N Deposition Effects on Vegetation and Soils in Alpine Ecosystems

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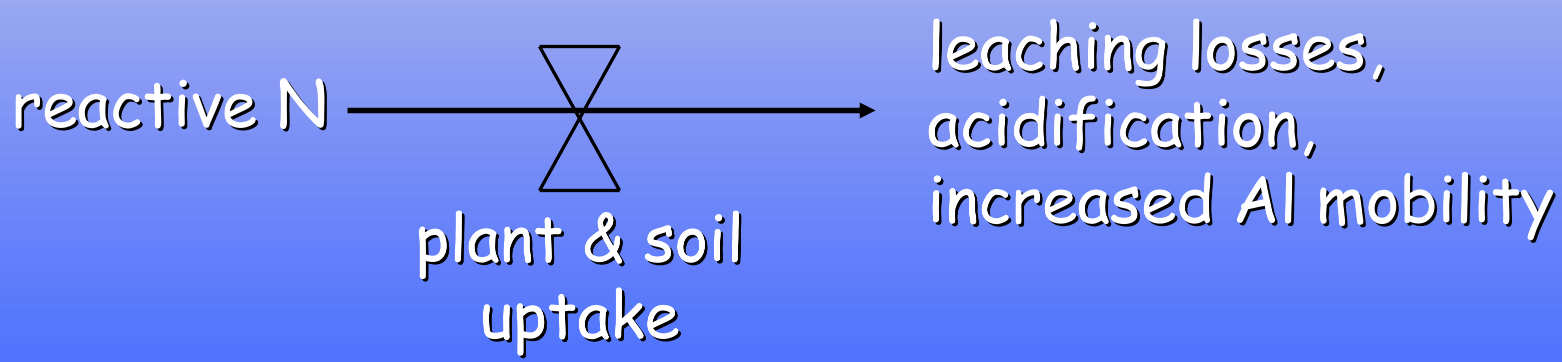
thanks to Cory Cleveland, Jill Baron, Lubos Halada, Courtney Meier, Anthony Darrouzet-Nardi

Two "phases" of N deposition:

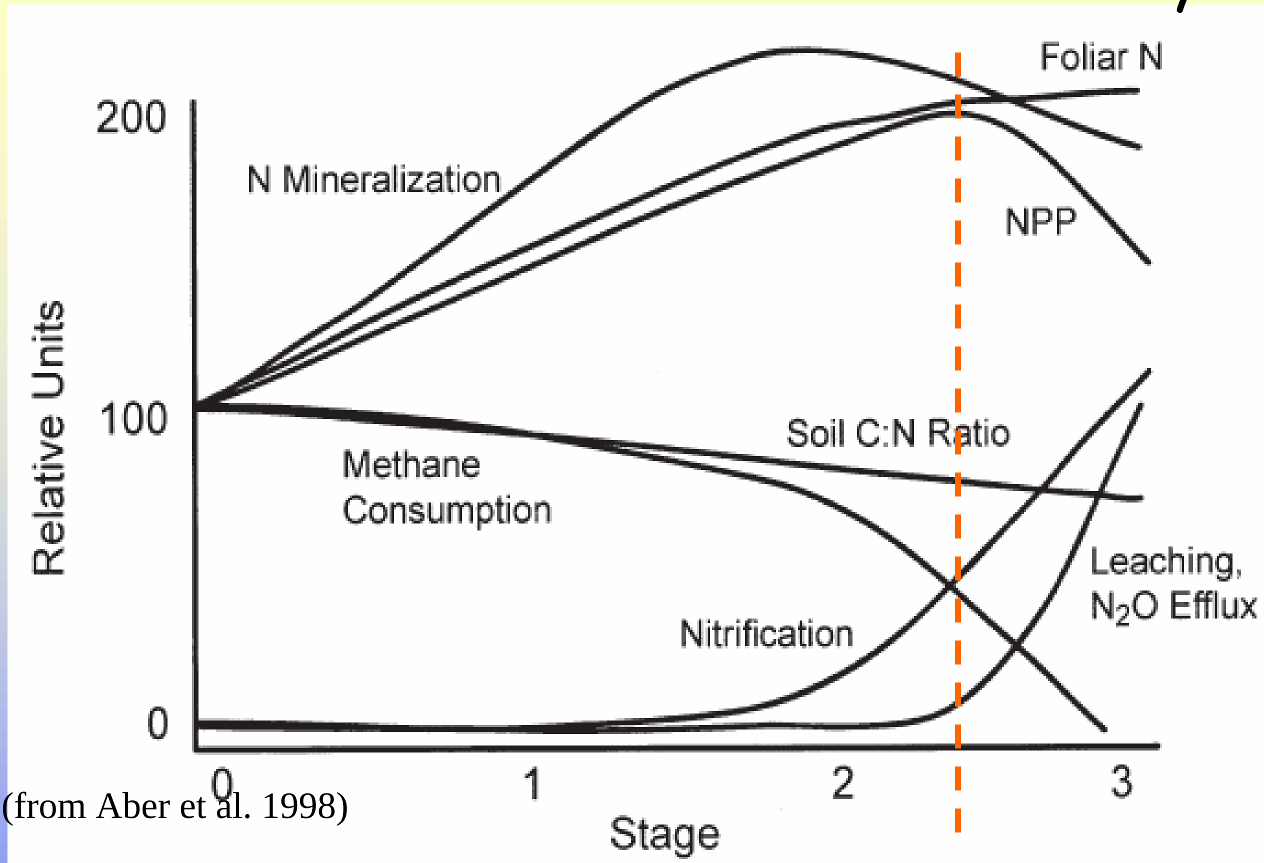
1) eutrophication- production in many temperate terrestrial ecosystems is limited by the supply of N (often associated with increases in nitrophilic plants)

2) acidification- "excess" NH_4^+ & NO_3^- lead to leaching of base cations & mobilization of soluble Al

Linked, due to the N sink of biomass



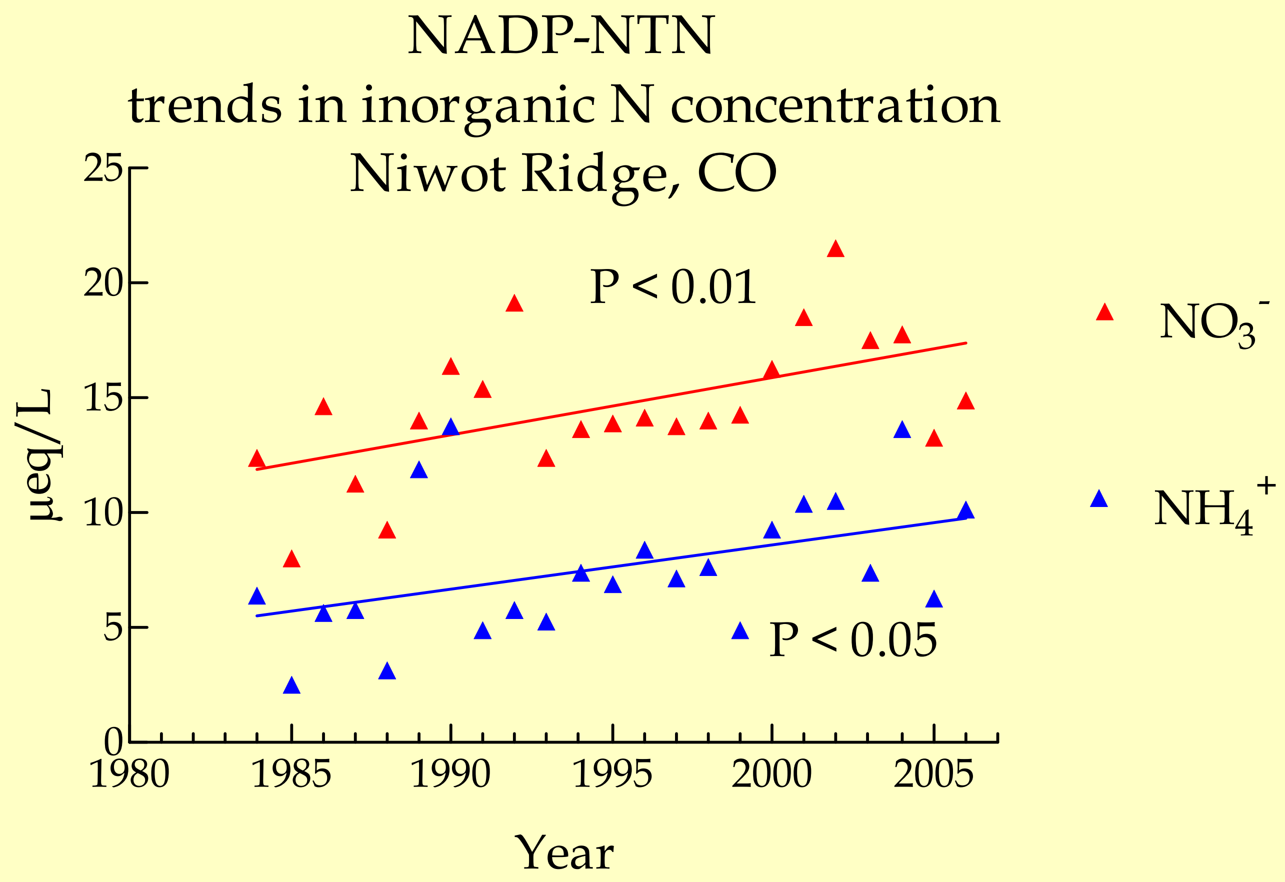
Aber N Saturation Model for Forest Ecosystems



(from Aber et al. 1998)

- how are eutrophication and acidification (leaching) linked temporally?
- how much of a sink is alpine vegetation?

N Deposition in the alpine of the S. Rockies



estimated total annual deposition 6 kg N/ha

Estimates of N critical loads in the alpine:

Amount: (kg ha^{-1} yr^{-1})	source:	basis:
4-10	Bowman et al. (2006)	vegetation change
4 *	Williams & Tonnessen (2000)	surface water chemistry
1.5	Baron (2006)	hindcasting analysis/ diatoms
3-4	Baron et al. (1994)	CENTURY model (N leaching)
10-15	Bobbink et al. (2002)	vegetation change (Europe)

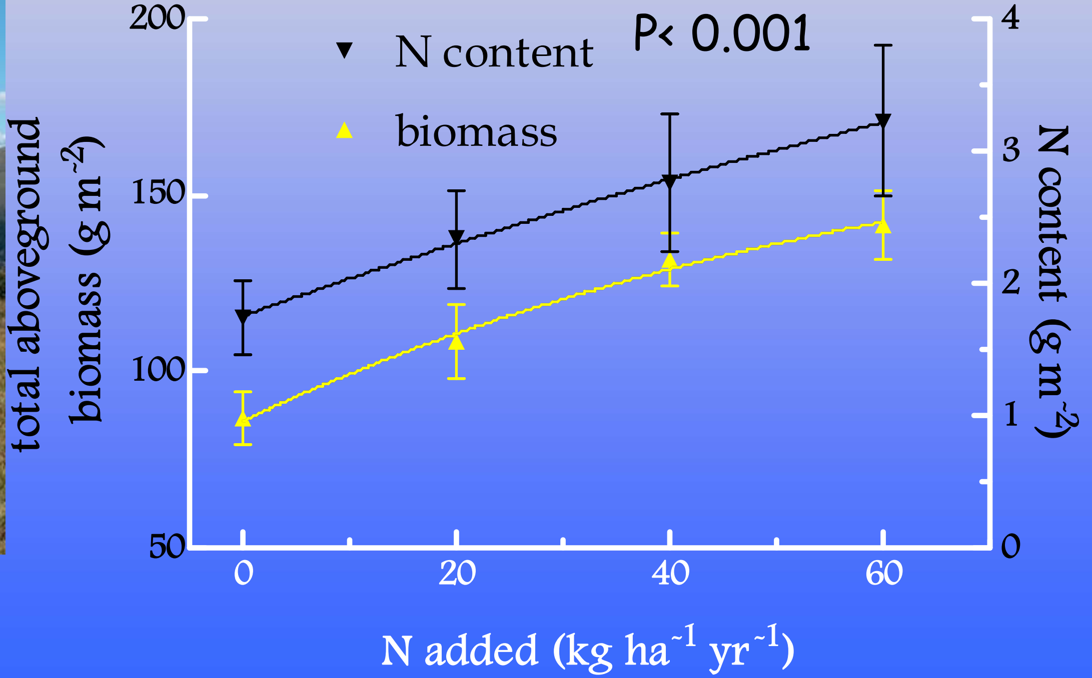
*wet only

Experimental N deposition in an alpine dry meadow, Niwot Ridge

Vegetation and soil resonses- 1998 to present
treatments of 20, 40, & 60 Kg N /ha/ yr

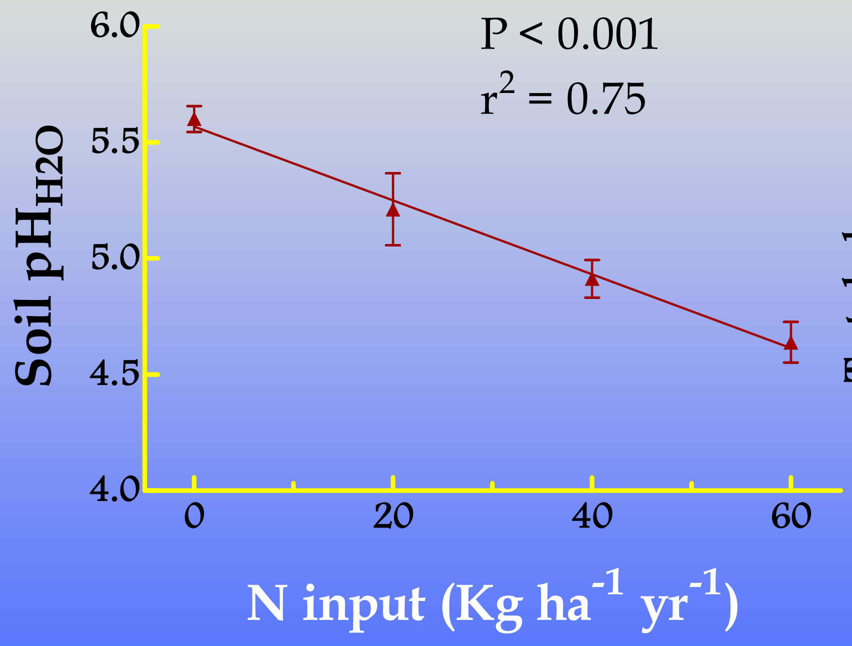
modest increase in aboveground biomass and N uptake (due entirely to changes in species abundances)

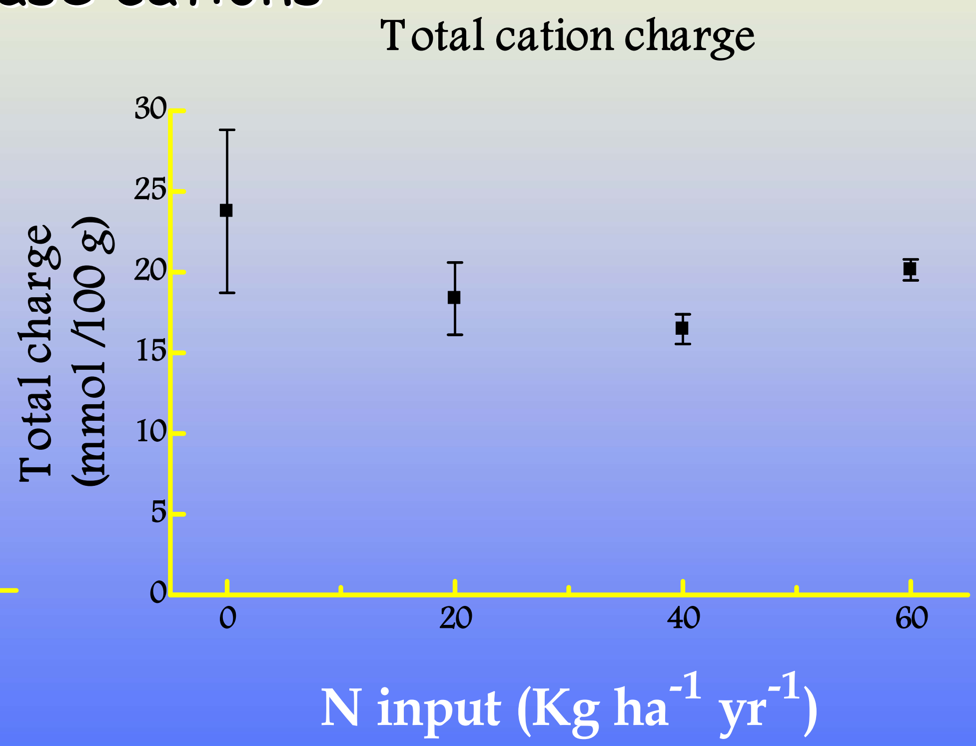
how much buffering of soil effects?



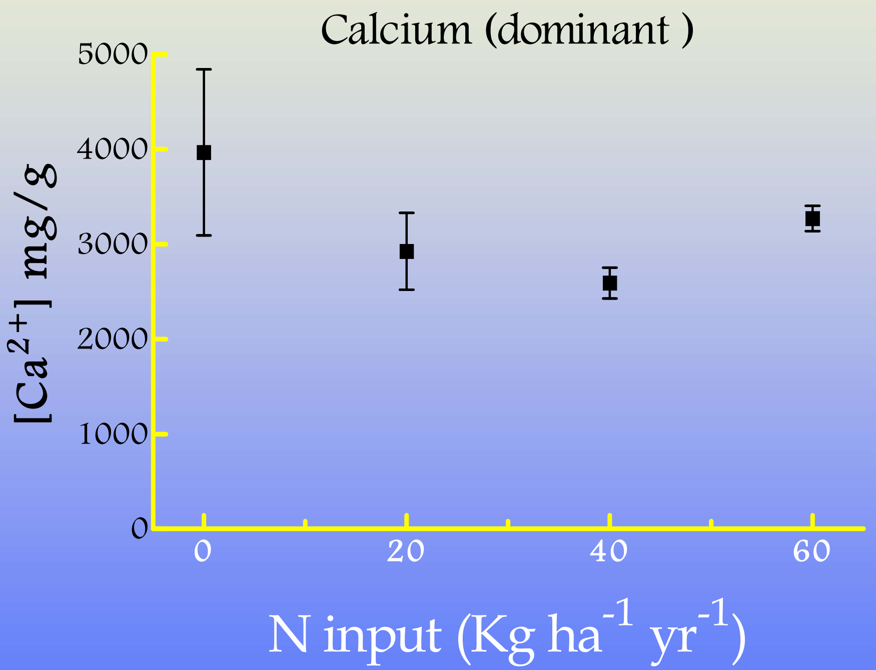
Soil responses to simulated N deposition
Niwot Ridge dry meadow

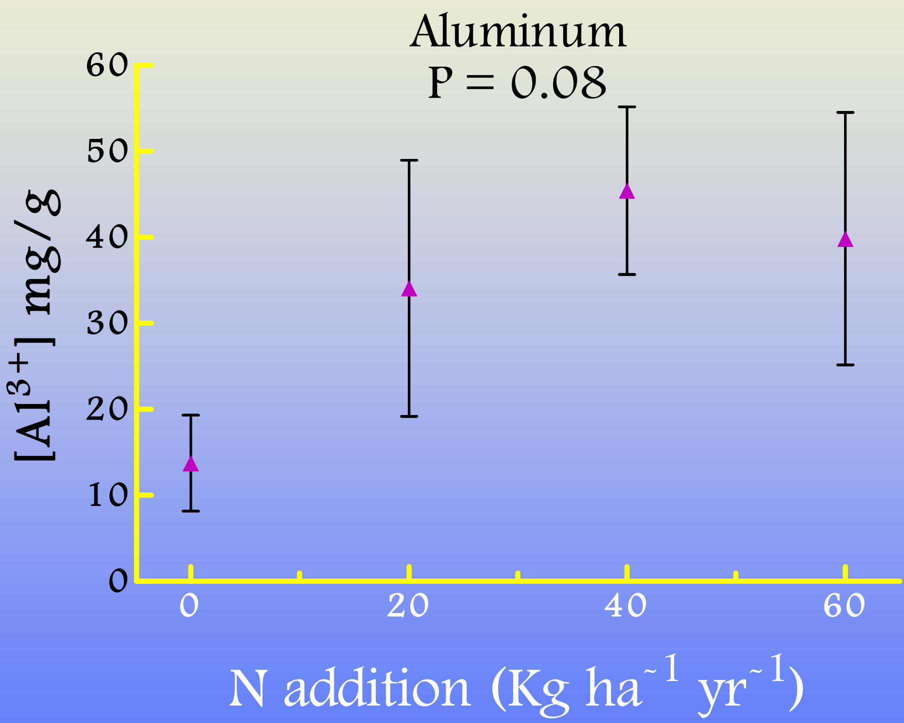
* increasing soil acidity
* trend towards loss of base cations





Soil responses to simulated N deposition
Extractable cations
* trend towards increasing Al

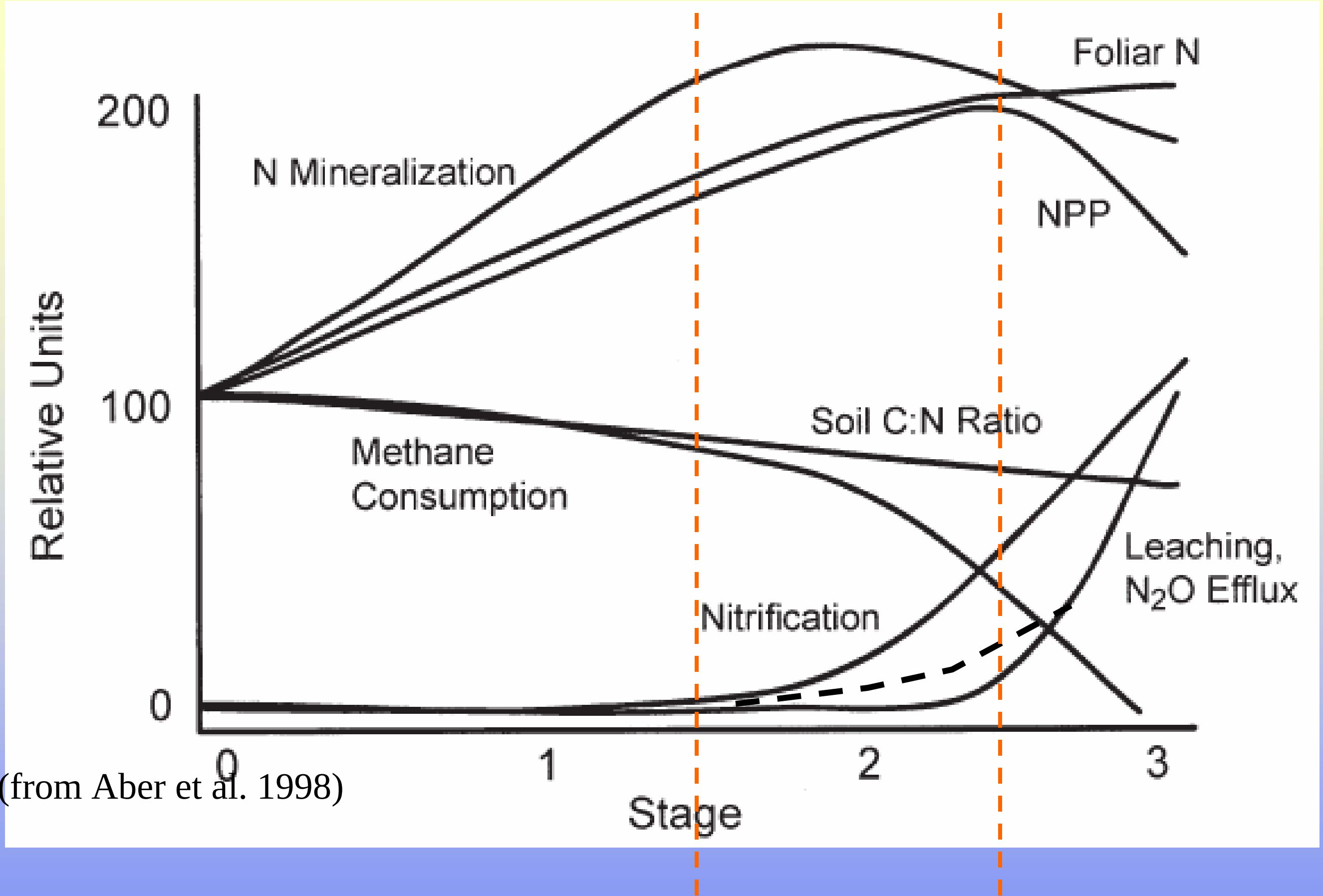




similar trends with increased loss of
other nutrient base cations (K, Mg)

Results indicate "eutrophication" effects, but insufficient buffering to prevent effects of N deposition on soil pH, loss of nutrient cations, and increased Al

Ongoing research addressing N critical loads, vegetation and soil responses to simulated N deposition in Rocky Mountain and Glacier National Parks

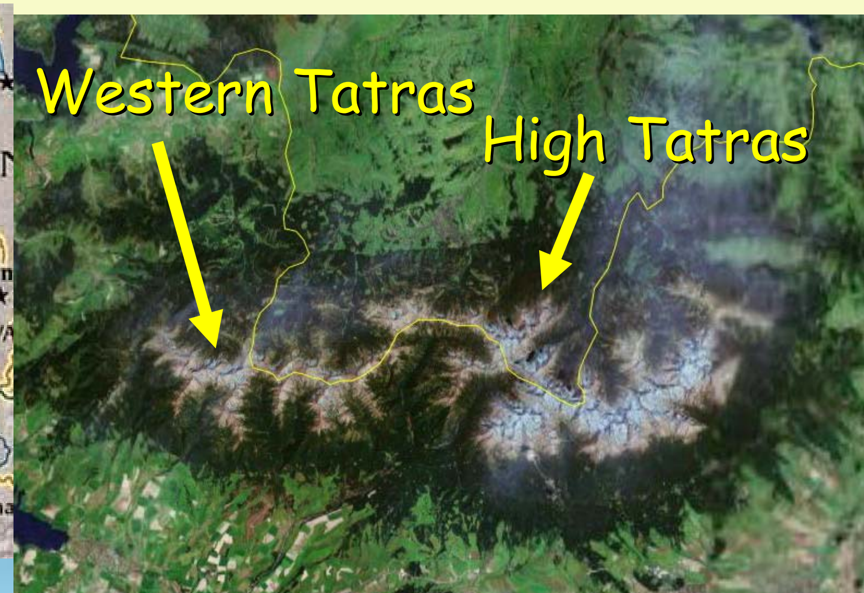


(from Aber et al. 1998)

where are we on the N saturation trajectory? are we taking a short cut?

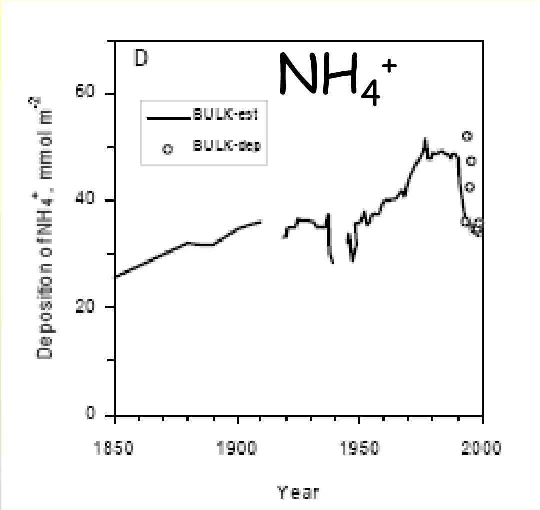
what happens later in the later stages?

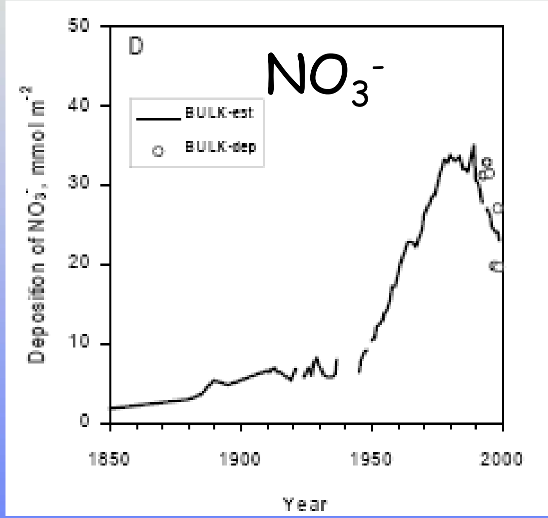
Western Tatra Mountains, Slovakia



Current estimated total N deposition
12 Kg N/ha/yr)

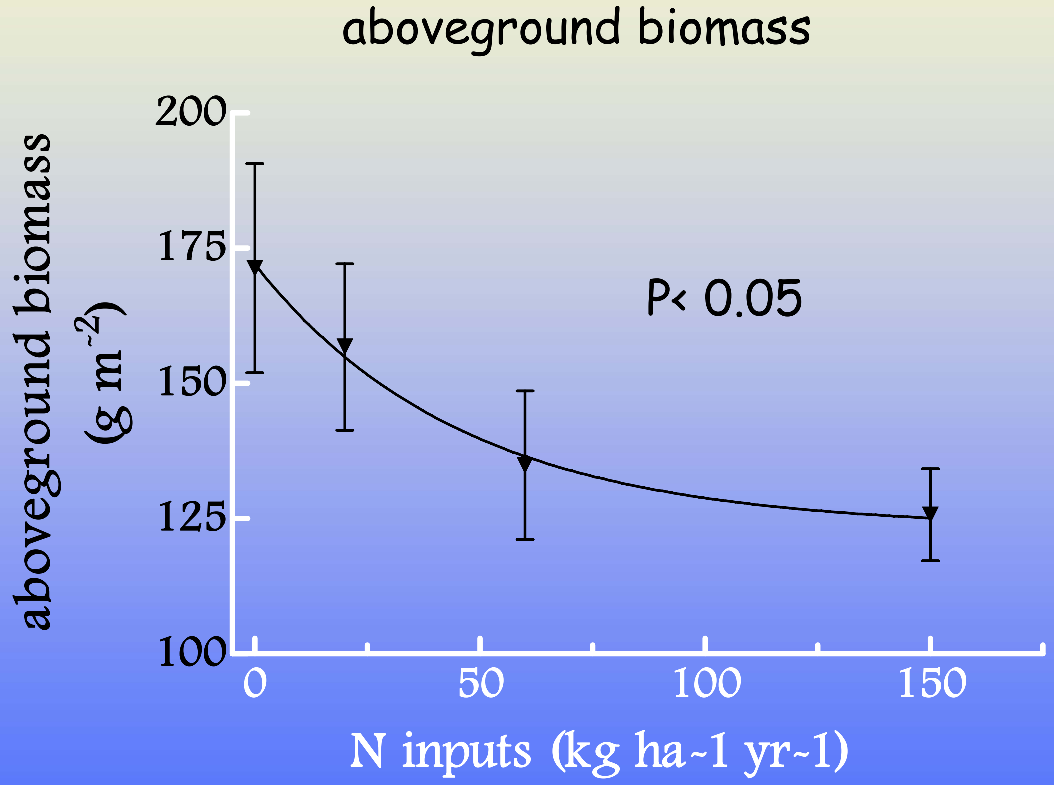
historic rates ca. 20 Kg N/ha/yr,
25 Kg S/ha/yr



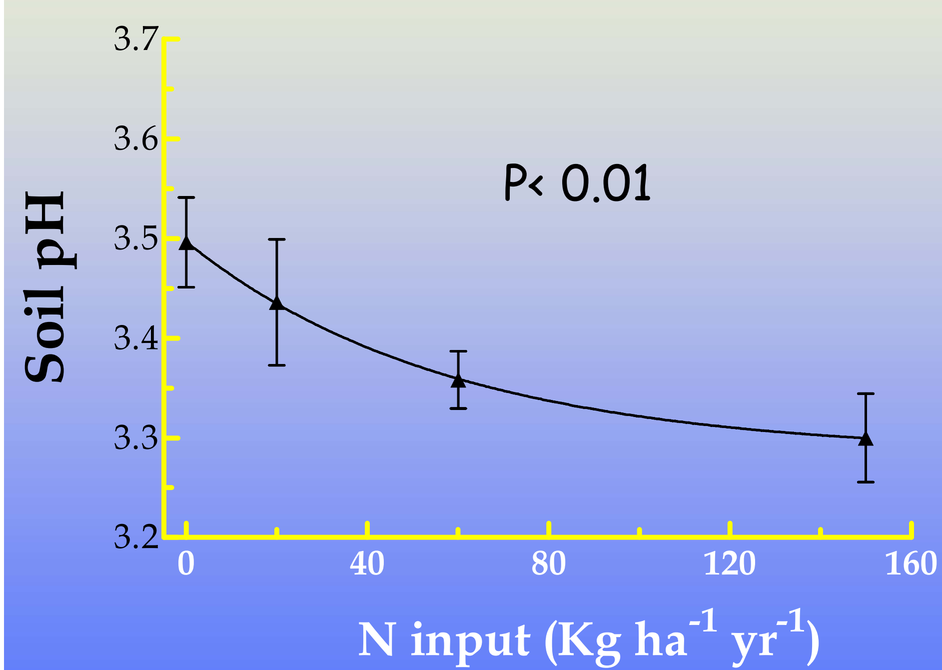


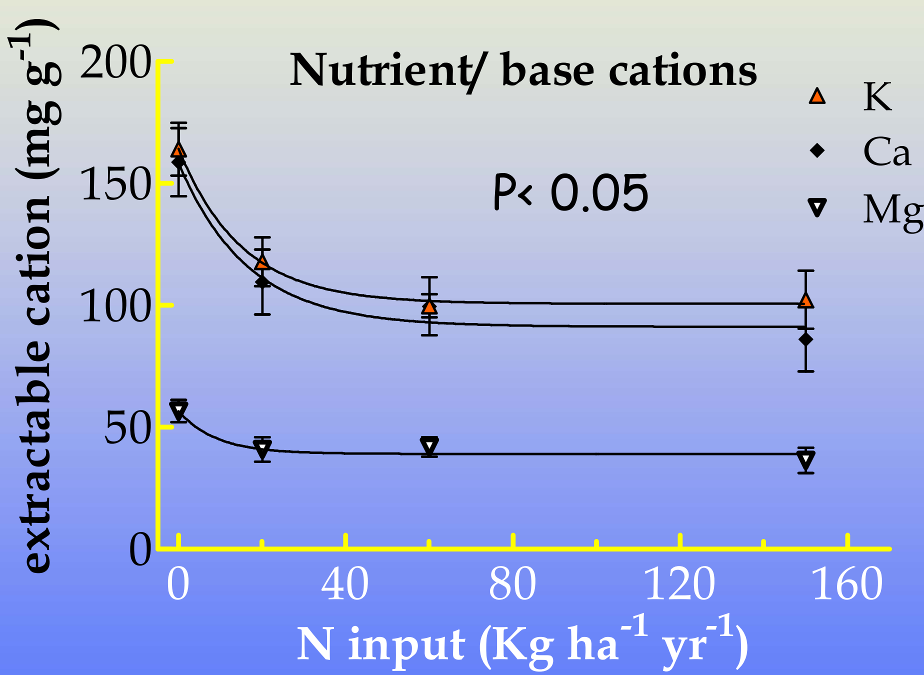
from Kopácek 2001

Biomass responses to simulated N deposition
* decreased production



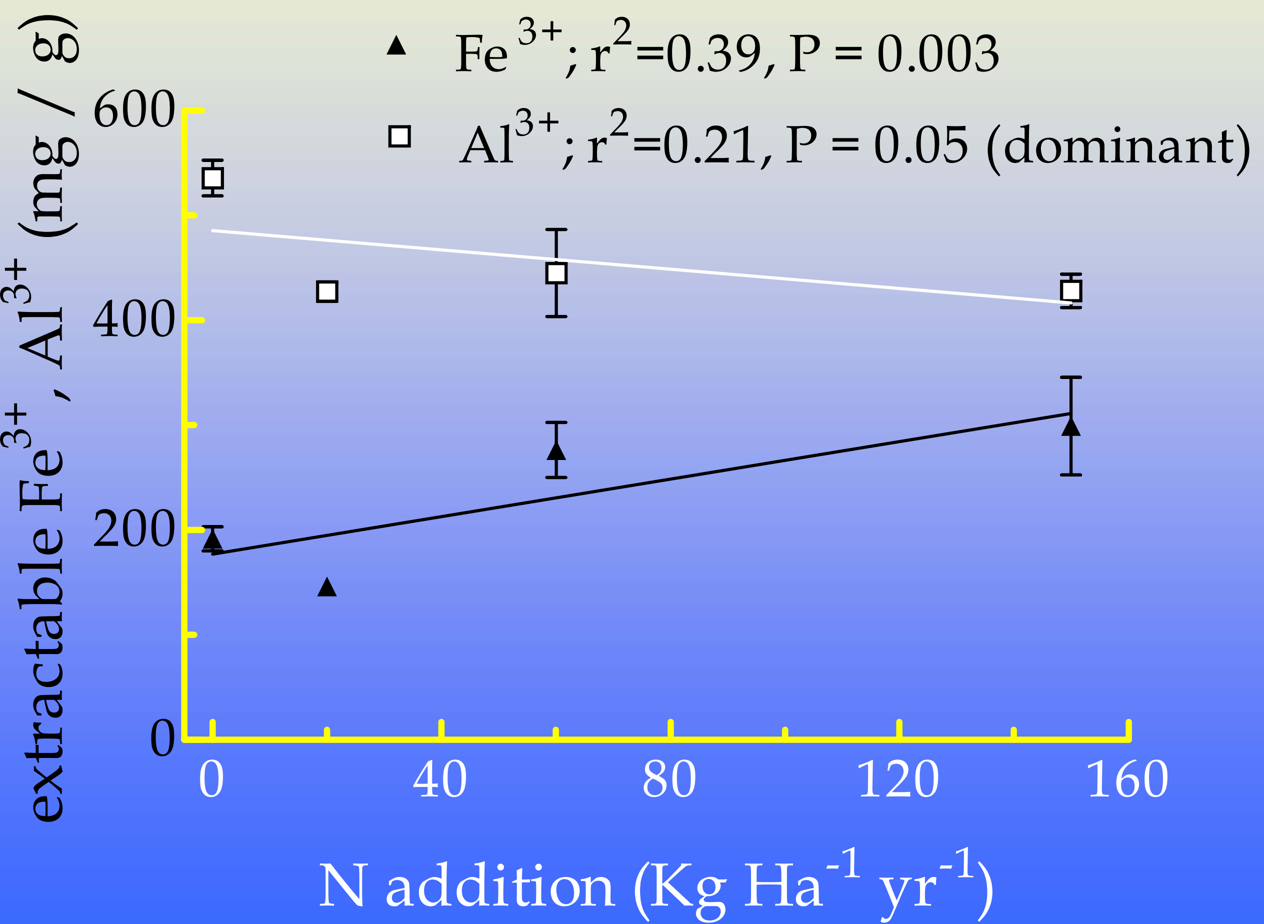
Soil responses to simulated N deposition, Mount Salatin
* increased acidity
* loss of already low base cations





Soil responses to simulated N deposition, Mount Salatin

* loss of Al, increase in Fe
* transition from base cation to Al to Fe buffering system



Summary

- Alpine dry meadow on Niwot Ridge shows simultaneous "eutrophication" and leaching (acidification) effects at higher rates of N deposition
- Biological buffering in alpine insufficient to prevent adverse environmental impacts with increased rates of N deposition
- At extreme levels of soil acidity in the Western Tatras, N deposition forces system towards Fe dominated buffering of soil
- Alpine systems with acidic parent material are at high risk to detrimental impacts of N deposition