# Temporal Variation in Mineral Soil N in a Crested Wheatgrass Planting

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Crested wheatgrass, a non-indigenous perennial grass, has been often planted to improve range condition and is one of few species to exclude the exotic annual grass *Bromus tectorum* (cheatgrass). We hypothesize that crested wheatgrass resists *B. tectorum* invasion by reducing soil N availability below a threshold level. This hypothesis was tested in a crested wheatgrass stand northeast of Reno, NV seeded in 1960. For one-year, soil samples (6 replicates) were collected monthly, 0-15 and 15-30 cm by microsite (beneath crested wheatgrass, beneath a shrub, and in an un-vegetated interspace). Attributes measured included soil T, soil moisture content, mineral N, and 30-day N mineralization potential. Overall, mineral N was greatest beneath crested wheatgrass (0.60 mmol $kg^{-1}$) and shrubs (0.61 mmol $kg^{-1}$) than un-vegetated interspaces (0.38 mmol $kg^{-1}$). Mineral N beneath crested wheatgrass ranged from 0.24 mmol $kg^{-1}$ in April, 2009 to 1.66 mmol $kg^{-1}$ in Jan., 2010, similar to other ecosystems we have quantified in the Great Basin. The molar proportion of $NH_4^+$-N in the extractable pool of crested wheatgrass averaged over 85% for the year and is far greater than other plant communities we have measured in the Great Basin. We conclude that crested wheatgrass does not suppress *B. tectorum* by controlling mineral N below a threshold level; rather, we hypothesize that it may limit nitrification and thereby reduce $NO_3^-$-N availability to the nitrophile *B. tectorum*.

# INTRODUCTION

Crested wheatgrass (*Agropyron desertorum*, *A. cristatum*), is an exotic perennial grass planted extensively in the west for forage, improving degraded rangelands, and erosion control. Established crested wheatgrass can suppress *Bromus tectorum* (cheatgrass), but no research has been undertaken to elucidate mechanisms. Our purpose is to report on seasonal mineral N concentrations and N mineralization potentials in a crested wheatgrass stand in northern Nevada, seeded in 1985. This stand has few *B. tectorum* plants suggesting some form of suppression. Our working hypothesis posits that established crested wheatgrass controls mineral soil N to a level below which *B. tectorum* is less competitive.

Dense stand of *B. tectorum* following wildfire in north-central Nevada. Fall germinating populations can give the grass a head start, ready to explode if winter and spring precipitation are optimal. Such high fuel loads of this fine and combustible tissue place landscapes at risk of future wildfires much larger in extent than before the landscape was invaded.

Landscape photo of the study site. Seeded to Hycrest crested wheatgrass in 1985, the vegetation community has slowly recruited shrub species such as *Ephedra nevadensis* (morman tea), *Artemisia tridentata* (big sagebrush), and *Prunus andersonii* (desert peach). The left foreground shows a population of *Bromus tectorum* (cheatgrass) that seems to invade in areas not occupied by crested wheatgrass. In healthy established stands of crested wheatgrass, *B. tectorum* is absent and exists as small individual plants that seem not to spread. It is important to note that even in areas where *B. tectorum* is absent, the seedbank does contain germinable populations.

# METHODLOGY

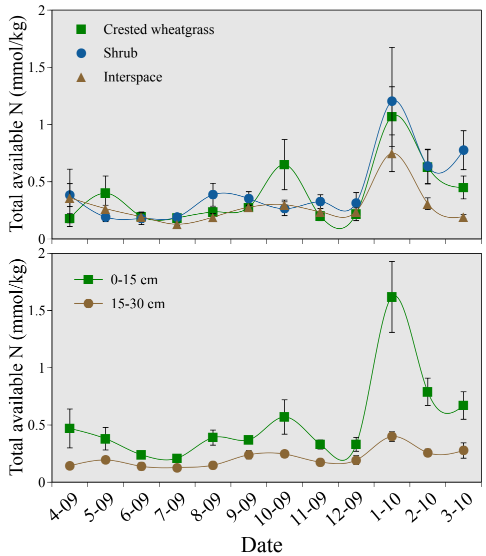
Hypothesis testing was done at a crested wheatgrass stand about 20 km north northwest of Reno, NV (39°40'51"N; 119°55'36"W) at an elevation of 1592 m. Average annual precipitation is 28 cm. The soil is a fine-loamy, mixed, superactive, mesic Haploxeralfic Argidurid. Following a wildfire in 1985, the area was seeded to cultivar Hycrest crested wheatgrass, a hybrid between *Agropyron cristatum* and *A. desertorum*. In March 2009, a 100 x 140 meter site was established in a uniform area with similar slope and aspect. *B. tectorum* is a minor component, but can assume dominance in areas in which crested wheatgrass did not establish or plants have been lost over time. A grid pattern was established and each month, 6 different randomly selected grid intersections were chosen for sampling. At each intersection, three microsites were sampled: center of the nearest crested wheatgrass, center of the nearest un-vegetated interspace, and subcanopy of the nearest shrub. Depths sampled were 0-15 and 15-30 cm. Soil was sieved to remove >2-mm particles and homogenized. A subsample was dried to 105°C for moisture content and to correct data to an oven dry basis. On fresh samples, we quantified KCl-extractable N (mineral N) and 30-day N mineralization potentials. Data were analyzed by ANOVA (Table 1) with categorical variables Time (12 months), Depth (0-15, 15-30 cm) and Microsite (crested wheatgrass, interspace, shrub subcanopy). Mean separation used Tukey's Honest Significant Difference test.

Table 1. ANOVA results.

| Attribute | Microsite(M) | Depth(D) | Time(T) | M x D | M x T | D x T | M x D x T |
|---|---|---|---|---|---|---|---|
| Total mineral N | 0.0040 | <0.0001 | <0.0001 | 0.0015 | <0.0001 | 0.0258 | 0.1363 |
| Net N mineralization potential | <0.0001 | <0.0001 | <0.0001 | 0.0027 | <0.0001 | <0.0001 | 0.2904 |
| Mole % $NH_4^+$-N in mineral pool | <0.0001 | 0.7939 | <0.0001 | 0.1563 | 0.0003 | 0.4056 | 0.9618 |

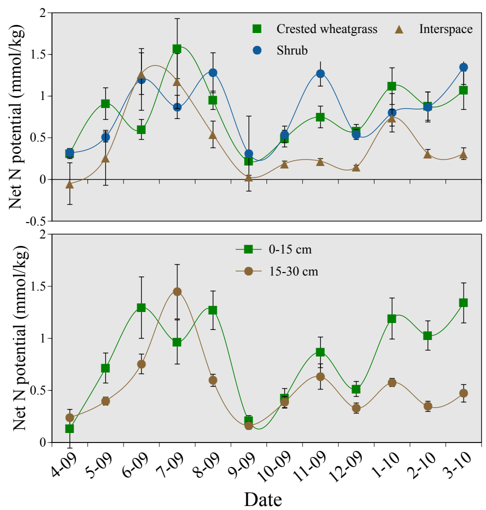
Close-up photos of the study site. Top photo shows total suppression of *B. tectorum* by crested wheatgrass. The largely un-vegetated interspaces can be occupied by the grasses *Poa secunda* (Sandberg bluegrass) and *Elymus elymoides* (bottlebrush squirreltail) and the forbs *Crepis acuminata* (hawksbeard) and *Lupinus* sps. Bottom photo shows area where crested wheatgrass did not established or has died. These areas can become completely occupied by *B. tectorum*.

# MINERAL N AND NET N MINERALIZATION POTENTIAL




RESULTS: Total mineral N (available) was affected by significant depth x time and microsite x time interactions (Table 1). Mineral N was similar among microsites during the growing season. It then increased during fall plant senescence, at which time, crested wheatgrass and shrub microsites had higher mineral N than interspace microsites. Mineral N was greatest in 0-15 cm depth increment relative to 15-30 cm.

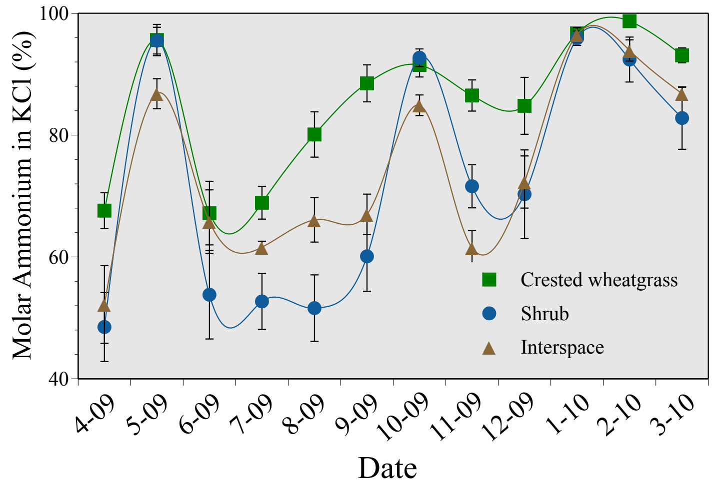
INTERPRETATION: Plant senescence combined with increased fall and winter precipitation likely contributed to greater mineral N during winter. For most dates, crested wheatgrass did not control mineral N to a lower level than other microsites and at first glance refutes the working hypothesis.




RESULTS: Net 30-day N mineralization potentials were affected by significant depth x time and microsite x time interactions (Table 1). During the growing season, there was considerable variation in N mineralization potentials among microsites. After plant senescence, crested wheatgrass and shrub microsites had greater N mineralization potentials than interspace microsites. For most dates, N mineralization potential was greater for the 0-15 cm depth increment than the 15-30 cm depth increment.

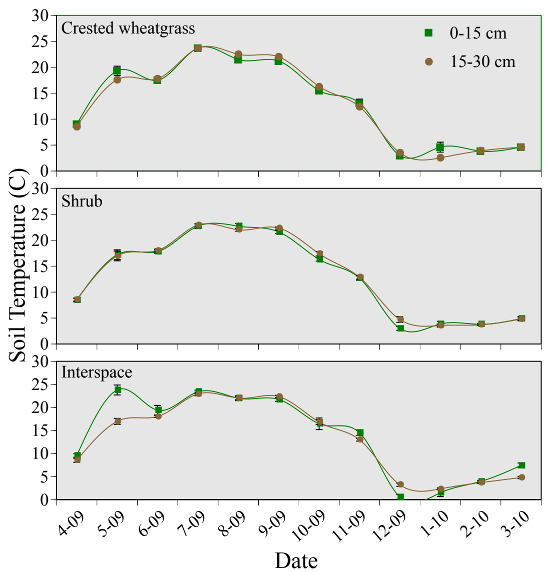
INTERPRETATION: Lower N mineralization potentials for interspace microsites may be due to less root exudation of C substrates for microbes that synthesize N-cleaving enzymes. Plant senescence combined with increased fall and winter precipitation likely contributed to greater mineral N during winter.

# MOLAR $NH_4^+$, SOIL TEMPERATURE, AND SOIL MOISTURE



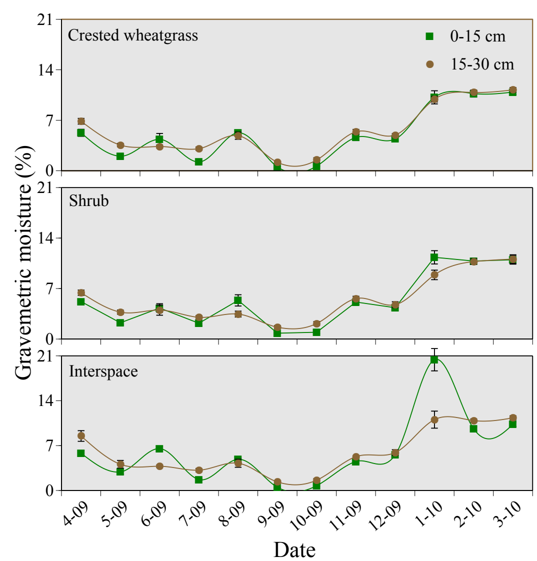

RESULTS: Microsite by date affected molar proportion of $NH_4^+$ in mineral N pool. For most dates, the molar $NH_4^+$ fraction was greater beneath crested wheatgrass, and exceeded 90% for six months.

INTERPRETATION: Our lab has never processed samples with this consistently high proportion of $NH_4^+$ in the N mineral fraction. We hypothesize that crested wheatgrass somehow limits nitrification.




RESULTS: For microsites and depths, there were minimal differences in soil T and gravimetric moisture contents. Warmer soil T on interspace microsites in May could be due to lack of shading. High soil water content in Jan. on surface interspaces may be due to melting snow on top of frozen soil.

INTERPRETATION: No relationship of mineral N concentration, net N mineralization potential, and molar proportion of $NH_4^+$ to soil T or moisture content.



# DISCUSSION

Our working hypothesis asks if crested wheatgrass controls the pool of mineral soil N ($NH_4^+$-N and $NO_3^-$-N) to levels below which *B. tectorum* is not as competitive. When one compares mineral N beneath crested wheatgrass to other ecosystems we have quantified (Table 2), we are forced to reject our working hypothesis. Our data suggests another possible mechanism by which established crested wheatgrass may suppress *B. tectorum*. We were quite surprised that for all dates, the molar proportion of $NH_4^+$-N in the extractable pool beneath crested wheatgrass exceeded 65% and for 6 months exceeded 90%, which are far higher values than obtained in other ecosystems (Table 2). Maintaining more mineral N in the $NH_4^+$-N form may decrease its availability to *B. tectorum*. In these arid environments with high temporal variability in soil water content, having a larger proportion of mineral N in the highly mobile $NO_3^-$-N form would increase the likelihood of transport to roots. We propose that a potentially fruitful research area of invasion ecology is to test a hypothesis that plant communities, which poise the proportion of $NH_4^+$-N in the mineral pool at high levels, may be resistant to *B. tectorum* invasion.

Table 2. Mineral soil N and molar proportion of $NH_4^+$-N in the mineral pool for several plant communities in Nevada[†].

| Location | Date | Community | Microsite | # samples | Parent material | Depth | Mineral N | Mole $NH_4^+$-N |
|---|---|---|---|---|---|---|---|---|
| | | | | | | cm | mmol/kg | % |
| 41°13'40"N | 12/01 | Intact sagebrush | Shrub interspace | 4 | Loess | 0-5 | 0.63(0.11) | 11.1(3.3) |
| 117°24'14"W | 12/01 | Intact sagebrush | Shrub interspace | 4 | Loess | 5-15 | 0.16(0.03) | 13.0(3.2) |
| | 12/01 | Intact sagebrush | Sagebrush subcanopy | 4 | Loess | 0-5 | 0.76(0.29) | 14.9(1.8) |
| | 12/01 | Intact sagebrush | Sagebrush subcanopy | 4 | Loess | 5-15 | 0.12(0.01) | 12.3(4.1) |
| | 12/01 | Burned sagebrush | Cheatgrass | 4 | Loess | 0-5 | 0.52(0.14) | 10.9(4.9) |
| | 12/01 | Burned sagebrush | Cheatgrass | 4 | Loess | 5-15 | 0.25(0.08) | 14.1(2.3) |
| 39°09'33"N | 5/02 | Pinyon-Juniper | Interspace | 4 | Welded Tuff | 0-3 | 1.67(0.23) | 51.3(6.2) |
| 117°23'33"W | 5/02 | Pinyon-Juniper | Interspace | 4 | Welded Tuff | 3-8 | 0.92(0.11) | 41.6(7.4) |
| | 5/02 | Pinyon-Juniper | Sagebrush subcanopy | 4 | Welded Tuff | 0-3 | 1.82(0.26) | 28.1(2.7) |
| | 5/02 | Pinyon-Juniper | Sagebrush subcanopy | 4 | Welded Tuff | 3-8 | 0.82(0.04) | 30.3(4.1) |
| | 5/02 | Pinyon-Juniper | Juniper understory | 4 | Welded Tuff | 0-3 | 1.02(0.34) | 43.8(2.8) |
| | 5/02 | Pinyon-Juniper | Juniper understory | 4 | Welded Tuff | 3-8 | 0.41(0.08) | 44.2(0.8) |
| 40°08'14"N | 4/98-5/10 | Invaded winterfat | Cheatgrass | 241 | Eolian sand | 0-20 | 0.21(0.02) | 32.3(1.9) |
| 120°04'38"W | 4/98-5/10 | Invaded winterfat | Winterfat | 83 | over lacustrine | 0-20 | 0.15(0.02) | 23.6(2.8) |

[†] Data from studies undertaken by ARS, Reno soils lab using similar analytical proctocols to the present study. Standard errors in parentheses.

Support dog, Herman, moving fence posts.