Organic nitrogen and invasion in intermountain grasslands.

Morgan Luce McLeod
Beau Larkin
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Introduction

Exotic plant invasion is commonly associated with increased plant biomass production, increased rates of nutrient cycling, and increased amounts of soil available nutrients such as nitrogen (N) (Liao et al. 2008). Interactions among these three factors may contribute to invader success when outcompeting natives. Most studies of invasion and N have focused on inorganic N forms, however organic nitrogen in the form of amino acids is also abundant in soil and has been recently recognized as a potentially important source of plant nutrition in N limited systems (Lipson 2000). Amino acid N makes up more than 20% of total N, and a smaller, but still significant fraction of free amino acids are available for rapid uptake by plants (Senwo and Tabatabai 1998).

The majority of organic N studies have focused on alpine or arctic environments where slow decomposition rates limit the amount of inorganic N available to plants. In invaded grasslands, a springtime combination of wet conditions and rapid plant and microbial growth may deplete inorganic N pools, thus uptake of organic N may be important to gain a competitive edge.

We aimed to answer the following question: do we observe increased amounts of inorganic and organic N in the spring, in invaded patches as compared to diverse native communities?

Field Methods

I measured soil inorganic and organic N pools in a mixed native community and invaded near-monoculture patches of cheat grass, spotted knapweed, leafy spurge, and sulfur cinquefoil.

Photos above show native (left) and invaded (leafy spurge; right) patches at the field site on the south aspect of Mount Sentinel.

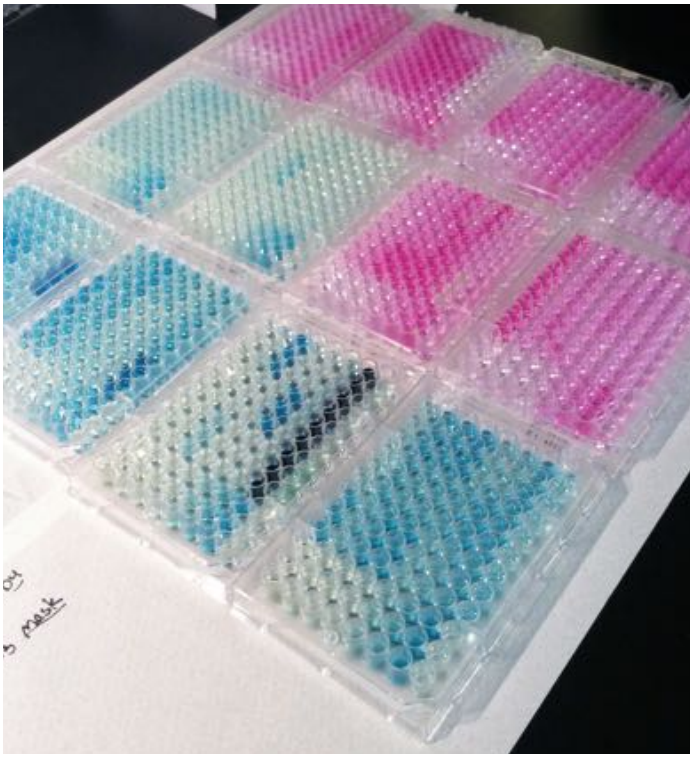
I sampled soil at 5 separate patches for each invader. All invaded patches were paired with a nearby native community. The patches were spread across three field sites; a hillside above Grant Creek (a), the South aspect of Mount Sentinel (b), and at the sheep camp and Whaley draw areas at MPG ranch (c).

I sampled soil May 12-14th, 2014. As the growing season proceeds, availability and forms of nitrogen shift in response to uptake and release by plants and microbes. During sampling plants were growing– but were not yet at peak rates of biomass production. We chose this time as we expected optimal conditions for organic N availability.

Lab Methods

To determine inorganic N pools, I extracted inorganic N using 2M KCl (Hart et al. 1994). Fifteen g of soil was added to 100 mL of 2M KCl, shaken on an orbital shaker for one hour, allowed to settle overnight, filtered, and along with an extraction blank, frozen until analysis. Concentrations of nitrate (NO_3^-) and ammonium (NH_4^+) in filtrates were determined colorimetrically using our Microplate Reader (BioTek, USA) after Weatherburn (1967) and Doane & Horwath (2003).

To determine organic N pools (amino acids), I used the fluormetric OPAME procedure (Jones et al. 2002). This is a contemporary method adapted for use with the microplate reader. Soil extracts (above) were mixed with a single reagent composed of a borate buffer, o-phthaldialdehyde and b-mercaptoethonol. The OPA and ME react with amino acids to form a fluorescent product that is detected by our plate reader.

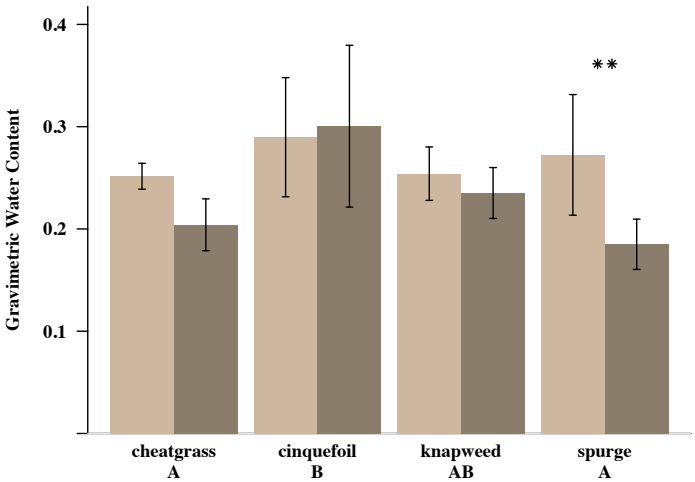


Photos above show ammonium (blue) and nitrate (pink) sample plates (left) and soil organic and inorganic nitrogen KCl extractions (right) in the lab.

Results and Conclusions

Figure 1 (left). Gravimetric water content of invaded (light brown) and native (dark brown) soils for cheat grass, cinquefoil, knapweed, and leafy spurge plots. Invaded leafy spurge soil was associated with significantly higher gravimetric water content than nearby native soil.

Figure 2 (right). Soil ammonium in invaded (light brown) and native (dark brown) soils. Leafy spurge invaded soil was associated with significantly higher soil ammonium than nearby native soil.



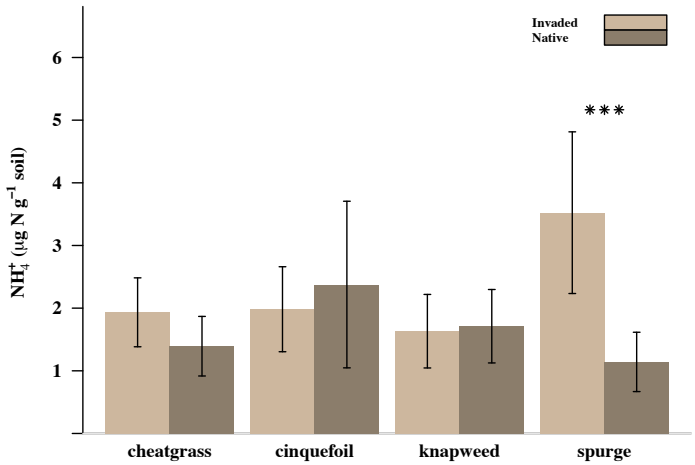


Figure 3. Soil nitrate in invaded (light brown) and native (dark brown) soils. Cheat grass and leafy spurge invaded soils were associated with significantly higher soil nitrate than nearby native soils. Knapweed invaded soil showed a trend toward higher soil nitrate.

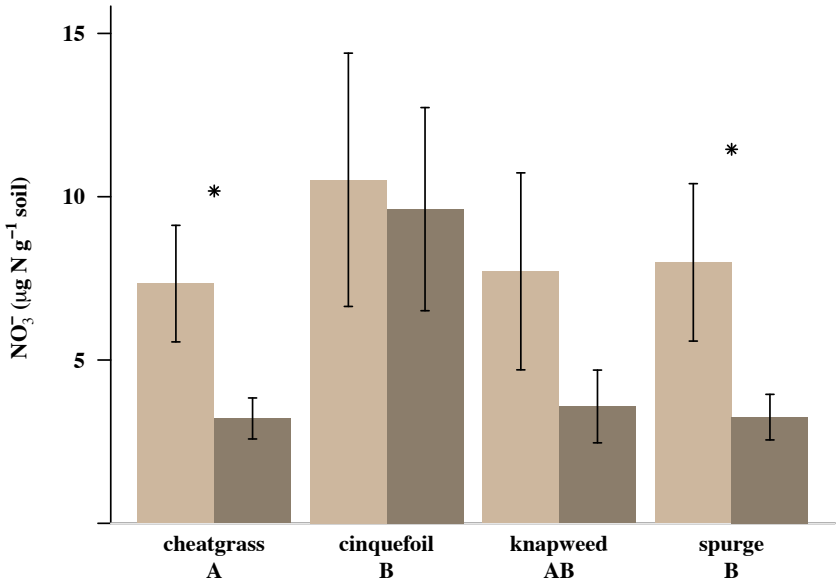
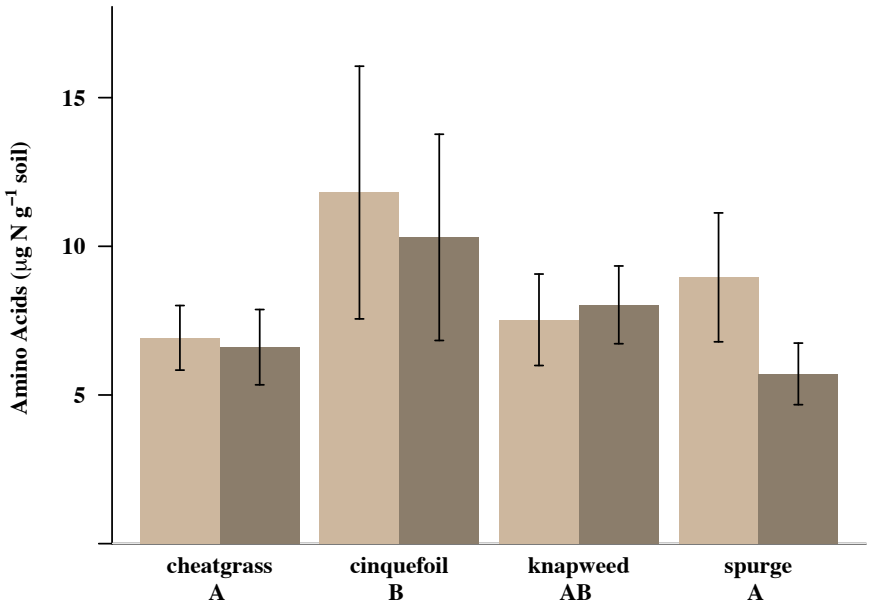


Figure 4. Extractable amino acids of invaded (light brown) and native (dark brown) soils for cheat grass, cinquefoil, knapweed, and leafy spurge plots. Invaded leafy spurge soil showed a trend toward higher amino acids than nearby native soils (P=0.08)



Conclusions

Sulfur cinquefoil invaded soil and nearby native soil did not follow the pattern of the other invaders. It tended to have higher soil moisture, more nitrate, and more amino acids. This indicates that sulfur cinquefoil may invade slightly different environments than the other species.

Soil invaded by leafy spurge tended to have higher gravimetric water content, ammonium, nitrate, and amino acids as compared to nearby native soil.

Organic nitrogen in the form of amino acids was available during leafy spurge's growth period.

Our pilot study was limited to 5 patches of each invader at 3 different locations in the Missoula and Bitterroot valleys. This sampling scheme may not be appropriate or have enough replication to pick up significant differences among invaded and native soil given all of the environmental variation among patches. A sampling scheme that incorporates a grid of points across the landscape with higher replication may be more effective in detecting differences.

Jones, David L., Andrew G. Owen, and John F. Farrar. "Simple method to enable the high resolution determination of total free amino acids in soil solutions and soil extracts." Soil Biology and Biochemistry 34.12 (2002): 1893-1902.

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Lipson, David, and Torgny Näsholm. "The unexpected versatility of plants: organic nitrogen use and availability in terrestrial ecosystems." Oecologia 128.3 (2001): 305-316.

Liao, C., Peng, R., Luo, Y., Zhou, X., Wu, X., Fang, C., et al. (2008). Altered ecosystem carbon and nitrogen cycles by plant invasion: a meta-analysis. New Phytologist, 177, 706-714.