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SUMMARY OF DOCTORAL THESIS

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Title: Effects of simulated nitrogen deposition on grassland in the northern Loess Plateau region of China
(中国黄土高原北部の草地に及ぼす模擬窒素降下の影響)

Human activities have increased atmospheric nitrogen deposition since the beginning of the Industrial Revolution. In Asia, emissions of reactive nitrogen have increased dramatically, and the increasing trend maintains in future. Galloway et al (2004) and Reay et al (2008) predicted that nitrogen deposition levels in eastern Asia would be the highest in the world by middle of the 21st century, and that China would contribute greatly to these increases. Increased N availability through N deposition has the potential to affect plant growth and soil N cycles, resulting in ecological and environmental changes, since nitrogen is the primary growth nutrient and always a limiting factor.

The Loess Plateau of China is a site of intensive study because of its serious soil erosion and typical land cover changes resulting from the famous “Grain for Green” Policy. By affecting plant growth in productivity and diversity, N deposition may regulated the water erosion process, SOC sequestration, and soil water cycle, but no information about N deposition effects is available as the references for current studies on the Loess Plateau. More over, N deposition could increase soil reactive N load, potentially deteriorate the non-point water nitrate pollution caused by soil erosion. This research was carried out aiming to provide information about the effect of N deposition on natural ecosystem of the Loess Plateau.

This study was carried out on the northern part of the Plateau. The region is a famous coal mine base, with the possibility of high N deposition due to massive combustion of fissile fuels. Considering that the initial soil fertility regulates the effects of N addition, with more infertility ecosystem would be more sensitive to N addition, the initial soil chemical properties of the five main land cover types in the region were analyzed, including crop land, orchard, artificial grassland, natural grassland, and shrubland. The results suggested that the natural grassland dominated by *Stipa bungeana*, which is also the main land cover type in the region, is lower in soil available N (about 8.2 mg kg^{-1}) than in crop land (19.4 mg kg^{-1}), orchards (16.8 mg kg^{-1}) and alfalfa grassland (9.7 mg kg^{-1}). Therefore, this study was targeted on the *S. bungeana* dominated grassland.

In this study, insitu plot experiments were carried out. Simulate N deposition was applied periodically by spraying NH_4NO_3 chemical fertilizer solution during growing season. Six treatments were included in the experiment: (1) a control, which received only distilled water; (2) low N (2.5 g N m^{-2} yr^{-1}); (3) medium N (5 g N m^{-2} yr^{-1}); (4) high N (10 g N m^{-2} yr^{-1}); (5) phosphorus (P, 3 g P

m^{-2} yr^{-1}); and (6) high N + P (10 g N + 3 g P m^{-2} yr^{-1}). The two phosphorus treatments applied as NaH_2PO_4 solution were included to test the possibility of P limitation developing at high N deposition level. Considering the sloping topography of the study area, the experiment was done on two sites with opposite slope aspect to represent diverse soil condition. At the end of the growing season, the plant productivity was measured, and plant and soil samples were collected for study of plant and soil chemistry responses.

After one year of simulated N deposition, plant growth was significantly enhanced by the increased N deposition. These results put forwards the suggestions that nutrient effects in the study area deserve attention in the future. Responses of aboveground biomass to N deposition differed somewhat between the sunny and shady sites. Under the same N treatment, the grass generally grew better on the shady site; while, the sunny site had a lower threshold for significant increase. But the aboveground biomass increment was similar on both sites.

Different responses of plant growth were found among species. The two main species, i.e. *S. bungeana* and *Lespedeza davurica*, were studied separately. The aboveground biomass of the dominant species, S. bungeana, which occupies more than 85% of the total aboveground biomass, was significantly promoted by nitrogen treatment. To the contrary of *S. bungeana*, the subordinate species *L. davurica* aboveground biomass showed a decrease trend under N treatment, but was significantly promoted by P treatment. The different responses of the two species may attribute to different plant properties and the plant ability in competing for sunlight and other nutrient other than nitrogen. Furthermore, these results implied that increasing nitrogen deposition is likely to induce diversity change.

Tissue chemical changes of the two species agreed with the growth response to N deposition. Nitrogen addition significantly increased the foliar nitrogen concentrations of *S. bungeana*. However, the increase in tissue N concentration against increasing N addition suggests that short-term increase in tissue C storage per unit added N shows declining trend. The significant increased N/P ratio of *S. bungeana* under 10 g N m^{-2} yr^{-1}treatment and a significant increased of aboveground biomass by high N plus P treatment, suggests that high N treatment amplified P limitation. Similar to the results of aboveground biomass, the N concentration of aboveground part of *L. davurica* was not changed significantly. From of the results of tissue chemistry as well as growth response, it can be concluded that the herb grass *S. bungeana* may require a great deal of nitrogen for optimum growth, while legume plant *L. davurica* may be more easily short of phosphorus.

Despite the increase of plant production, soil organic carbon and total N was not significantly changed, which could partly attributed to the slow turn-over process of litter and the great buffering capacity of soil. However, the high N treatment significantly increased NO_3-N concentrations in the 0-40 cm soil layer compared with the control for the shady slope; the difference at the sunny site extended to a 60 cm soil depth.

Slopes on the Loess Plateau occupy more than 60% of the total area. This research may be pertinent to similar ecosystems in the region but the temporal and spatial distribution of soil water and soil nutrients can vary greatly. This research suggests that similar studies would need to be conducted in other areas of the Loess Plateau in order to determine the relative sensitivities of those ecosystems to the factors associated with N deposition that we have noted in this preliminary study.