

## Soil nitrogen mineralization not affected by grass species traits

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### Abstract

Species N use traits was evaluated as a mechanism whereby *Bromus inermis* (*Bromus*), an established invasive, might alter soil N supply in a Northern mixed-grass prairie. We compared soils under stands of *Bromus* with those from three representative native grasses of different litter C/N: *Andropogon gerardii* (*Andropogon*), *Nassella viridula* (*Nassella*) and *Pascopyrum smithii* (*Pascopyrum*); in ascending order of litter quality. Net mineralization (per g soil N) measured in year-long laboratory incubations showed no differences in comparisons of *Bromus* with two of the three native grasses: *Andropogon* and *Nassella*. Higher mineralization in *Pascopyrum* stands relative to *Bromus* was consistent with its higher litter quality. However, an unusually high occurrence of an N-fixing legume in *Pascopyrum* stands, potentially favoring high mineralization rates, confounded any conclusions regarding the effects of plant N use on N mineralization. Instead of an initial flush of net mineralization, as would be expected in laboratory incubation, we observed an initial lag phase. This lag in net N mineralization coincided with high microbial activity (respiration) that suggests strong N limitation of the microbial biomass. Further support for the importance of immobilization initially came from modeling mineralization dynamics, which was explained better when we accounted for microbial growth in our model. The absence of strong differences in net mineralization beneath these grasses suggests that differences in plant N use alone were unlikely to influence soil N mineralization through substrate quality, particularly under strong N control of the microbial biomass.

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### 1. Introduction

Plant species traits related to N use and allocation to structure directly determine litter quality (Heal et al., 1997; Murphy et al., 2002). Traits such as productivity and mean residence time of N in vegetation have an effect on litter quality in terms of the C/N ratio and the concentration of secondary compounds. The slow decomposition of poor quality litter (Swift et al., 1979) can therefore link species composition with ecosystem nutrient status through soil N supply.

Support for a species effect on soil nutrient supply has been demonstrated for forest ecosystems (Pastor et al., 1984; McClougherty et al., 1985; Pastor and Post, 1986;

Mladenoff, 1987; Zak et al., 1989; Lovett et al., 2004; but also see Verchot et al., 2001). Evidence from grasslands is less consistent. In a comparison of five grass monoculture stands, Wedin and Tilman (1990) found significant differences in field estimates of N mineralization that were supported by laboratory measurements of N mineralization potential (Wedin and Pastor, 1993). Differences in mineralization resulted from differences in the activity of a small but labile fraction of soil organic nitrogen. In semiarid short grass steppe, Vinton and Burke (1995) found ecosystem structural attributes, particularly patterns in plant cover, to be a more important determinant of soil N dynamics than species-driven effects. In other words, the distribution of vegetation was more important than which species were present. Knops et al. (2002) suggested generally strong microbial control over N cycling which results in a microbial bottleneck; thus potential species-driven effects on N mineralization resulting from differences in N use may

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be masked by immobilization and result in no net differences in mineralization.

Our focus in this study is plant N use traits, not plant N input, altering soil N supply. We are investigating how traits such as photosynthetic pathway and stature, with an effect on litter C/N, can influence soil N supply. This relationship is particularly interesting when considering that the N cycle is largely biologically driven and predominantly closed, such that internal N cycling accounts for the majority of N flux. Our goal was to evaluate the effect of an invasive perennial grass, *Bromus inermis* (*Bromus*), on soil N processes following its establishment in a Northern mixed-grass prairie. We wished to evaluate the underlying mechanisms by monitoring microbial activity and modeling N mineralization kinetics. Do differences in litter quality among graminoids of the Northern mixed-grass prairie result in differences in soil N supply? We expected the differences in litter quality between *Bromus* and the native grasses, resulting from differences in plant stature and N use strategies, would alter soil N mineralization potential and would be largely driven by alterations in the size and decomposition rate of a small but labile pool of soil organic nitrogen. A secondary objective was to examine indices of substrate quality, for soil and litter, which correlate with mineralization parameters.

## 2. Methods

### 2.1. Site description

The study was conducted on the Fort Pierre National Grassland located in central South Dakota (lat. 43°89' N, long 100°28' W). Mean annual precipitation is 576 mm and mean annual temperature is 8.6 °C, with a 124-day growing season (South Dakota Office of Climatology, unpublished data). Soils of the series Opal sansarc are fine textured vertisols, formed from residuum of shale parent material of montmorillonitic mineralogy (Schumacher, 1986). The high content of smectitic clays results in a relatively high capacity for ammonium fixation and physical protection of soil organic matter. The vegetation is characteristic of the Northern mixed-grass prairie, consisting of a mixture of warm- and cool-season grasses that vary in stature between short, mid-height, and tall grasses.

### 2.2. Experimental layout

The particular sites selected for this study were dominated by *Andropogon gerardii* (*Andropogon*), alone constituting 23–34% of total canopy cover estimates. Cool season grasses: *Nassella viridula* (*Nassella*), constituted 9–22%, and *Pascopyrum smithii* (*Pascopyrum*) constituted 0.2–5% of total canopy cover. *Bromus inermis* (*Bromus*) was established as a codominant in the ungrazed site, where it constituted 21% of total canopy cover versus only 8% in the grazed site. Also prominent was an exotic N-fixing legume (*Melilotus* sp.) (Table 1).

Table 1

Vegetation composition determined as percentage species cover estimates from five, 20 m transects per site

Site-scale vegetation composition as percent cover		
	Grazed	Ungrazed
<i>Andropogon gerardii</i> —ANGE	33.98 ± 27.1	22.80 ± 22.2
<i>Nassella viridula</i> —NAVI	8.48 ± 10.1	21.62 ± 17.7
<i>Pascopyrum smithii</i> —PASM	5.19 ± 6.9	0.17 ± 0.3
<i>Bromus inermis</i> —BRIN	8.20 ± 17.8	20.62 ± 35.4
Other grasses and sedges	4.65 ± 6.5	1.08 ± 1.5
Legumes	28.00 ± 19.4	21.68 ± 11.9
Forbs	8.04 ± 5.4	6.68 ± 4.8
Shrubs	3.60 ± 7.0	6.02 ± 7.8

Data are means ± SD.

We selected two sites that differed only in grazing history to incorporate land use as a potential source of variability. The ungrazed pasture had not been grazed by cattle for 9 years prior to the study, while the grazed pasture had been grazed at a moderate level every other year. To focus on species-driven differences we sampled relatively homogeneous stands (this was more successful for some species than others), about 5 m in diameter. Plots consisted of a stand of *Bromus* paired with an adjacent stand, within 0–4 m, dominated by one of the three native grasses [*Andropogon gerardii* (*Andropogon*, C<sub>4</sub>, tallgrass), *Nassella viridula* (*Nassella*, C<sub>3</sub>, mid-height grass) and *Pascopyrum smithii* (*Pascopyrum*, C<sub>3</sub>, mid-height grass)]. Paired stands were replicated four times in each of two grazing sites for a total of 24 plots. Comparisons were restricted to paired stands within a plot to control within-site variability. This conservative approach limited the number of possible comparisons, but also the effects of potential confounding factors since comparisons were only made on samples within a few meters of each other.

### 2.3. Soil and litter sampling and analysis

Five, 2.5-cm-diameter by 20-cm-depth cores were collected at the end of the growing season in August 2002 and composited for each stand. Fresh samples were passed through a 2 mm sieve and allowed to air-dry, removing coarse particles and bulk root biomass. Remaining visible detritus and root material was picked out by hand. A subsample was homogenized by grinding in a ball mill and analyzed for total C and N using a Leco CHN-1000 analyzer (Leco, St. Joseph, Michigan, USA). Total C was corrected for carbonates using a pressure-calimeter method (Sherrod et al., 2002). Field capacity was determined as gravimetric water content of samples that were saturated then allowed to drain overnight. Particle size analysis was determined using the hydrometer method. Senescent aboveground biomass was collected at the end of the growing season in October 2003 from four, 20 × 50 cm quadrats per plot and pooled for analysis. Samples were

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