# Nitrogen Dynamics Across Gaps in Young, Thinned Forests of the Density Management Study

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Nitrogen (N) availability in soils plays a critical role in forest productivity, dynamics and development. Variations in N availability have been shown to affect tree growth and structural development, decay and turnover of leaves and woody detritus, diversity of understory and soil microbial communities, and many other factors. Consequently, understanding the spatial and temporal dynamics of N in forest soils can be crucial to understanding forest ecosystems as a whole.

The impacts of traditional silvicultural practices on N dynamics have historically been the subject of intense study. Clearcut forest harvest, for instance, has been shown to increase the production of nitrate ($NO_3^-$), a highly soluble ion, in forest soils. Subsequent N loss through $NO_3^-$ leaching may lead to decreased site productivity and downstream water quality impairment. The potential impacts of modern silvicultural practices on soil N dynamics, as might result during gap creation to restore complex forest structure, remain less well understood.

The following study will investigate the effects of gap creation on litter and soil N dynamics in three young, thinned forests of western Oregon. It will focus on three main questions:

- How do soil pools and cycling of plant-available N vary across gaps and into the adjacent forest matrix?
- Does gap size affect the magnitude of these differences?
- What factors (e.g. quantity and quality of litter input, soil moisture, etc.) can explain N dynamics in silviculturally created gaps?

## METHODS

### *Study Sites*

This study includes three initial thinning sites in the BLM Density Management Study (DMS): Delph Creek, Green Peak and Keel Mountain (Figure 1). Keel Mountain and Green Peak soils developed primarily from sandstone, while Delph Creek soils formed from a mixture of andesite, tuff and volcanic ash.

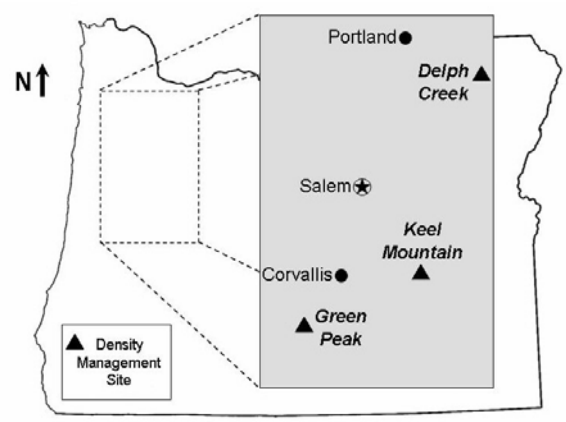


*Figure 1. Map of selected Density Management Study (DMS) sites: Delph Creek, Green Peak, and Keel Mountain*

In all three sites, dominant overstory species are Western hemlock (*Tsuga heterophylla*) and Douglas-fir (*Pseudotsuga menziesii*) and characteristic understory species include sword fern (*Polystichum munitum*), bracken fern (*Pteridium aquilinum*), wood sorrel (*Oxalis oregana*), salal (*Gaultheria shallon*), dwarf Oregon grape (*Mahonia nervosa*) and several *Rubus* species.

At each site, three large gaps (0.4-ha) and three small gaps (0.1-ha) were chosen. Gaps were created between 1997 and 2000 and underplanted with Douglas-fir, western hemlock, grand fir (*Abies grandis*) and western red cedar (*Thuja plicata*) between 2000 and 2001. In most cases, gaps were created in moderate thinning treatments (80 TPA), but some existed in variable thinning treatments (40-120 TPA).

### *Transect Setup*

In each gap, transects were run through the center point and continue 40 m into the forest matrix on each side (Figure 2). In large gaps, nine 10 m x 4 m plots were positioned along the transect: one at the center, two 20 m from the center, two 40 m from the center (at gap edge), two 60 m from the center, and two 80 m from the center. In small gaps, similar plots were placed at seven points along the transect: one at the center, two 20 m from the center (at gap edge), two 40 m from the center, and two 60 m from the center. Efforts were made to maintain a north-south bearing on all transects but may have deviated slightly to avoid roads, riparian areas, neighboring gaps and other obstructions.

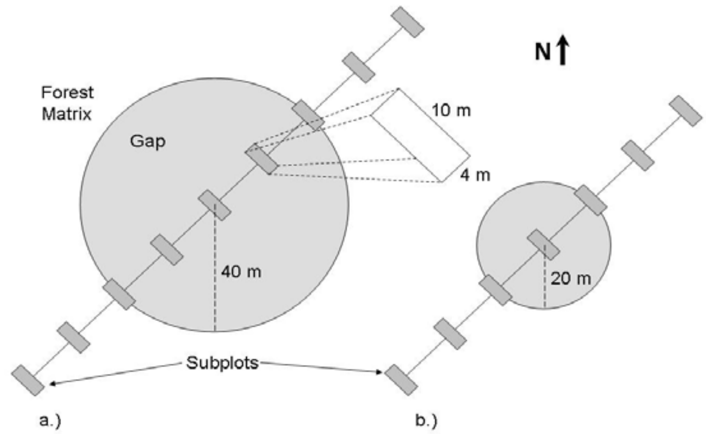


*Figure 2. Transect and subplot layout of a.) large gaps (0.4 ha) and b.) small gaps (0.1 ha)*

### *Field and Laboratory Measurements*

We are performing a series of field- and laboratory-based measures of N dynamics across gap transects. Field measures provide information on how vegetation and microclimate act together to influence N dynamics across gaps. Laboratory measures of soil N availability under controlled conditions will allow us to separate the relative importance of vegetation from microclimate effects on N dynamics. Together, these measures help to assess whether gaps influence N cycling directly by altering soil microclimate, or via more indirect means, such as N recycling between soils and recovering vegetation.

Nitrogen recycling from plants to soils via litterfall is estimated by collection of litter in two 37 cm x 25 cm litter baskets at each plot along gap transects. Litter is dried at 65° C, weighed, and analyzed for total N and carbon (C) on an elemental analyzer. Total C and N pools in forest floor (Oe/Oa horizon) and surface mineral soil (0-10 cm) across transects are being measured, as well as available pools of $NO_3^-$-N and $NH_4^+$-N. Another set of subsamples is fumigated with chloroform prior to extraction to determine the content of C and N in microbial biomass. Net rates of N mineralization (the microbially-mediated conversion of organic N to $NH_4^+$) and nitrification (conversion of $NH_4^+$ to $NO_3^-$) are determined seasonally in the forest floor and soil of each plot using a combination of *in situ* incubations and ion exchange resin bags. For all samplings, a set of forest floor and soil subsamples is dried at 105° C for 48 hours to determine gravimetric moisture content. In addition, relative decomposition rates are being estimated across transects using mass loss of a standardized substrate (wooden tongue depressors).

A lab incubation of forest floor and soil samples collected from each plot is being used to determine N mineralization and nitrification potentials under standardized conditions. Subsamples of forest floor and soil are placed in flasks, left open to the air, maintained at 60% water holding capacity, and incubated for 28 days at 25° C. Comparison of pre- and post-incubation $NH_4^+$ and $NO_3^-$ concentrations is used to determine rates of net N mineralization and nitrification in the absence of plant uptake and microclimate variations that exist across gaps in the field.

### *Data Analyses*

Analysis of variance (ANOVA) will be used to determine statistical differences in N pools, net N mineralization and nitrification rates (both *in situ* and lab-incubated), microbial C and N, soil moisture, and litter inputs between different positions in gaps. ANOVA will also be used to determine if these variables differ at similar positions in large and small gaps. Multiple regression will be used to determine the correlation of microbial C and N, soil moisture, and litter inputs on N pools and net N mineralization and nitrification rates. Overall, these analyses seek to determine what patterns of N dynamics result from gap creation, and the potential drivers of these patterns, relative to intact matrix forest.

## STUDY TIMELINE

Litter inputs and decomposition rates were assessed from November 2005 to November 2006. N pools, soil moisture, and microbial C and N of forest floor and soil were measured in January, May, and August 2006 to coincide with the beginning of three 28-day *in situ* incubation events. Ion exchange resins were incubated beneath the forest floor and in the surface mineral soil from November 2005 to November 2006. Lab incubations of the upper mineral soil were carried out in August 2006. Data analysis is currently in progress.

The Cooperative Forest Ecosystem Research (CFER) program was developed to facilitate sound management of forest ecosystems, with emphasis on meeting priority research information needs of the Bureau of Land Management (BLM) and the Oregon Department of Forestry (ODF) in Western Oregon.

The information contained in this document is preliminary in nature and has not been peer-reviewed. The data are not guaranteed to be correct or complete. Users are cautioned to consider carefully the provisional nature of the information.

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Program cooperators include: