



Conference Abstract

The Interactive Effects of Experimental Warming and Nitrogen Deposition on Plant Community Structure, Biomass, and Soil Chemistry in an Alpine Grassland Ecosystem

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Abstract

The study of global changes impact on natural ecosystems is one of the current priorities of ecological research due to their recent scale and speed. Alpine grasslands are sensitive ecosystems well-suited for investigating how ecosystem is responding to rapid environmental change. With aim to investigate the impact of increased temperature and nitrogen input on the structure and processes in an alpine ecosystem we established in 2009 a field experiment on Mt. Kráľova hoľa in Central Slovakia (<https://deims.org/61c12307-2669-46c1-bf0b-94d40cc6b111>). Four treatments were used: increased temperature (T), increased nitrogen input (N), combined increased temperature and nitrogen input (NT), and control (C). Each treatment included six replicates (24 plots total) arranged in a blocked design. Nitrogen addition (10 kg N ha⁻¹ yr⁻¹) was applied as NH₄NO₃ solution in five applications during the growing season, while temperature was raised using open-top chambers (OTCs) designed following ITEX standards. The research plots were established in typical, species-poor, two-layer vegetation of the subalpine zone on silicate bedrock within the *Juncion trifidi* alliance.

Experimental manipulation of temperature and nitrogen input in permanent plots in Mt. Kráľova hoľa showed a differentiated effect of individual treatments on the biomass and structure of the plant community of alpine grasslands. The results show that both nitrogen and temperature increase significantly boosted aboveground biomass. Nitrogen addition (N) has been found to benefit mainly graminoids like *Avenella flexuosa* and *Festuca supina*, while dwarf shrubs and mosses experienced moderate biomass increases. The NT treatment resulted in further amplification of graminoid biomass, where *Luzula alpinopilosa* and *Juncus trifidus* became dominant, leading to suppression of other functional groups: it may inhibit the growth of dwarf scrub and mosses and results in lichens elimination. In contrast, warming alone (T) yielded the highest overall biomass, driven by the growth of dwarf shrubs, mosses, and lichens, even though graminoids responded modestly. These findings align with global patterns, where dominant species and functional groups play a major role in stabilizing ecosystems under changing conditions. The control treatment shows lower overall biomass than any other treatment, indicating that the experimentally increased temperature and/or nitrogen input improves environmental conditions for plant growth.

The Redundancy analysis (RDA) of vegetation records shows that the control treatment (C) is closely correlated with the increased temperature treatment (T). The remaining two treatments, i.e. N- and NT treatments are negatively correlated with two former treatments. Species *Avenella flexuosa*, *Festuca supina*, *Carex bigelowii* and *Polytrichum alpinum* are positively correlated with added nitrogen treatment (N). The positive correlation with combined NT treatment exhibit *Luzula alpinopilosa*, *Juncus trifidus*, and *Senecio carpaticus*, while other species are negatively correlated: *Homogyne alpina*, *Hieracium alpinum*, *Cladonia* spp. Species *Cetraria islandica*, *Hypnum* sp., *Soldanella hungarica*, *Campanula alpina*, *Oreogalum montanum*, *Potentilla aurea*, and *Nardus stricta*, are correlated with C- and T-treatments and these species are most affected by N addition.

The ecosystem likely did not utilize all of the added nitrogen, with some leaching into the soil solution, as evidenced by increases in both nitrate and ammonium nitrogen in the lysimeter water. The addition of nitrogen decreased soil pH, with acidic soils becoming even more acidic, and decreased the exchange capacity of ions. There was an increase in the conductivity of lysimeter waters, indicating the leaching of ions from soil particles into the soil solution. We confirmed the leaching of basic cations calcium, magnesium, phosphorus, and potassium into the soil solution, as well as increased concentrations of aluminium, manganese, and zinc. The increase in dissolved organic carbon in the treatments with increased temperature suggests higher decomposition.

The study highlights how nitrogen addition can alter community structure, including through shading effects caused by fast-growing graminoids. Understanding these interactions is key for the effective management of alpine grasslands, which face growing risks from climate change and human-driven nitrogen deposition.

Keywords

Soil Chemistry, Alpine grassland, Experimental Warming, Nitrogen Deposition, Biomass

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Conflicts of interest

The authors have declared that no competing interests exist.