Resistance of southern montane heathlands to different nitrogen loads

Elena Marcos, Javier Calvo-Fernández, Ángela Taboada, Andreas Fichtner, Werner Härdtle, Leonor Calvo

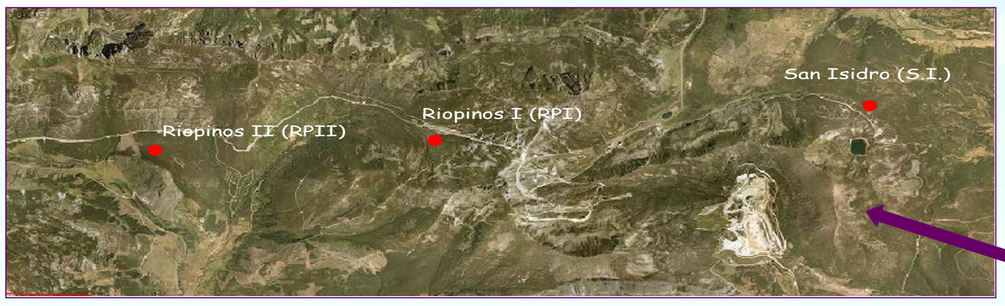
* Area of Ecology. Faculty of Biological and Environmental Sciences. University of León. 24071 León. Spain

INTRODUCTION

Elevated nitrogen (N) inputs into terrestrial ecosystems generally cause harmful effects to the ecosystems' health. Particularly, those adapted to low levels of N availability, such as montane heathlands, are more vulnerable to increased N inputs. Furthermore, the life-cycle stage of the heathland vegetation might influence its susceptibility to N loading. The N critical load is a valuable tool to assess the heathland resistance to changes in N availability.

In this study we established, based on empirical evidences, the N critical load for montane heathlands located at their southern-most distribution area, in relation to *Calluna vulgaris* heathland life-cycle stages: young- and mature-phase.

STUDY AREA



Distribution of *Calluna vulgaris* in Europe

Soils are Umbrisols developed over shales and sandstones (San Isidro) and quartzite rocks (Riopinos I and Riopinos II). Vegetation is dominated by *Calluna vulgaris*. N background deposition has been calculated in 4.6 kg N ha^{-1} yr^{-1}.

METHODOLOGY

Young stands

2 m × 2 m: C | N10 | N20 | N50 | x 3

Mature stands

C | N10 | N20 | N50 | x 3

In each plot (2x 2 m) we measured plant and soil response variables during 2015

Experimental plots

In 2013, in each of the three study sites (SI, RPI and RPII), we selected two heathland stands of different ages: (1) young stands (8 years) and (2) mature stands (>40 years). Nine replicate plots (2x2 m) per treatment were established (three per study site) for each age. Plots received 0 (natural deposition; C), 10 (N_{10}), 20 (N_{20}) and 50 (N_{50}) kg N ha^{-1} yr^{-1} as NH_4NO_3 during two years.

Vegetation cover sampling

Vegetation response variables: species cover (*Calluna vulgaris, Erica tetralix, Vaccinium myrtillus, Cetraria* sp., *Cladonia* sp.); life form cover (annual and perennial forbs, annual and perennial graminoids, woody, bryophytes, and lichens); plant species richness; *Calluna* flowering; current year's *Calluna* shoot length; *Calluna* shoot N and P contents, and N:P ratios.

Calluna shoot

5 cm

Soil response variables: litter N and P contents, N:P ratios; extractable NH_4^+ and NO_3^-; total N; soil organic C; available P; microbial biomass N and C, C:N ratio; enzymatic activities (acid phosphatase, urease, and β-glucosidase).

Estimation of N critical load

⋆ One way ANOVA including treatment as fixed factor

⋆ **N critical load:** the lowest N treatment (N_{10}, N_{20} and N_{50}) at which the response variable showed a significant change with respect to the control treatment (N_0).

RESULTS

A significant increase in shoot N content was found at N_{10} treatment in **young heathlands**. It was necessary a higher N load (N_{20}) to detect changes in *Calluna* vital rates (flowering, growth), and soil variables (litter N content and soil ammonium). However, in **mature stands** a significant increase was found at N_{10} treatment in *Calluna* vital rates (flowering and growth) and *Calluna* chemistry (shoot N content). Changes in soil variables (ammonium and microbial C:N ratio) were only found at N_{50} treatment. No changes were found in species composition and richness

View of flowering of mature stands in Riopinos I

Young heathlands

N treatment	N10	N20	N50	p-value
No. flowers	ns	↑ ***	↑ ***	0.000
Calluna shoot length	ns	ns	↑ ***	0.000
Calluna shoot N content	↑ ***	↑ ***	↑ ***	0.000
Litter N	ns	ns	↑ **	0.005
Calluna N:P ratio	ns	↑ **	↑ ***	0.000
NH_4^+	ns	ns	↑ *	0.028

Mature heathlands

N treatment	N10	N20	N50	p-value
No. flowers	↑ ***	↑ ***	↑ ***	0.000
Calluna shoot length	↑ ***	↑ ***	↑ ***	0.000
Calluna shoot N content	↑ **	↑ **	↑ ***	0.000
Calluna N:P ratio	ns	↑ *	↑ *	0.011
Microbial C:N ratio	ns	ns	↓ **	0.034

Direction of response (↑ increased or ↓ decreased) and significance level [*** ($p < 0.001$), ** ($0.01 > p > 0.001$), * ($0.05 > p > 0.01$), and ns ($p > 0.05$)] of different N treatments (N10, N20 and N50) respect to the control N treatment (N0). Significance level of 'N treatment' effect for each response variable is presented as p-value.

Conclusions

The current N critical loads in montane heathlands are established within the range 10-20 kg N ha^{-1} yr^{-1} for young and mature stands. However, the effects of higher N availability were different depending of growth phase. Mature heathlands showed more sensitivity to low N input that young ones. The main indicators of the impact of higher N inputs were: *Calluna* flowering, growth and shoot N content.

This study has been supported by the following projects: CGL2006-10998-C02-01 from Ministerio de Educación y Ciencia y LE039A05 from Junta de Castilla y León.