Project Summary
Rocky Mountains Cooperative Ecosystem Studies Unit

Project Title: Plant Community and Soil Nitrogen Responses to Nitrogen Deposition in Two Northern Great Plains National Parks

Discipline: Natural
Type of Project: Research
Funding Agency: National Park Service
Other Partners/Cooperators: Colorado State University
Effective Dates: 9/20/2008 – 8/1/2013
Funding Amount: $130,200 (FY11: $20,200; FY08: $110,000)

Investigators and Agency Representative:
NPS Contact: Tamara Blett, NPS ARD, PO Box 25287, Denver CO 80225, 303-969-2011, Tamara_blett@nps.gov

Investigator: Alan K. Knapp, Department of Biology, Colorado State University, Fort Collins, CO 80523, 970 491-7010, aknapp@colostate.edu

Researcher: Amy Symstad, U.S. Geological Survey, Northern Prairie Wildlife Research Center Black, Hills Station , Wind Cave National Park , 26611 U.S. Highway 385 , Hot Springs, SD 57747 , 605-745-1191, asymstad@usgs.gov

Project Abstract:
Problem Statement:
The National Park Service (NPS) has an affirmative responsibility under the Clean Air Act Amendments of 1977 to prevent significant deterioration to air quality related values (AQRV) in Class 1 parks, including Badlands NP and Wind Cave NP. This project will help to determine the effects of nitrogen (N) deposition on a variety of vegetation types in these two northern Great Plains parks. These two parks are located relatively close to each other and are expected to experience relatively similar N deposition in the future. However, soil types and vegetation composition differences between the two parks suggest that ecological responses to increased N deposition could be quite different between the two. Nitrogen fertilization experiments in other grasslands suggest that it is reasonable to expect that primary production, species richness, and/or abundance of invasive exotic species will serve as important response metrics to monitor to assess the impacts of air quality changes. The results of this project will begin to define the dose-response of northern Great Plains grassland vegetation and soils to inorganic N. This will provide mechanistic insight necessary for interpreting trends in plant community composition measured by the NPS Vital Signs Monitoring Program with respect to changing air quality, as well as provide critical information needed to inform policy decisions on air quality emission levels in the region.

Background:
Until recently, the northern Great Plains have been recognized for their clean air. Low industrialization rates in the region have maintained low levels of atmospheric pollutants such as particulate matter, nitrogen (ammonium and nitrate), sulfur, and ozone. For example, current nitrogen deposition rates at Wind Cave National Park (southwestern South Dakota) are only 3.0-3.5 kg $ha^{-1}yr^{-1}$, as estimated from NADP and CASTNet data. This does not include gaseous NH_3 or organic N, which are unknown but likely to be low in this region. However, recent surges in coal mining, coal-bed methane and oil drilling, and construction of coal-burning power plants in the region threaten this clean air. In fact, three of the ten national parks most threatened by coal-fired power plants currently being developed are in the northern Great Plains (Baxter et al. 2008). Six power plants, which could emit 7,843 tons of nitrogen oxides (NO_x) per year, are proposed for construction within 300 km of Badlands and Wind Cave National Parks. One large power plant that could emit 2,286 tons of NO_x per year is proposed for construction just 90 km from Theodore Roosevelt National Park (Baxter et al. 2008). Although the soils in most of the region buffer vegetation resources from the detrimental effects of acid deposition associated with sulfur and nitrogen (Fenn et al. 2003), effects of nitrogen fertilization on the diversity and composition of the native prairie communities that dominate the vegetation in NPS units and surrounding lands could be substantial..

Nitrogen fertilization experiments in other grasslands of North America have shown significant decreases in species richness from fertilization rates as low as 12 kg N $ha^{-1}yr^{-1}$ above natural deposition rates (Piper et al. 2005; Suding et al. 2005; Clark and Tilman 2008). N-induced changes in composition include shifts in warm:cool season grass ratios (Samuel and Hart 1998), reductions in legume cover (Piper et al. 2005), expansion of forest into grassland (Kochy and Wilson 2001) and sometimes drastic increases in invasive species abundance (Schwinning et al. 2005). Experimental nitrogen addition of 45 kg N $ha^{-1}yr^{-1}$ led to a 20-fold increase in the biomass of an invasive species in badlands sparse vegetation at Badlands National Park (Van Riper 2005). Nitrogen fertilization

has also been shown to accelerate the onset of water stress in two native grasses (Schwinning et al. 2005) and to affect N cycling and retention, as well as ecosystem carbon storage (e.g., Wedin and Tilman 1996).

Predicting future N deposition rates is difficult because of uncertainty about the extent and intensity of future energy development in the northern Great Plains. The effects of potentially higher deposition on the vegetation in national parks in the region are even more difficult to predict because little information about the response of plant communities in the northern Great Plains exists. Extrapolation from experiments in other regions and vegetation types is unwise, as responses and the mechanisms behind them vary widely among environments (Suding et al. 2005; Clark et al. 2007). In northern Great Plains grasslands, this variability is likely to occur between areas of higher and lower natural productivity, as determined by soil types (e.g., Mollisols with relatively high organic material content on grassy bluffs *versus* undeveloped badlands material not even classified as soil at Badlands NP) and slope position (deeper, moister soils at slope bottoms *versus* thin-soiled, rocky hilltops). Variability in the vegetation responses to nitrogen deposition is also likely to occur in response to seasonal growing conditions (i.e., precipitation), as water and nitrogen appear to be co-limiting factors to vegetation growth in semi-arid regions such as the northern Great Plains (Hooper and Johnson 1999).

Any impacts of increased N deposition on plant community diversity and composition are likely to affect other components of grassland ecosystems, including forage quality and quantity for native ungulates and other herbivores, floral resources for pollinators, and nutrient concentrations in surface and ground waters. Thus, information on the effects of various rates of nitrogen deposition on northern Great Plains vegetation must be derived locally and soon.

Objectives

1. Experimentally investigate the effects of nitrogen fertilization on plant composition, diversity, and productivity and soil potential N mineralization (i.e., microbial activity) in a variety of herbaceous vegetation types in two northern Great Plains NPS units.
2. Determine N_{crit} for plant composition, diversity, and potential N mineralization in these vegetation types; N_{crit} is the atmospheric nitrogen deposition rate above which a parameter is significantly impacted (Porter et al. 2005).
3. Evaluate differences in these effects and levels between normal and high precipitation conditions.

The results from this work will be complementary and integral for interpreting trends in Vital Signs vegetation monitoring data.

Outcomes with Completion Dates:

List of Products:

a. Data in format compatible with NGPN data management structure.
b. Annual accomplishment reports
c. Final report in form of USGS technical report
d. One or more publications in peer-reviewed journal(s) for widespread dissemination

Due Date for Final Report and/or Project Deliverables: July 1, 2013

Keywords: Nitrogen fertilization, air quality, Great Plains grassland vegetation, Wind Cave National Park , Badlands National Park, Colorado State University