Soil nitrogen turnover and release 25 & 50 years after harvesting subalpine forests in the Rocky Mountains of central Colorado

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Overview

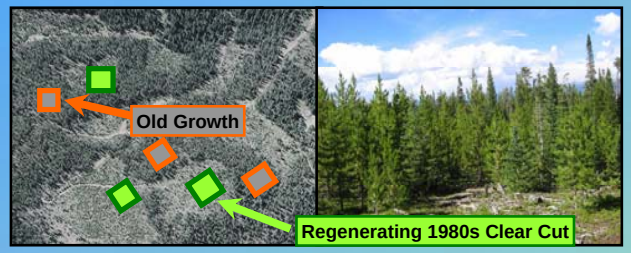
Removal of subalpine forest canopy increases snow accumulation, shallow subsurface flow and nutrient export from high-elevation watersheds. In the central Colorado Rockies, augmented streamflow and subsurface nitrogen (N) export continue for at least 50 and 20 years, respectively, following two separate clear cut harvests. Few studies have measured the long-term effects of forest harvesting on the biogeochemical processes responsible for watershed-scale N dynamics. This study quantifies soil N pools, turnover and release from two catchments where harvesting was conducted in the mid 1950s and early 1980s as part of paired watershed research at the Fraser Experimental Forest.

Our findings indicate that in high-elevation forests, the soil processes that control nitrate production and release remain significantly altered 25 years after harvesting and like other ecosystem properties may require a half century to recover from canopy removal.

Study Site

The Fool Creek Watershed, USFS Fraser Experimental Forest (elevation 3000 - 3500 m). Between 1954 & 1956, half the basal area was removed from the forested portion of the basin leaving alternating clear-cut and leave strips. Openings ranged from 20 to 100 m (1 to 6 tree heights) in width by about 150 m.

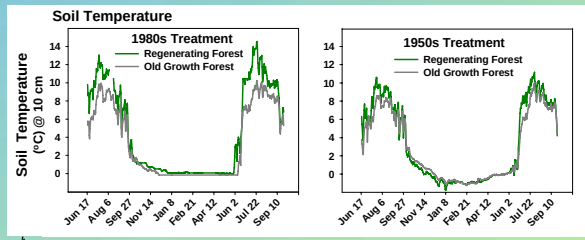
- Our study sites are located in the Fool Creek and Deadhorse watersheds at the USDA Forest Service, Fraser Experimental Forest near Granby, Colorado. The Fraser Experimental Forest is on the western edge of the Front Range of the Colorado Rockies and contains 9,300 ha of subalpine and alpine ecosystems.
- Average annual precipitation is ~ 600mm/ yr (~2/3 as snow), MAT is 0.5ºC. The overstory consists of Englemann spruce (*Picea englemannii*), subalpine fir (*Abies lasiocarpa*) and lodgepole pine (*Pinus contorta*). Portions of both watersheds extend above treeline.
- In the early 1980's, approximately 30% of the upper basin of Deadhorse Creek was harvested in irregular shaped clearcuts. Clearcuts ranged in size from 1 to 5 ha.



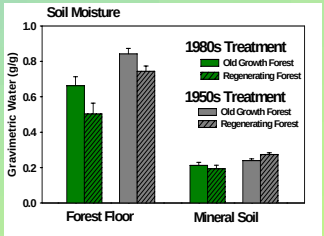
Sampling was conducted in Fool Creek and Deadhorse Creek (mid 1950s & 1980s harvests, respectively) in 5 paired Old Growth forest and regenerating clear cut plots (30 x 30m) per study watershed.

Plant available inorganic soil nitrogen pools and net N production were estimated using ion exchange resin bags (IER) and *in situ* net mineralization & nitrification assays.

Mixed anion and cation resin bags collected nitrate and ammonium percolating through forest floor and the upper 10 cm of mineral soil. Soil was incubated in closed-top PVC cores during 3 sequential monthly growing season periods followed by a nine month overwinter incubation. Total mineral soil, forest floor, shrub layer and overstory N and C pools have been sampled and will be reported following analysis.

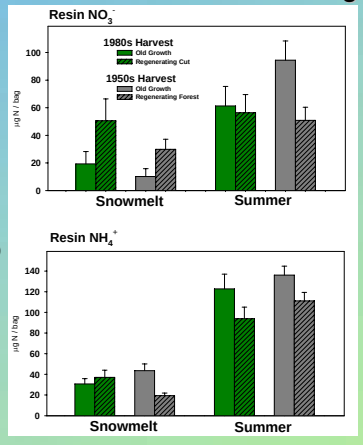


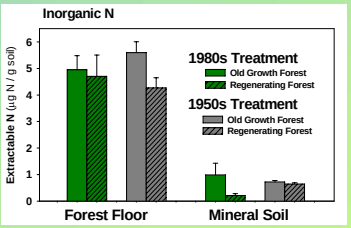
- Growing season soil temperature (10cm) averaged 1 & 2 degrees warmer in regenerating compared to old growth forests for the 1950s & 1980s harvest treatments respectively.
- Soil temperature under winter snow pack were not significantly different between regenerating and old growth forests for either harvest treatment.

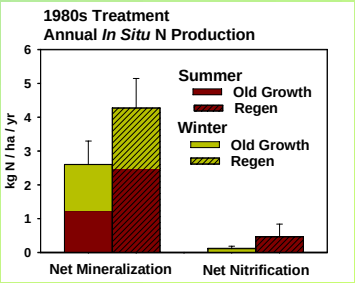


- The forest floor in harvested stands was significantly drier (10 - 20%) than adjacent old growth.
- Gravimetric water in the top 10 cm of mineral soil did not differ for the 1980s treatment areas, but was lower in the older cuts.

Nitrogen Dynamics







Resin N

- In 25-year-old harvest areas, there was 1.7–fold more total IER-N released during spring snowmelt compared to adjacent uncut stands.
- In both age harvests, snowmelt nitrate was more than double and the proportion of total IER-N moving as nitrate was greater.
- Ammonium was lower in both age regenerating harvest areas during summer months.
- In the 50 year-old harvest areas, decreased ammonium offsets the increase in nitrate-N percolating in snowmelt.

Extractable Inorganic N

- Mineral soil in the forest regenerating from the 1980s harvests had 21% the extractable N of adjacent unharvested areas.
- Forest floor contained five times more extractable N (NH_4 + NO_3) than mineral soil, with >95% in the ammonium form. Similarly, N mineralized in forest floor was 5-fold higher than that in mineral soil.

Net N Transformations

- There was 1.7 and 0.3 kg / ha more N mineralized and nitrified annually in the mineral soil of 25-year-old regenerating forest compared to uncut stands. The significant difference occurred during summer months when N turnover in harvested areas was twice that in adjacent old growth.
- N transformations did not differ in 50 year-old stands and adjacent old growth forest in Fool Creek.

Nitrogen Export

- Combined with greater snowpack and subsurface flow in regenerating Fool Creek and Deadhorse stands, higher N movement (25 & 50 yr stands) and nitrate production (25 yr stands) indicate the potential for elevated watershed N export for half a century after subalpine forest harvest.