National Park Service
U.S. Department of the Interior

Rocky Mountain National Park
Continental Divide Research Learning Center

Trees Respond to Nitrogen Deposition

The Question: Has nitrogen deposition from air pollution affected the biogeochemistry of Colorado Front Range high-elevation old-growth Engelmann spruce (*Picea engelmannii*) forests?

As gardeners know supplying nutrients in an unbalanced way may result in a loss of plant health. Trees and other plants need nutrients (e.g., nitrogen) to grow but unnaturally high levels may induce stress upon a tree's protective system. Too much nitrogen can cause trees to grow branches rather than roots, store less food, become structurally weaker, and more prone to insect attack. Adding nitrogen to soil increases soil microbial activity, which leads to greater nitrogen mobility and possible threats to aquatic life such as salamanders and fish. Excess nitrogen beyond that required for plant and microbial growth results in a loss of soil nutrients such as calcium and magnesium. This imbalance can lead to an increase in toxic elements such as aluminum.

Unnaturally high levels of nitrogen may induce stress upon the spruce tree's protective system.

The field of biogeochemistry studies how nutrient matter cycles within ecosystems. The fate of particular elements such as nitrogen has implications for public and environmental health. In this study a research team led by Heather Rueth at Colorado State University explored the response of Engelmann spruce trees to nitrogen deposition, an atmospheric pollutant prevalent on the east side of the Colorado Front Range including Rocky Mountain National Park.

Scientists studied Engelmann spruce trees to assess the effects of nitrogen deposition.

The Project: Compare forests east and west of the Continental Divide.

Due to the proximity of urban and agricultural emission sources, atmospheric nitrogen inputs are higher east of the Continental Divide in north-central Colorado than they are to the west. Thus to evaluate this difference, scientists studied 12 high-elevation, old-growth spruce forest stands, half east and half west of the Continental Divide. Scientists matched stand characteristics such as species composition, elevation, site history, and climate as closely as possible across east- and west-side forests. They collected needles from Engelmann spruce branches and ground them to fine powder in order to compare foliage. They next evaluated needle weight, nitrogen, and other nutrient contents, and along with the underlying soil, they analyzed the needles for percent carbon and nitrogen. Soils were also sampled to determine microbial activity (to assess nitrogen cycling rates) and yearly leaching losses of nitrogen. The investigators then performed statistical tests to determine differences between east and west study sites.

The Results: Nitrogen deposition has caused measurable changes in forests on the east side of the Continental Divide.

Soil and foliar percent nitrogen were significantly higher in the eastern sites as compared to the western sites. Significantly higher nitrogen cycling rates and greater needle weight were found at eastern sites suggesting greater plant nitrogen availability and increased fertilization. These findings show that many biogeochemical factors in east-side Colorado Front Range spruce forests are significantly different than west-side forests. Because the forest characteristics were otherwise comparable, results strongly suggest the differences in tree and soil biogeochemistry are due to nitrogen deposition. East-side Engelmann spruce forests have reached a point where slight changes in the nitrogen balance can be identified. These results indicate that unnatural levels of nitrogen affect even the charismatic megaflora, which suggest implications for not only the aquatic ecosystem but also the terrestrial ecosystem.

This summary is based on published, peer-reviewed and/or unpublished reports available at the time of writing. It is not intended as a statement of park policy or as a definitive account of research results. For more information on the park's research program, see www.nps.gov/romo Written by: Colleen Flanagan Date: March 2006 Updated: January 2008 Photo credit: NPS-RMNP
H.M. Rueth and J.S. Baron. 2002. Differences in Englemann Spruce Forest Biogeochemistry East and West of the Continental Divide in Colorado, USA. Ecosystems *5: 45–57.*