Cheatgrass invasion and soil microbial communities

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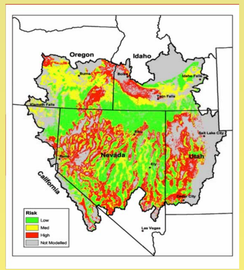
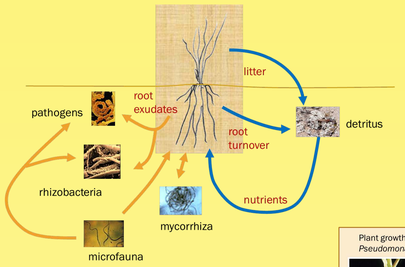
The Problem



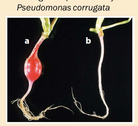
SAGEMAP, 2003

Bromus tectorum (cheatgrass) has invaded substantial areas in the Intermountain West and has potential to expand even further. The phenological (winter annual) and physiological (prolific seed producer, tolerates low water potential for seed germination) characteristics of cheat grass, together with its trait to increase rangeland fire occurrence and intensity, have been suggested to be responsible for its success as an invader (Eviner et al., 2010).
However, this does not explain cheatgrass success in sites that do not see increased fire frequency, lack of succession, especially during wet periods, and its invasion of native sites.

Aboveground – Belowground Interactions



Plant growth promotion by *Pseudomonas corrugata*



Lugtenberg and Kamilova, 2009

Soil organisms play an important role in nutrient cycling, decomposition, and soil formation.. Above-ground plant communities and below-ground microbial communities are linked through a variety of feedback mechanisms. Plant litter and dead roots provide resources for microbial decomposers, while soil microbes recycle nutrients and make them available for plant growth.
Symbioses between plants and below-ground microbes provide a mutualistic framework for enhancing the exploitation of resources by both partners..
Plants also provide a food source for soil microbes via root exudates, while microbes that colonize plant roots can provide protection from plant pathogens or serve a plant growth promoting role.

What about Cheatgrass ?

Cheatgrass in sagebrush-bunchgrass community

- ↑ Heterotrophic bacteria, fungi, actinomycetes — Bolton et al., 1993
- ↓ Nematode populations
- ↑ Amoebae populations — Booth et al., 2003

Cheatgrass in Stipa/Hilaria grassland

- ↑ Fungal numbers and species
- ↓ Fungal infections in *Bromus*
- ↑ Bacteria-feeding nematodes in *Stipa* community
- ↓ Bacteria-feeding nematodes in *Hilaria* community — Belnap and Phillips, 2001

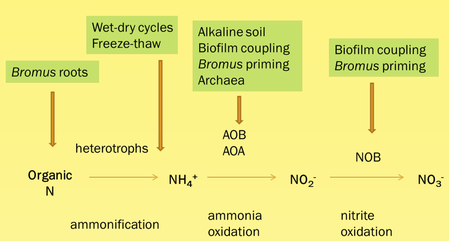
Soil N in Cheatgrass Invaded Sites

- ↑ Total soil N 7/8 studies
- ↑ Soil NH_4^+ 2/3 studies
- ↑ Nitrification/Nitrification Potential 2/3 studies
- ↑ Soil NO_3^- 3/5 studies

Svejcar and Sheley, 2001
Booth et al., 2003
Hooker et al., 2008
Adair and Burke 2010

NO_3^- peaking in summer

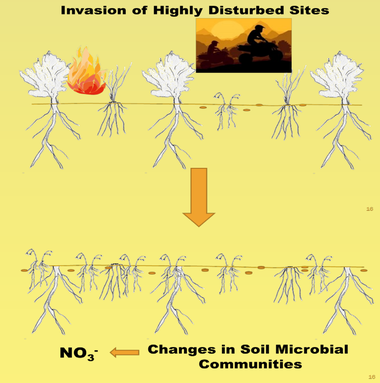
Proposed Effects of Cheatgrass Invasion on Soil N Cycling



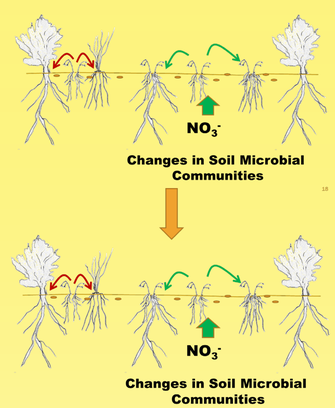
The additional biomass provided by the roots of the annual grass *Bromus tectorum* is turned over on an annual basis adding C and NH_4^+ to the soils directly underneath cheatgrass. The resulting NH_4^+ serves as substrate for nitrifying microorganisms which are favored by abiotic edaphic conditions and *Bromus*-soil microbe interactions. The phenology of cheatgrass as a winter annual allows it to maximize increased nutrient availability prior to native plant species such as shrubs and to a certain extent perennial grasses. (AOA ammonia oxidizing Archaea, AOB ammonia oxidizing bacteria, NOB nitrite oxidizing bacteria)

How Cheatgrass Replaces Native Communities

Invasion of Highly Disturbed Sites



Invasion of Native Communities



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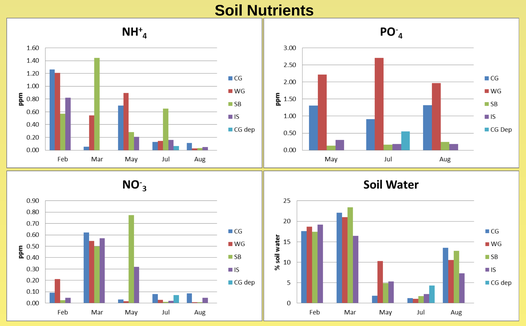
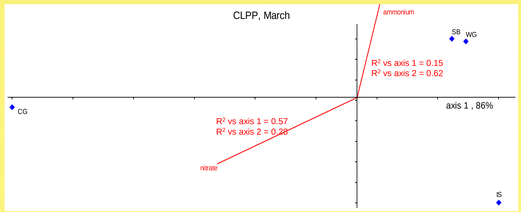
Pilot Test Data

Soil Nutrients



Community Level Physiological Profiles



The study site is located in a sagebrush/bunchgrass community in the Eastern portion of the Great Basin in Utah at an elevation of
Soil samples were collected with a 10 cm long soil corer in March, May, July and August of 2014. Soil nutrients were extracted with either 2 M KCl or an acid extraction solution (LaMotte, Chestertown, PA)), followed by wet chemistry analysis (SMART 2 colorimeter, LaMotte). Community Level Physiological Profiles (CLPP) were obtained by adding soil extracts in Ringer solution or PBS to ECO 96 well plates (Biolog, Hayward, CA) followed by incubation at room temperature. Absorbance readings at day 9,were used for multivariate analysis using PC-ORD (MJM Software Design, Gleneden Beach, OR).
The four plots (CG, WG, SB, IS) were significantly different for substrate utilization profiles with PERMANOVA testing (p = 0.002). Principal component analysis of substrate utilization in March samples shows divergence of the individual sample sites and correlation with individual nutrients.

References

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