

# Landscape-scale patterns in N biogeochemistry of high-elevation watersheds



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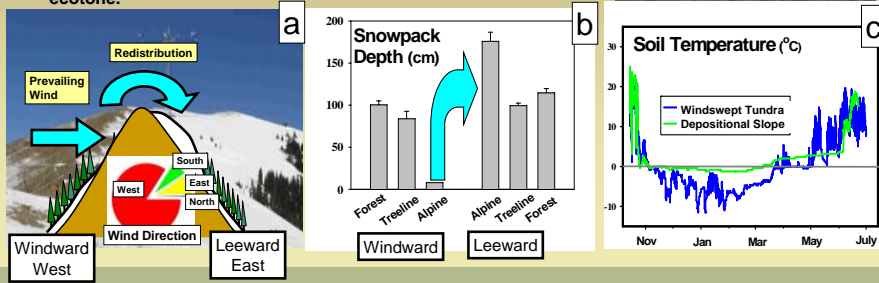
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## Alpine Landscape Patterns

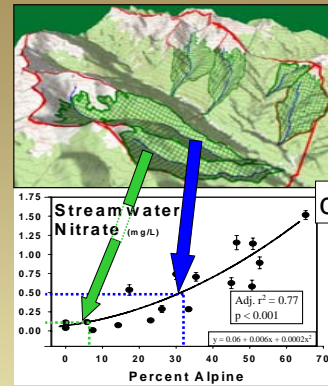
Removal of snow from windward slopes exposes these landscapes to colder wintertime soil temperatures & higher frequency of freeze-thaw events (a).

In contrast, increased snow accumulation on leeward slopes (b) dampens subnivean temperature fluctuations (c) and maintains adequate conditions to sustain wintertime soil microbial activity.

Our preliminary work on alpine ecosystems at the Fraser Experimental Forest in central Colorado indicates that nitrogen dynamics & the soil chemical environment differ between windswept & leeward alpine slopes & across the alpine-subalpine ecotone.

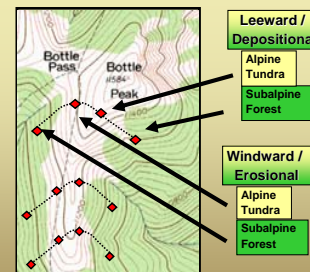


## Alpine Biogeochemistry Influences Watershed N Export



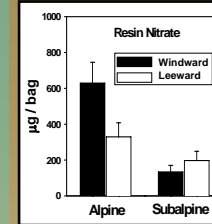
The strong relationship between streamwater inorganic N & alpine cover in Fraser watersheds (d) demonstrates the importance of alpine biogeochemistry on watershed N export.

It is unclear to what extent landscape-scale variability in snow accumulation & soil development contribute to this pattern.



This project samples transects on 3 ridges in central Colorado where treeline occurs from 3340 - 3630 m.

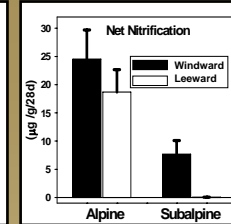
## Soil Processes



As expected, resin-available nitrate is higher in the alpine.

More interestingly, windward & leeward alpine soils differ by about 100%.

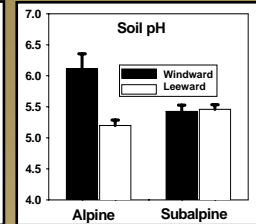
Similar vegetation occurs on both aspects, so it appears that differences originate from factors controlling nitrate production or leaching.



When incubated at constant moisture & temperature alpine topography had little effect on nitrification.

Substrate supports comparable nitrifier activity on both alpine aspects.

Environmental factors may be more critical than organic matter quality in regulating alpine microbial processes.

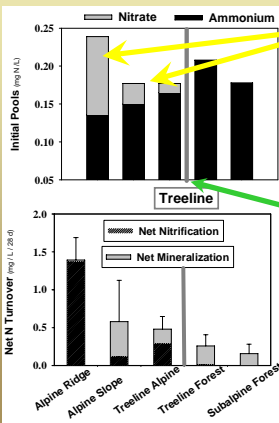


Soil acidity & nitrate display similar patterns, possibly indicating a shift in relative importance of physical vs. chemical weathering across the alpine ridge.

Physical processes, such as cryoturbation, consume H<sup>+</sup> & may buffer against increased acidification.

In contrast, on leeward & subalpine slopes, greater organic acids from litter combined with increased snowpack & soil moisture to favor chemical weathering & lower pH.

## Treeline Patterns



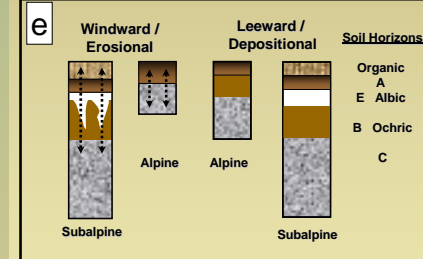
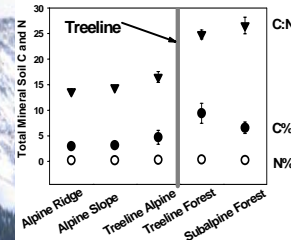
Within the alpine landscape, windblown areas differ from depositional areas

## Treeline

Soil nitrate & nitrification decline abruptly below treeline

Treeline differences in N dynamics relate to the :

- Short alpine growing season & low plant N demand
- Weakly-developed alpine soils & limited residence time of snowmelt within groundwater flow paths
- Tundra v.s. forest differences in litter & soil organic matter quality



Hypothetical model (e) of high-elevation soil development on windward & leeward aspects.

Cryoturbation (dashed arrows) occurs more frequently on windswept slopes resulting in poorly-defined horizons.

On leeward sites with persistent snowpack, combined chemical & physical weathering result in more distinct soil horizons.

## Pedogenic Links

This on-going study will characterize the distinct biogeochemical & pedological conditions within alpine landscapes & across the treeline ecotone in order to explain patterns of watershed N export & improve predictions regarding the impact of climate change on watershed processes.