

2012 Investigator's Annual Report

Alien Invasion: Effects of Atmospheric Nitrogen Deposition on Sagebrush Steppe Vegetation Dynamics at Upper Columbia Basin Network Parks PMIS # 144709

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The objectives of this research are to measure wet and dry deposition of nitrogen (N) in UCBN Parks (CRMO, HAFO, CIRO, and MIIN), as well as measure soil and plant N concentrations, sample native and invasive vegetation to determine the relationships between N deposition and vegetation-type conversion, and use MODIS imagery to further test the relationship between vegetation change and N deposition.

During the third year of this project we analyzed the ambient passive samplers and concluded measuring bulk deposition of N using resin columns in both open and throughfall samplers. The modifications we made to the bulk deposition samplers in June 2011 were effective in reduced bird contamination during the two six-month exposure periods, June 2011 to November 2011 and November 2011 to June 2012, but some sites still had high contamination in the interspace sites. Vegetation survey data from 2009 and 2010 was downloaded from HAFO and CRMO and compared with the CMAQ modeled deposition gradient. *Artemisia tridentata* leaf tissue collected in 2010 from each site where deposition was measured was measured for % leaf N and leaf N $\delta^{15}\text{N}$.

The data collected from passive samplers deployed across the study area in 2010/2011 indicate that NH_3 is the dominant atmospheric contaminant present. The highest concentrations of NH_3 occurred during the summer months and remained high across many sites bordering the Snake River Plains (Figure 1). Based on Kriging Analysis in ArcGIS, there is a larger land area impacted by high levels of N deposition than was evident based on the CMAQ model (Figure 2). During the winter, the range of high concentration NH_3 zones was reduced, but there were still high levels recorded at the sites near the high urbanization zones surrounding Twin Falls. Due to dominant wind patterns and geographic features, the pollution originating from the plains does not travel down towards City of Rocks National Monument or the northern end of Craters of the Moon National Monument.

All throughfall resin samples have been extracted and analyzed for NO_3^- , NH_4^+ , PO_4^+ , and SO_4^- . Open air deposition values are incomplete across the gradient due a large amount of bird contamination in the resin collectors. The alterations made to the collectors in spring 2011 removed the majority of bird contamination, but there was still some contamination (based on PO_4^+ levels) at the sites where high ambient NH_3 was measured. Although, annual open-air bulk deposition ($\text{kg ha}^{-1} \text{ yr}^{-1}$) was positively correlated with yearly mean ambient NH_3 concentrations at sites where the bulk deposition collectors were not contaminated ($r^2=0.901$, $p<0.005$) (Figure 4). Using the regression equation to convert ambient concentrations to annual deposition values indicates that the high sites may have deposition levels as high as $8\text{-}9 \text{ kg ha}^{-1} \text{ yr}^{-1}$ (Table 1), exceeding modeled values by 48%.

The data from the NPS was a broad scale survey that only recorded the vegetation class of plants at each site. Due to this, responses to diversity and richness across the gradient could not be measured. Using data gathered from past NPS projects we have noted increases in the presence of invasive grass and forbs at sites with increasing N deposition (Figure 5). The most

common annual grass at these sites is *Bromus tectorum*, suggesting that the increase in nitrogen inputs to the site leads to an increase in invasive grass cover. Concurrently the cover of shrubs and bunch grasses decreased at these same sites with increasing N deposition (Figure 6). Bunch grasses in this area tend to be native, suggesting there is a loss of native cover at these sites with a concomitant increase of invasive species. Overlap between vegetation and N deposition data was limited to CRMO and HAFO. Sites were not compared by previous land use.

The amount of N in *Artimisia tridentata* leaf tissue increased as deposition increased (Figure 7A). The increase in the amount of N in the soil provides a larger pool of for *A. tridentata* to uptake. The leaf tissue $\delta^{15}\text{N}$ was more enriched as average NH_3 increased (Figure 7B). The leaf $\delta^{15}\text{N}$ of vegetation is controlled by the pools of nitrogen that it assimilates in its roots. The variability of leaf $\delta^{15}\text{N}$ decreases at higher deposition sites suggesting that there is a more homogenous pool of available nitrogen due to increased deposition.

Remaining analyses to be run include extractable soil NO_3^- and NH_4^+ as well as total C and N.

Funds expended in FY09: \$31457 of a total \$33566

Funds received for FY10 and FY11: \$36176 plus \$30258

Total funds awarded: \$100000 (10/09-9/12)

Figures:

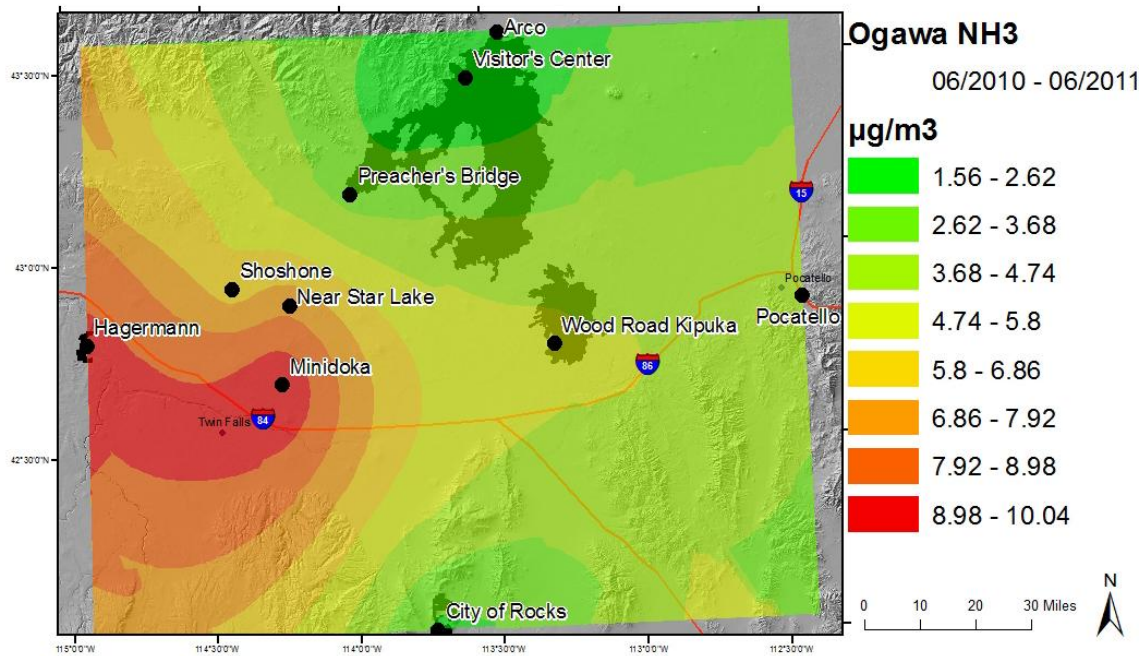


Figure 1. Mean concentration of ambient NH₃ across the study area based on the average of six 2-week exposure periods between June 2010 and June 2011.

CMAQ 12km resolution model of NH₄ deposition in southern Idaho

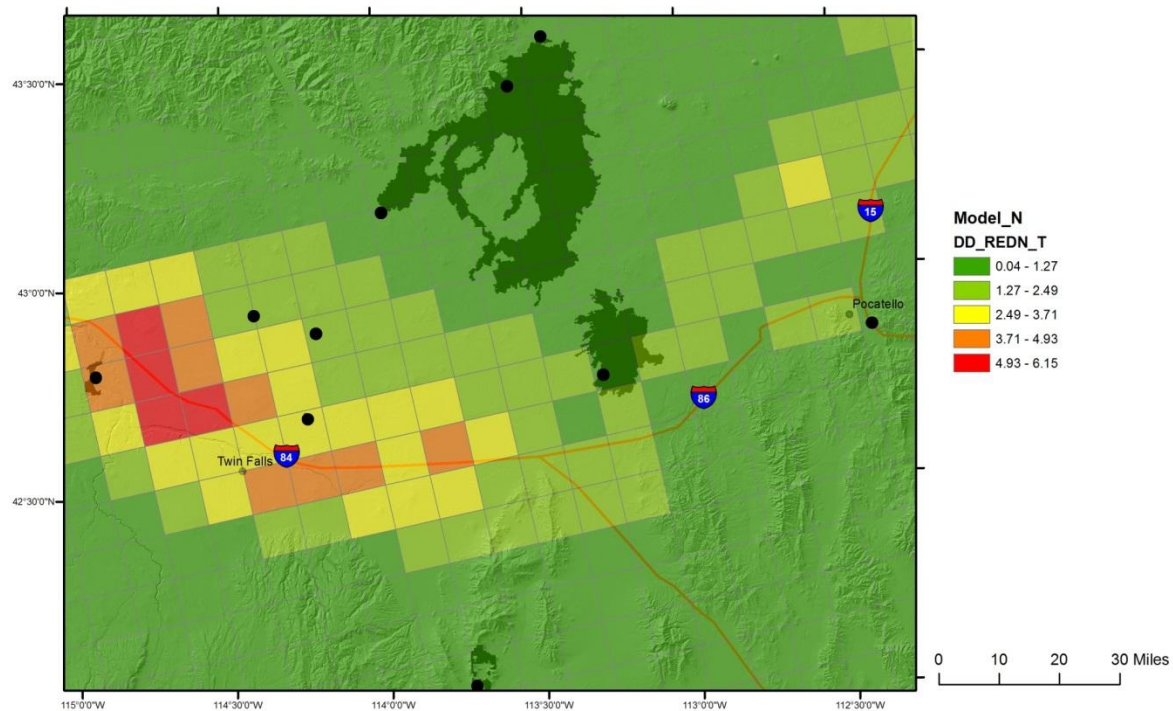


Figure 2. CMAQ modeled deposition of NH₄⁺-N over the study region.

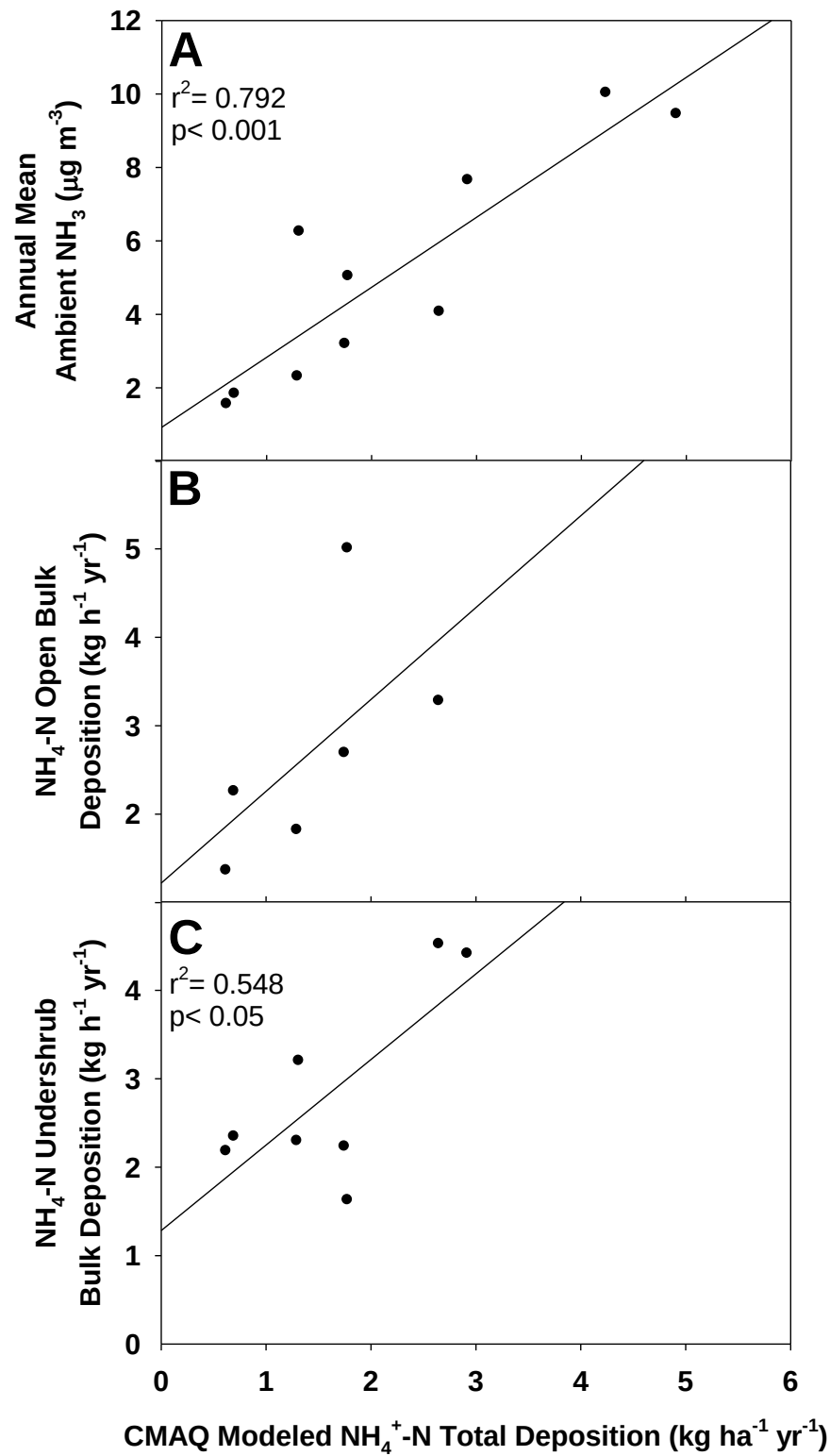


Figure 3. Relationship between 12km resolution CMAQ modeled wet + dry $\text{NH}_4^+\text{-N}$ deposition and (A) ambient NH_3 Concentration, (B) Bulk deposition in open areas, and (C) bulk deposition measured under shrubs.

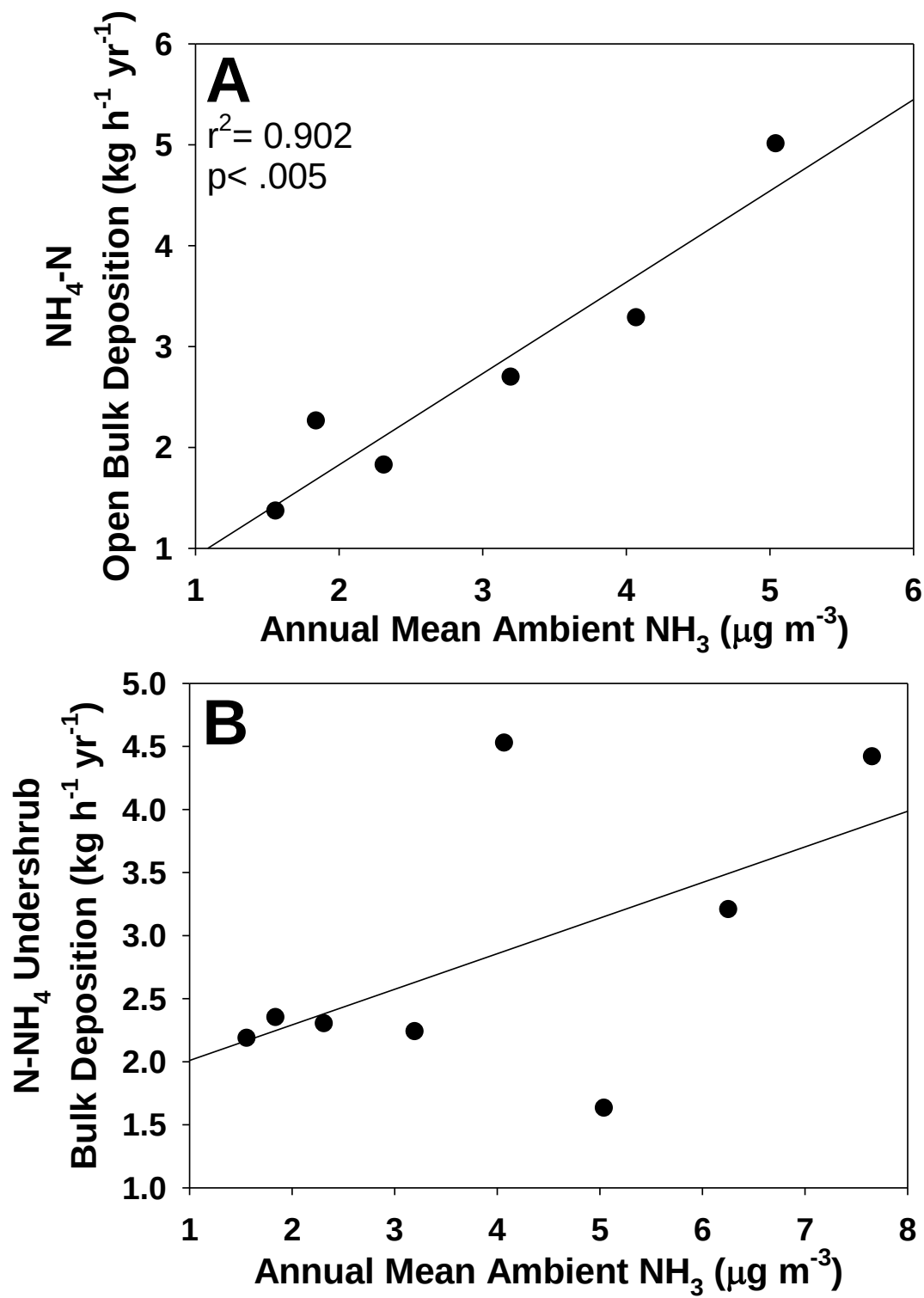


Figure 4. There is a positive linear relationship between mean annual ambient NH_3 concentration and annual NH_4^+ -N deposition to open air IER-collectors (A). There is a positive, non significant trend between annual ambient NH_3 concentration and undershrub bulk deposition of NH_4^+ -N (B).

Site	Annual Open Deposition $\text{NH}_4^+\text{-N}$ Deposition ($\text{kg h}^{-1} \text{yr}^{-1}$)	Annual Undershrub $\text{NH}_4^+\text{-N}$ Deposition ($\text{kg h}^{-1} \text{yr}^{-1}$)	Annual Mean Ambient NH_3 ($\mu\text{g m}^{-3}$)	Estimated $\text{NH}_4^+\text{-N}$ Deposition ($\text{kg h}^{-1} \text{yr}^{-1}$)
Arco	1.37	2.18	1.56	1.43
City of Rocks	1.82	2.30	2.32	2.11
Hagermann	<i>Contaminated</i>	<i>Contaminated</i>	9.46	8.58
Minidoka	<i>Contaminated</i>	<i>Contaminated</i>	10.04	9.10
Pocatello	3.28	4.52	4.07	3.70
Preacher's Bridge	2.69	2.24	3.20	2.91
Shoshone	<i>Contaminated</i>	3.20	6.26	5.68
Star Lake	<i>Contaminated</i>	4.42	7.66	6.95
CRMO Visitor's Center	2.26	2.35	1.84	1.69
Wood Road Kipuka	5.01	1.63	5.04	4.58

Table 1. Annual measured open and undershrub bulk deposition, ambient NH_3 concentration, and calculated annual deposition using the regression equation from Figure 4. The deposition N-NH_4^+ values are from IER-based measurements and the ambient NH_3 are from passive samplers. Four of the bulk deposition sites had samples that were contaminated by bird activity.

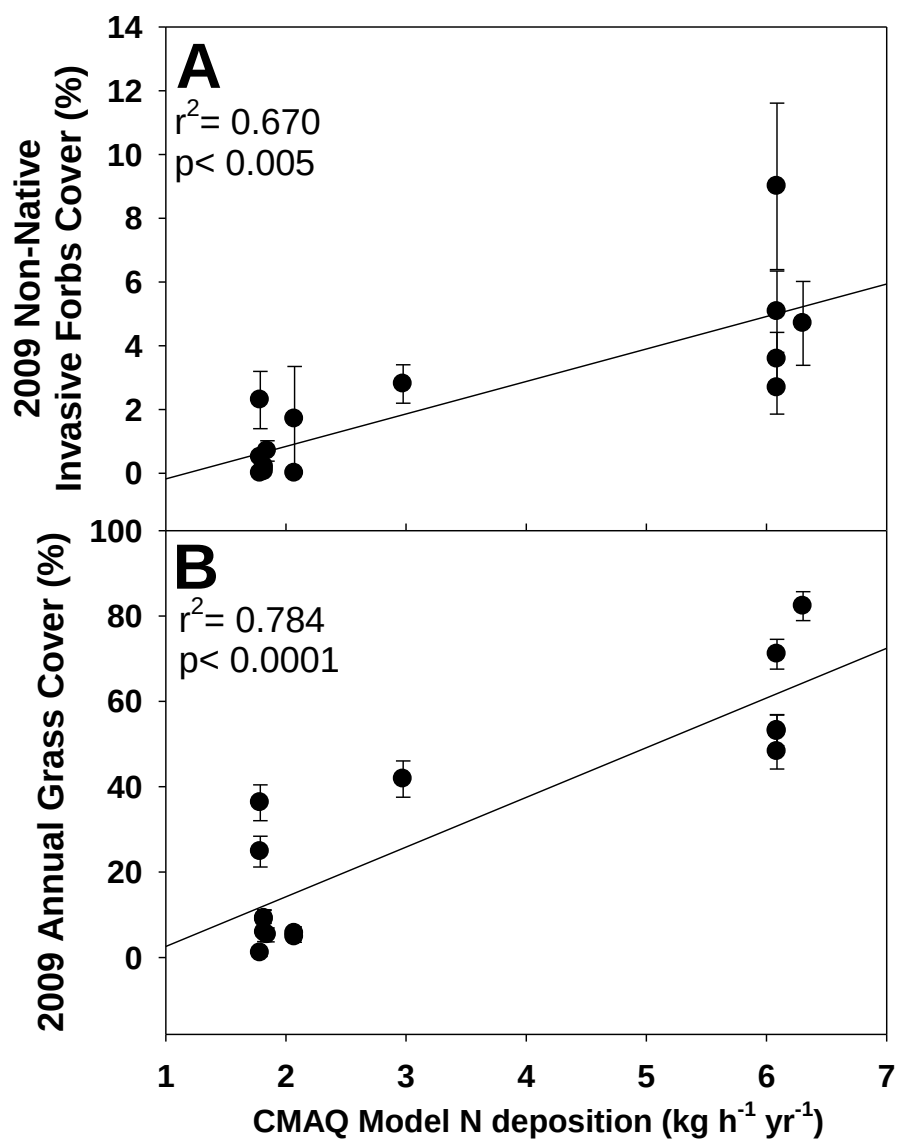


Figure 5. As nitrogen deposition increases across the gradient, the total cover of Exotic invasive forbs (A) and annual grasses increase (B).

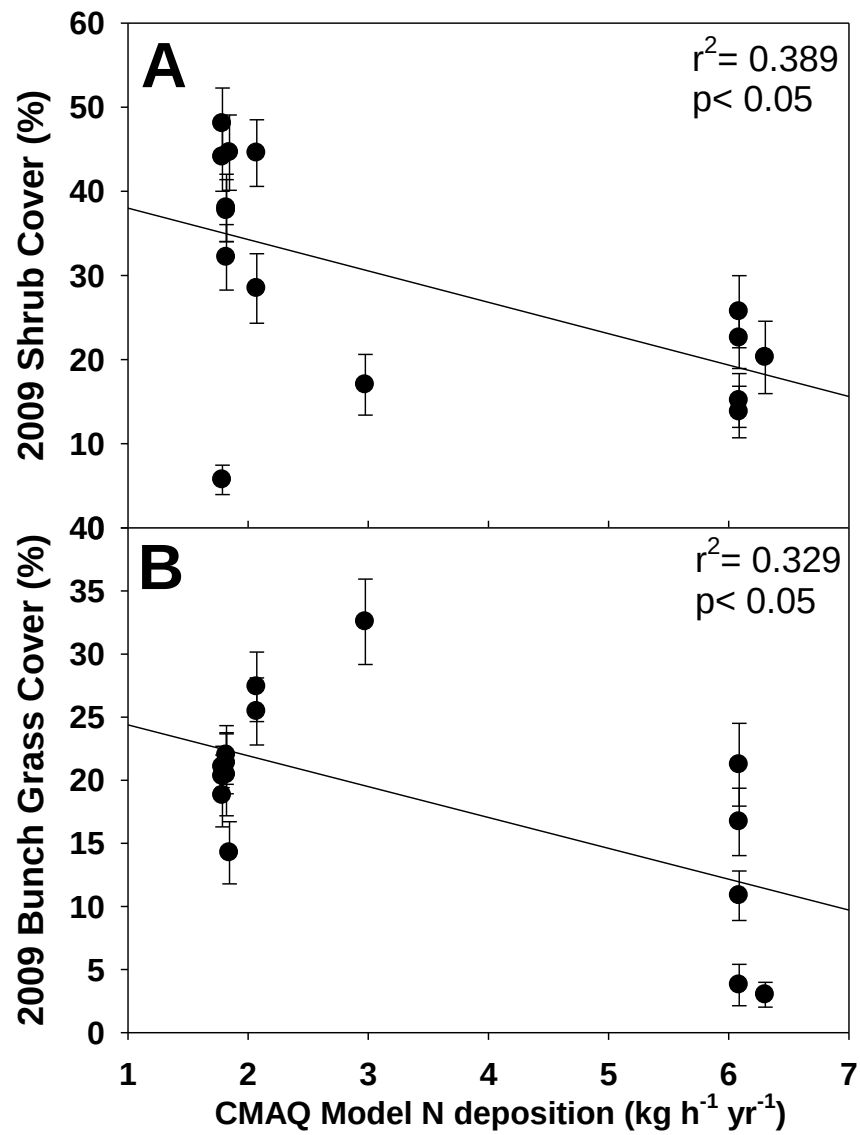


Figure 6. As nitrogen inputs to the soil increase across the gradient, shrub cover (A) and bunch grass cover both decrease.

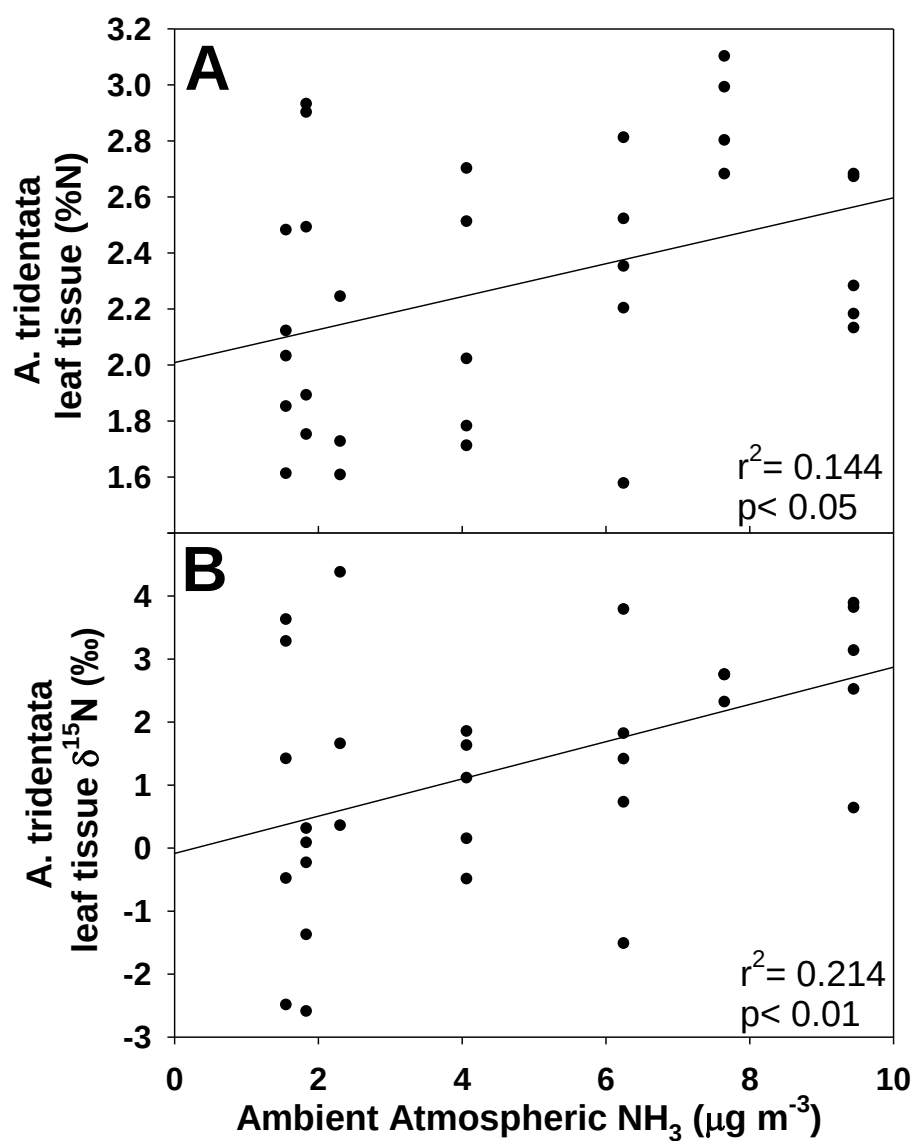


Figure 7. *Artemisia tridentata* leaf tissue N (A) and leaf tissue $\delta^{15}\text{N}$ (B) both increase with exposure to an increasing amount of atmospheric NH_3 .