Project Summary
Rocky Mountains Cooperative Ecosystem Studies Unit

Project Title: Measurement of Nitrogen and CO_2 Production from Seasonally Frozen Alpine Tundra Soils

Discipline: Natural
Type of Project: Research
Funding Agency: National Park Service
Other Partners/Cooperators: Metropolitan State College of Denver
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Investigators and Agency Representative:
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Project Abstract: Human activities have more than doubled amount of nitrogen in the biosphere. Precipitation in the Green Lakes Valley and nearby Niwot Ridge have shown an increase since 1967, which corresponds with a doubling of inorganic nitrogen deposition (Williams *et al.*, 2002). In high deposition lakes in Rocky Mountain National Park, this has resulted in enhanced phytoplankton growth such that phosphorous has become the limiting variable (Elser *et al.*, 2009). According to algal chlorins in Sky Pond, Colorado, a substantial shift in nitrogen cycling has occurred over the past 60 years because of development along the Front Range corridor (Enders *et al.*, 2008). In Rocky Mountain National Park, it appears a threshold has been crossed (Baron *et al.,* 2009). In the Loch Vale watershed, mean wet nitrogen deposition has not increased, but mean annual net export has increased, suggesting that melting ice in glaciers and rock glaciers has exposed sediments from which nitrogen can be flushed (Baron *et al.,* 2009).

The Colorado Front Range is a dynamic system in which anthropogenic inputs can be transported and redistributed from terrestrial to aquatic ecosystems to alter ecosystem health (Hood *et al.*, 2005; Seastedt *et al.*, 2004). In particular, nitrogen deposition has acidified soils through leaching of basic cations. With a reduced pH, increased availability of elements toxic to plants have reduced plant biodiversity (Bowman *et al.*, 2008). In the mountain west, modeling results indicate that the most sensitive lakes to acidic deposition are in Rocky Mountain National Park and Grand Teton National Park (Nanus *et al.*, 2009). The concentration of inorganic nitrogen in snowpack is high, is converted by biological and geochemical reactions, and is released as an ionic pulse (Williams *et al.*, 2009). As a result, water quality remains an issue because water stored in mountains often supply drinking water to nearby urban areas (Ley *et al.*, 2004). It is important to determine areas of significant nitrogen production in seasonally frozen alpine soils. As a soil which was previously frozen thaws from a warming climate, new locations for microbial activity are exposed, increasing the potential for nitrogen transport to alpine lakes and streams. In addition, species can be affected by additional nitrogen input, causing grasses or other sedge species to outcompete other species, potentially reducing tundra species diversity or reducing stunning summer blooms that are unique to Rocky Mountain National Park. Increased nitrogen deposition might also cause plants to grow more, which would initially remove some carbon from the atmosphere, but in the long term, it also could cause soils to lose more of their carbon, adding CO_2 to the atmosphere.

Arctic permafrost soils contain nearly twice as much carbon as the atmosphere. When these soils thaw, large quantities of carbon are lost, mainly in the form of methane and carbon dioxide through decomposition (Lee *et al.*, 2010; Maslin *et al.*, 2010). Alpine tundra shows lower total carbon dioxide uptake over shorter periods compared to forested sites; however, alpine tundra has greater total respiration over longer periods (Blanken *et al.*, 2009). According to Waldrop *et al.* (2010), respiration is higher in permafrost soils compared to active layer soils; this

suggests that a positive feedback to warming exists. Findings in Siberia, Alaska, and northern Sweden imply that soil carbon that was once stored in deep permafrost is being released (Kuhry *et al.* 2010). According to climatic data from Europe and Western US, an increase in moisture availability has resulted in a six-fold increase in carbon dioxide respiration, despite only a 0.3 to 0.5° C temperature increase (Monson *et al.*, 2006). Recently, permafrost soils have also been shown to release nitrous oxides (Elberling *et al.*, 2010). Helmig *et al.* (2009) found that nitrogen oxide concentrations were highest at the bottom of the snowpack and experienced an upward flux of nitrogen oxide, which suggests that subnival soils are the origin.

This study will provide a seasonal analysis of greenhouse gas production from high elevation sites. It is important to assess potential impacts of a changing climate on the tundra ecosystem. Excess nitrogen can affect species diversity and abundance as well as tundra blooms, an important Visitor attraction which makes Rocky Mountain National Park unique. Additional carbon released from previously frozen alpine soils is an unaccounted source of CO_2 which could enhance the effects of warming in the alpine.

The objectives of this project are as follows:

1. Determine seasonal production of Nitrogen (in the form of Nitrite, Nitrate, and Ammonia) and CO_2 from high elevation soils;
2. Evaluate the effects of soil type, soil temperature, soil moisture, and site location on rates of Nitrogen and CO_2 production;
3. Examine soil microbes which are predominantly found in alpine soils; and
4. Expose underrepresented and underserved MSCD students to hands-on, applied research in order to better prepare them for graduate school or future employment.

Outcomes with Completion Dates: A draft report due Dec. 31, 2011. A final report due February 28, 2012

Keywords: Nitrogen, CO_2, soils, alpine tundra, Rocky Mountain National Park, Metropolitan State College of Denver