N deposition can accelerate the degradation succession from grasses- and sedges-dominated plant communities into forbs-dominated ones in overgrazed alpine grassland systems on Qinghai-Tibetan Plateau

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Abstract

Alpine grasslands are sensitive to grazing and atmospheric deposition of nitrogen (N). With the increase of N deposition, experimental investigations of the effects of grazing on alpine grassland vegetation with the background of N deposition are scarce. In this study, we examined the effects of overgrazing and overgrazing with N deposition on eco-physiologies of alpine grassland plants at the functional group level. We found that both overgrazing and overgrazing with N deposition obviously changed species composition and the dominance of three plant functional groups (PFGs) in alpine meadow and alpine steppe. Under overgrazing and overgrazing with N deposition treatment, forb tended to be predominant in the whole plant community, while grass and sedge dominance was obviously decreased. In addition, we found that the underlying eco-physiological processes that lead to forb-dominant were different under overgrazing and overgrazing with N deposition. Overgrazing with N deposition obviously tended to increase forb dominance both directly by selective herbivory and indirectly by enhancing forb photosynthetic capacity. Our results suggested that long-term overgrazing with N deposition will lead to a more favorable living environment for forbs, making the grassland community of alpine grasslands on the Qinghai-Tibetan Plateau likely shift to forb-dominant in the future.

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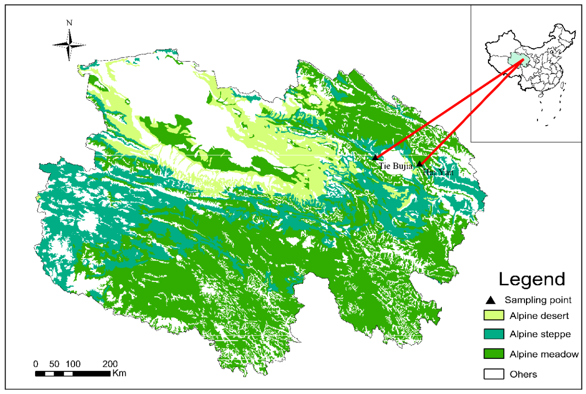

Figure1 Location of study sites in Qinghai Province, China

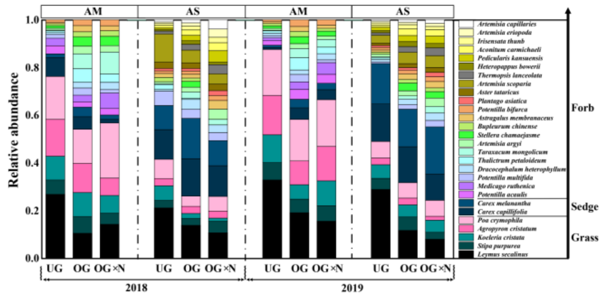

Figure 2 Species composition in two types of alpine grasslands of Qinghai-Tibetan Plateau under overgrazing and overgrazing with N deposition in 2018 and 2019. UG represents ungrazed; OG, overgrazing; OG×N, overgrazing with N deposition; AM: alpine meadow; AS: alpine steppe.

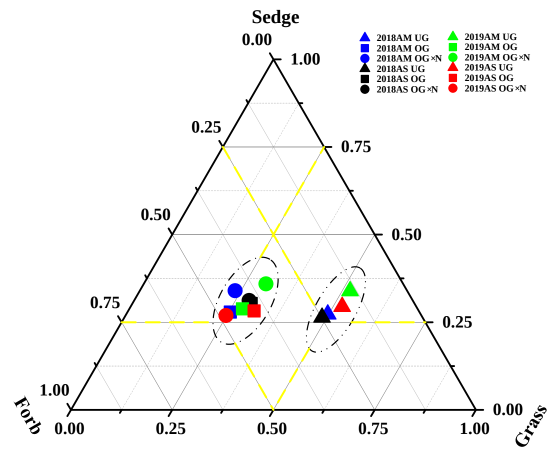

Figure 3 Dominance of three functional groups in two types of alpine grasslands of Qinghai-Tibetan Plateau under overgrazing and overgrazing with N deposition in 2018 and 2019. UG represents ungrazed; OG, overgrazing; OG×N, overgrazing with N deposition; AM, alpine meadow; AS, alpine steppe.

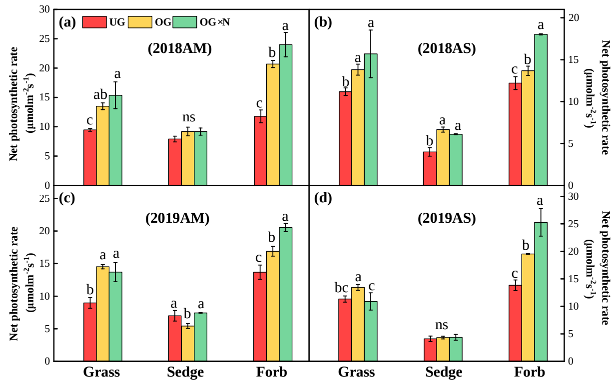

Figure 4 Effects of overgrazing and overgrazing with N deposition on net photosynthetic rate of three different functional groups (PFGs) in two types of alpine grasslands of the Qinghai-Tibetan Plateau in 2018 and 2019. **(a)** 2018 alpine meadow, **(b)** 2018 alpine steppe **(c)** 2019 alpine meadow **(d)** 2019 alpine steppe. UG represents ungrazed; OG, overgrazing; OG×N, overgrazing with N deposition; AM, alpine meadow; AS, alpine steppe. Values are the mean ± SD; lower case letters indicate significant differences among treatments ($P < 0.05$).

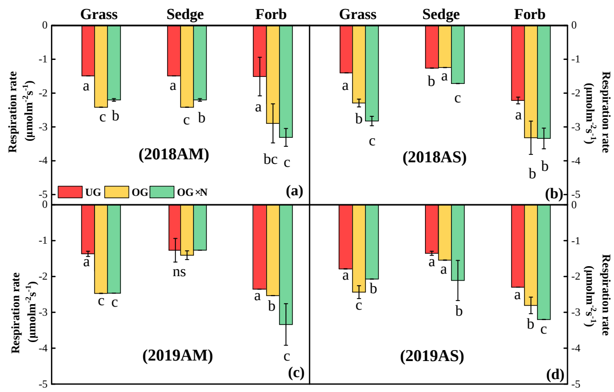

Figure 5 Effects of overgrazing and overgrazing with N deposition on respiration of three different plant functional groups (PFGs) in two types of alpine grasslands of Qinghai-Tibetan Plateau in 2018 and 2019. **(a)** 2018 alpine meadow, **(b)** 2018 alpine steppe **(c)** 2019 alpine meadow **(d)** 2019 alpine steppe. UG represents ungrazed; OG, overgrazing; OG×N, overgrazing with N deposition; AM, alpine meadow; AS, alpine steppe. Values are the mean ± SD; lower case letters indicate significant differences among treatments ($P < 0.05$).

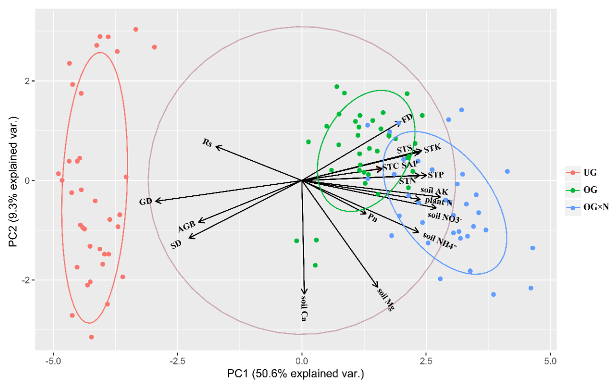

Figure 6 Principal component analysis (PCA) for the relationship for all the plant characters and soil properties under different treatments. The length of a variable vector in the representation space is indicative of the variable's level of contribution. STC, soil total carbon; STN, soil total nitrogen; STP, soil total phosphorus; STS, soil total Sulphur; STK, soil total potassium; soil Ca, soil calcium; soil Mg, soil magnesium; plant N, plant nitrogen; SAK, soil available potassium; SAP, soil available phosphorus, NO_3^- , nitrate nitrogen; NH_4^+, ammonium nitrogen; *P*n, net photosynthetic rate; *R*s, respiration rate; GD, grass dominance; SD, sedge dominance; FD, forb dominance; AGB, total aboveground biomass; UG, ungrazed; OG, overgrazing; OG×N, overgrazing with N deposition.

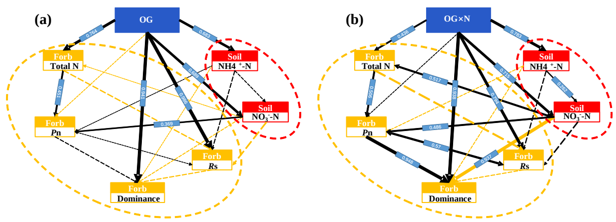

Figure 7 Path analysis for forb dominance under overgrazing and overgrazing with N deposition. Solid black lines indicate a significantly positive relationship ($P < 0.05$), and solid green lines indicate a significantly negative relationship ($P < 0.05$). The dashed blue or brown lines indicate weakly ($P > 0.05$) positive or negative relationships, respectively. The width of arrows is proportional to the strength of the path coefficients. **(a)** OG: ($\chi 2 = 0.924$, P = 0.630, GFI = 0.989, NFI=0.992, RMSEA < 0.05). **(b)** OG×N:($\chi 2 = 1.757$, P = 0.415, GFI = 0.979, NFI=0.992, RMSEA <0.05). NO_3^--N, nitrate nitrogen; NH_4^+-N, ammonium nitrogen; *P*n, net photosynthetic rate; *R*s, respiration rate; OG, overgrazing; OG×N, overgrazing with N deposition.