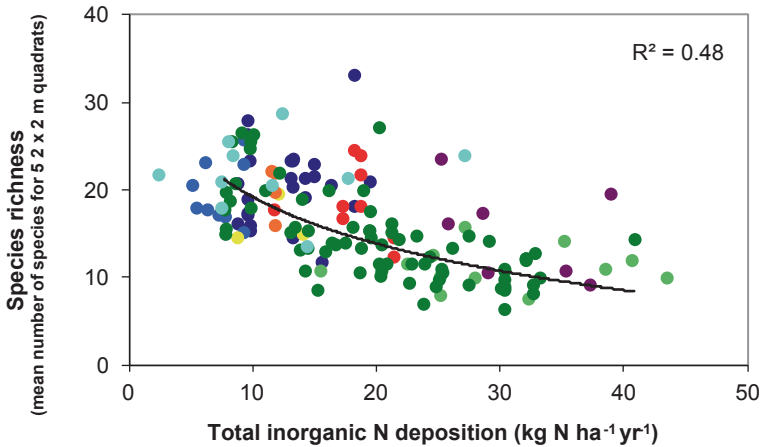
Country	Number of grasslands surveyed
Belgium	9
Denmark	3
France	25
Germany	12
Eire, Ulster and Isle of Man	11
Netherlands	7
Sweden	4
Norway	9
Great Britain	73

## 26.1 Introduction

In 2004, Stevens et al. demonstrated a strong negative relationship between the level of ambient nitrogen (N) deposition and the species richness of acid grasslands across Great Britain, after accounting for other variables that affect diversity. Since then, negative correlations between N deposition and species richness have been reported in heathland and other grassland communities (Maskell et al. 2010). These findings corroborate experimental evidence gathered over many years showing the potential for declines in species richness and changes in composition in a broad range of habitats (e.g. Bobbink et al. 1998; Mountford et al. 1993; Clark and Tilman 2008). Despite strong experimental evidence, until now there has been little evidence at an international scale of how chronic N deposition is actually affecting the species richness and species composition of habitats. The BEGIN (Biodiversity of European Grasslands—Impact of Nitrogen deposition) project set out to address this knowledge gap with an international survey of acid grasslands.

## 26.2 Methods

153 acid grasslands belonging to the *Violin caninae* alliance were surveyed within the Atlantic biogeographic zone of Europe. Table 26.1 gives the locations of the grasslands. These were selected to cover the range of ambient N deposition in Europe and to give a distribution of sites at different latitudes and longitudes for different deposition values. The grasslands surveyed were not agriculturally improved and were managed by grazing or cutting. A full description of each site was made including latitude, longitude, aspect, slope, extent of grassland, soil depth and surrounding plant communities. At each site, five randomly located 2 m × 2 m quadrats were surveyed and all vascular plants and bryophytes were identified to species level. Cover was estimated using the Domin scale, to reduce the error associated with different people estimating cover by eye. To obtain the cover of functional groups, average values for Domin scores were used. Because Domin scores are ordinal, the average values can only be used to show relative changes. In order to calculate a grass: forb ratio, Domin scores were converted to percent cover by taking



**Fig. 26.1** Graph to show decline in species richness with increasing N deposition in 153 acid grasslands in the Atlantic biogeographic region of Europe. *Red*—Belgium, *yellow*—Denmark, *dark blue*—France, *dark green*—Great Britain, *light green*—Germany, *turquoise*—Ireland, Northern Ireland and Isle of Man, *purple*—Netherlands, *light blue*—Norway and *orange*—Sweden

the middle value in each cover grouping. These were then added together to give a total cover for each group in each quadrat and a mean was calculated for each site.

For each site, N deposition data were modelled using the EMEP-based IDEM model (Pieterse et al. 2007) or national deposition models depending on which were available in each of the countries surveyed. National models were used for Germany (Gauger et al. 2002), the Netherlands (Asman and van Jaarsveld 1992) and Great Britain (NEG-TAP 2001; Smith et al. 2000). Comparisons between the models found good agreement in most regions, although uncertainty in the estimates produced is likely to vary between models.

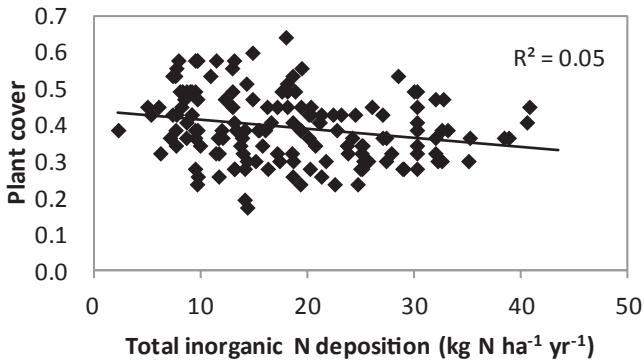
Simple regression was conducted using SPSS v17. All variables were checked for normality and corrected if necessary.

## 26.3 Results

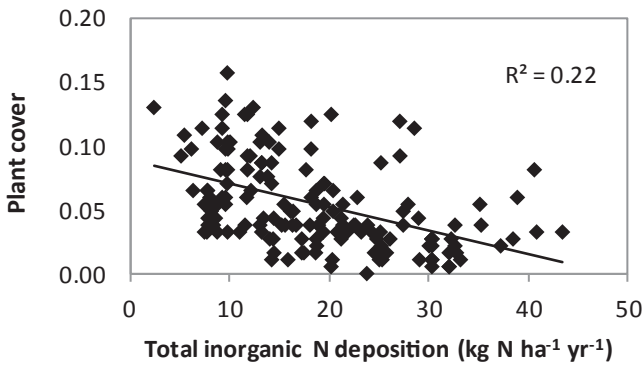
Earlier data from Great Britain (Stevens et al. 2004) showed a strong linear decline in species richness with increasing N deposition in 68 grasslands along the N deposition transect. The survey of ten additional sites in the UK confirmed this relationship giving a highly significant decline in species richness with increasing N deposition ( $r^2=0.44$ ,  $p<0.001$  with new sites;  $r^2=0.55$ ,  $p<0.001$  without new sites). The results also showed clear declines in species richness across Europe ( $r^2=0.36$ ,  $p<0.001$ , Fig. 26.1) (Stevens et al. 2010).

Examining this relationship in more detail for the whole data set across the Atlantic zone by looking at the cover of functional groups (Fig. 26.2) gives a clearer

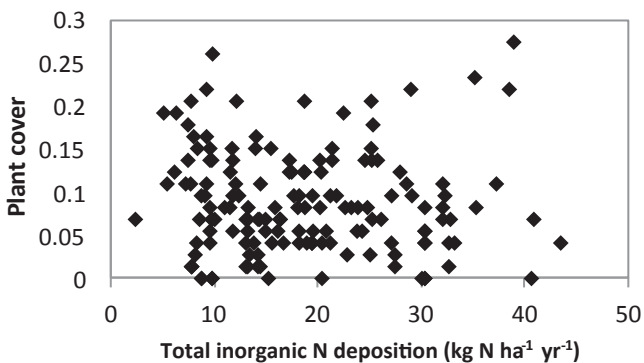
## Grass



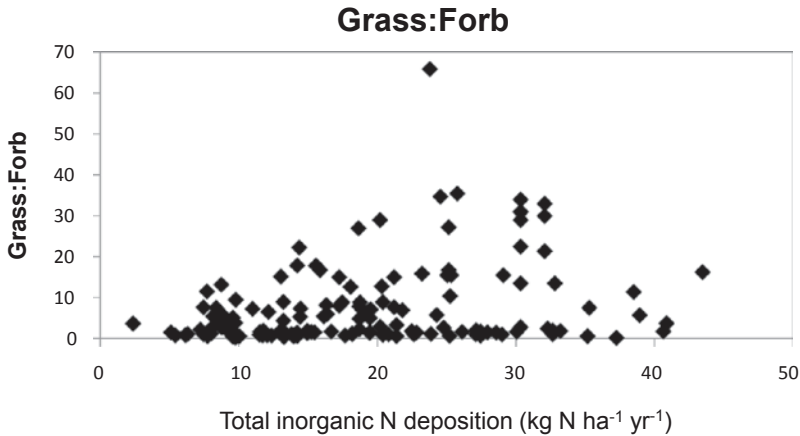
## Forb



## Bryophyte



**Fig. 26.2** Change in cover of functional groups with increasing N deposition in 153 acid grasslands in the Atlantic biogeographic region of Europe. Plant cover is calculated using a mean Domin score and can be considered relative cover



**Fig. 26.3** Change in grass: forb ratio (based on estimated cover) with increasing N deposition in 153 acid grasslands in the Atlantic biogeographic region of Europe

idea of the changes that are occurring in the *Violion caninae* alliance. Grasses show a slight, but significant, decline in their cover, however the relationship is weak and the change in cover is very small. Forbs show a strong decline in cover along the N deposition gradient. The cover of bryophytes shows no significant relationship with N deposition but there is a slight decline in total cover with N deposition. Other variables, such as climate, have not been considered in this analysis. For further analysis of functional groups see Stevens et al. (2010).

The grass: forb ratio (Fig. 26.3) shows a tendency to be low at low deposition sites, but to become more variable at high deposition sites but this relationship is not significant.

## 26.4 Discussion

The results from this survey confirm the relationship between N deposition and species richness previously found in the UK by Stevens et al. (2004) and demonstrate it at an international scale (Fig. 26.1). The reduction in species richness in countries other than the UK show very similar results to those observed in the UK. These losses of species richness do not mean that species become locally extinct, or even that species are consistently lost from the grassland, although this is sometimes the case. A loss of species richness represents a reduced occurrence of species in five 2 m × 2 m quadrats placed within an area of one hectare.

The loss of species richness can be examined in more detail by looking at changes in the cover of the three functional groups of grasses, forbs and bryophytes. Grasses showed a small decrease in cover. This relationship is also very weak. Conversely, forbs show a very clear decline in cover with increasing N deposition. For the UK alone relationships were analysed using percentage cover and showed much clearer

declines in cover of forb species, an increase in the cover of grasses and no change in bryophytes (Stevens et al. 2006). Comparison between the two methods of cover estimation is problematic but the direction of change in the results can be compared. The results show similar trends for forbs and bryophytes between the two analyses whereas grasses show the opposite result. Further work would be needed to determine if this is a consequence of the cover estimation used in the later survey or if this is a genuine difference between the UK response of vegetation and the response observed in the larger survey.

There are a number of potential reasons for the decline in forb and grass cover. Acidification may be causing a reduction in the occurrence and cover of species less able to tolerate acidic soil conditions (Tyler 2003). Eutrophication could lead to an increase in productivity of competitive species resulting in the suppression of less competitive species (Bobbink et al. 1998) but this is not consistent with the overall drop in cover values at high deposition sites. N deposition can also increase sensitivity to secondary stressors, both abiotic such as frost (e.g. Carroll et al. 1999) and biotic such as phytophagy (e.g. Brunsting and Heil 1985).

Bryophytes do not show any change in cover with N deposition although examining the abundance of individual species may reveal trends with some species increasing and others decreasing in relations to N deposition.

Because cover was estimated using the Domin scale, there is some loss of detail in the information. If percentage cover had been used, the trend for grasses may have been clearer. However, estimation of percentage cover varies between surveyors, so using percent cover would have increased error within the data set.

The grass: forb ratio has been shown to be a good indicator of N deposition in acid grasslands (Stevens et al. 2009). The use of Domin values for plant cover meant that the grass: forb ratio had to be estimated. There is a trend in the data for high grass: forb ratios to only occur at high deposition sites. This relationship is clearly driven by the strong decline in forb cover.

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