Understanding the Interactive Effects of Nitrogen Deposition, Global Warming, and Increased Snowfall on the Encroachment of Woody Shrubs into the Alpine Tundra

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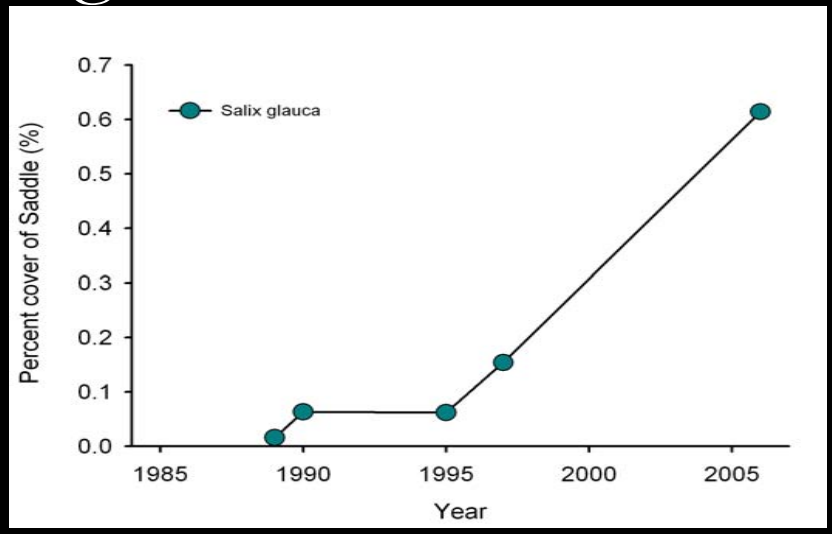
Woody shrubs are increasing in abundance on Niwot Ridge, CO



Mechanisms promoting encroachment in the arctic tundra: Snow-shrub-microbe-soil feedback

Warming

Shrub Density

Snow Depth

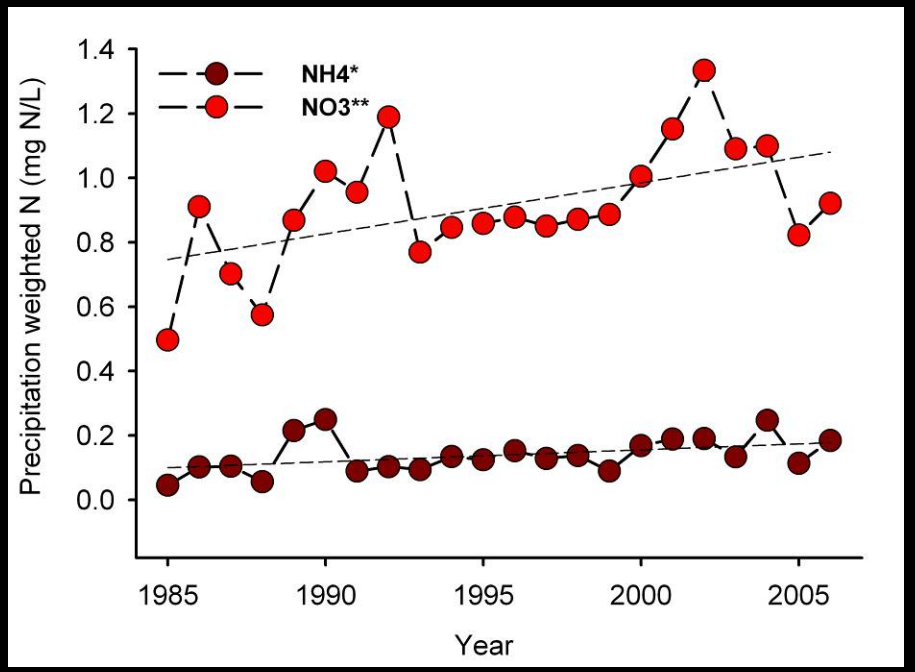
Soil Temperature

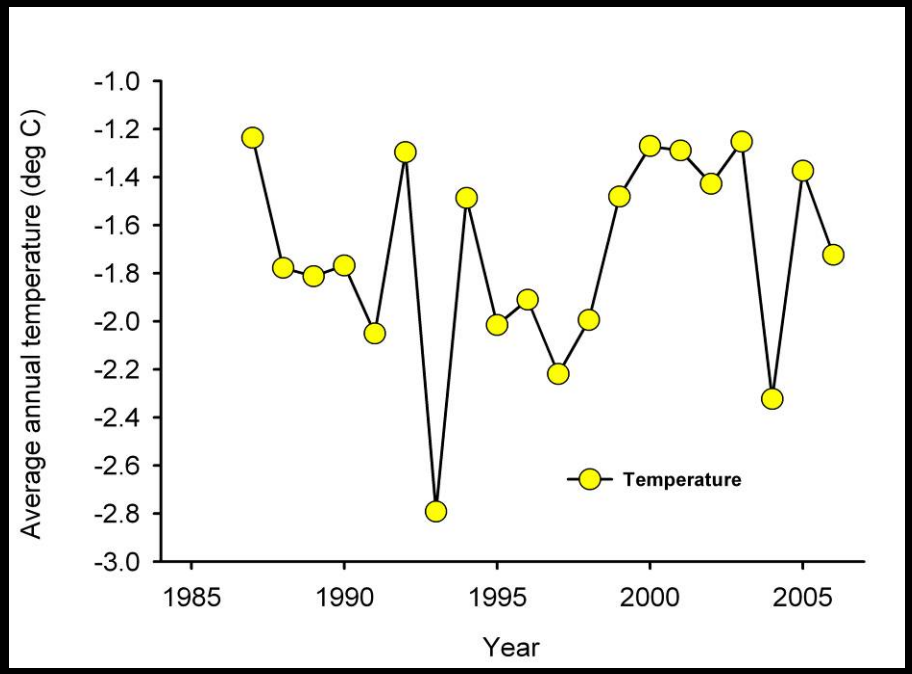
Microbial Activity

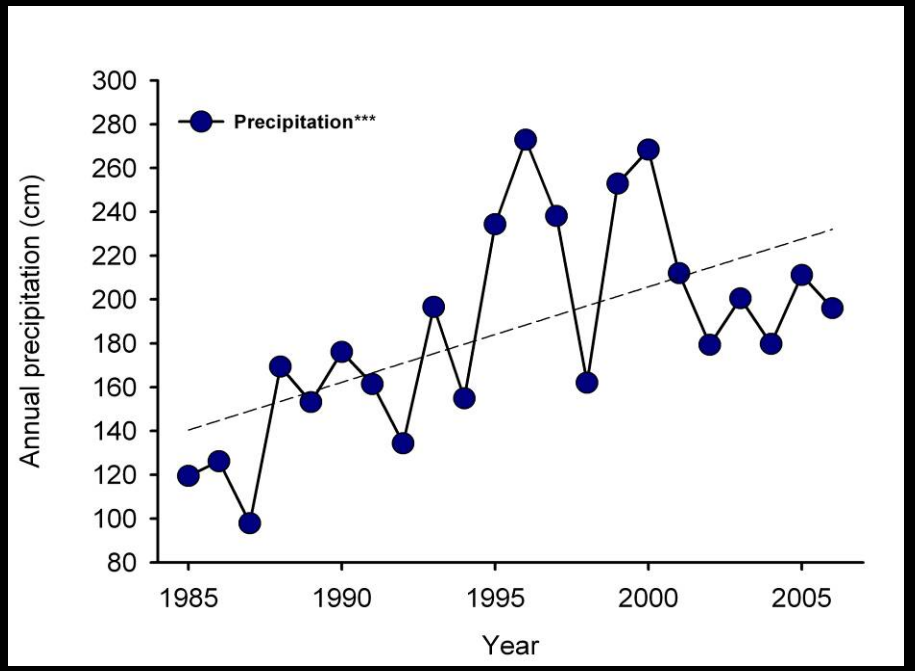
Nutrient Availability

Adapted from Sturm et al. 2001, Journal of Climate

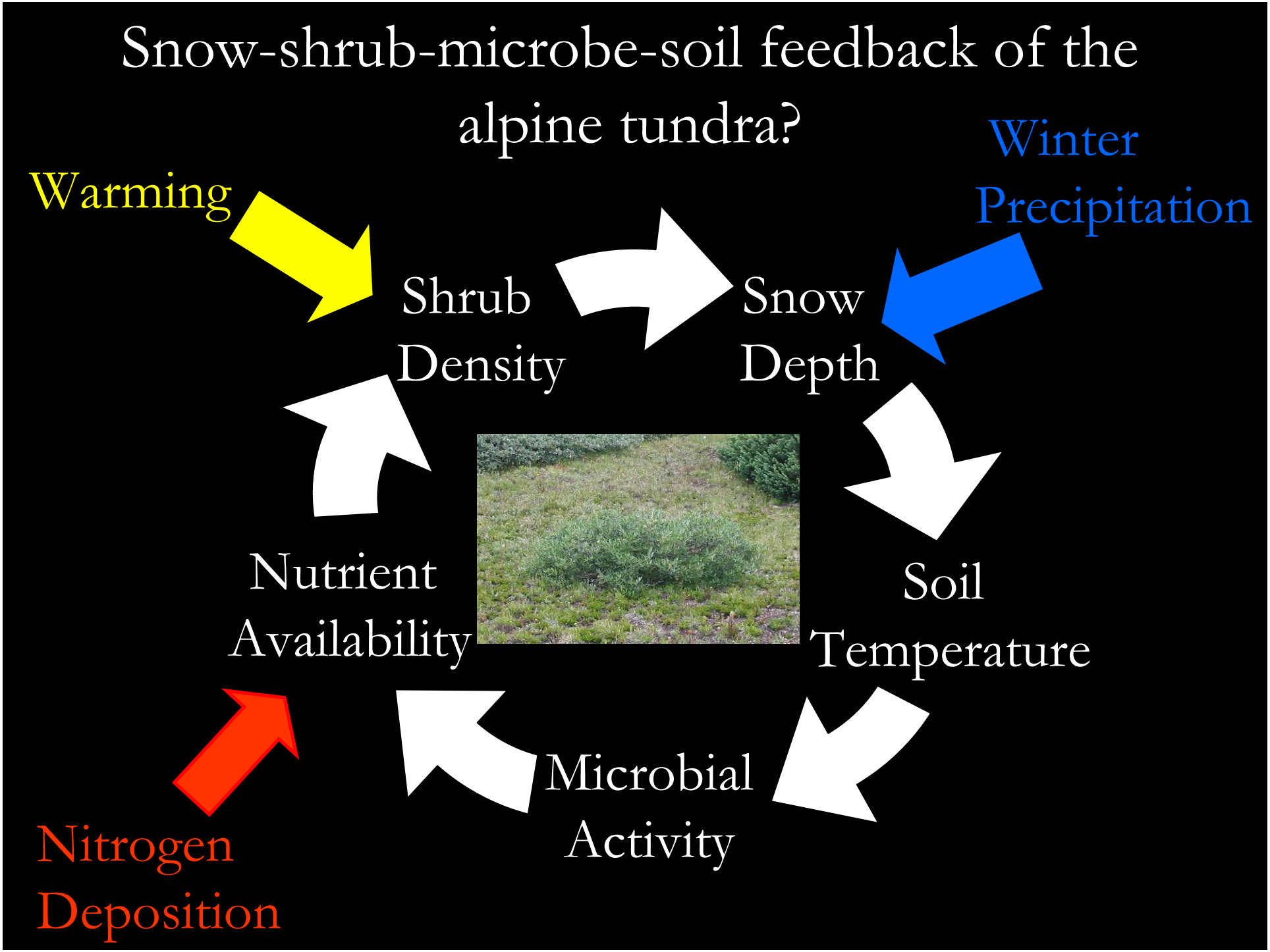
Does global climate change and N deposition promote woody encroachment in the alpine tundra?







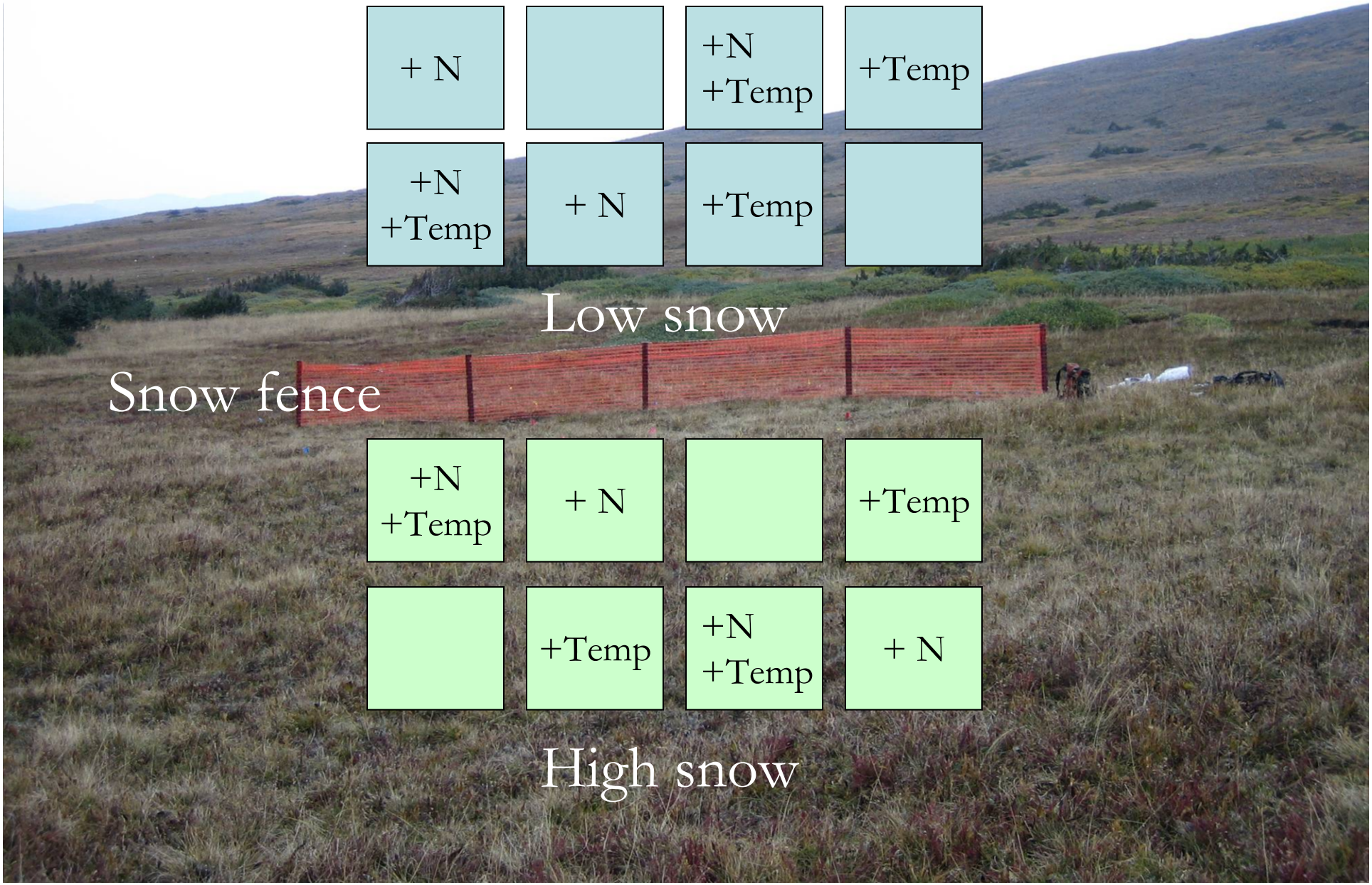
Snow-shrub-microbe-soil feedback of the alpine tundra?



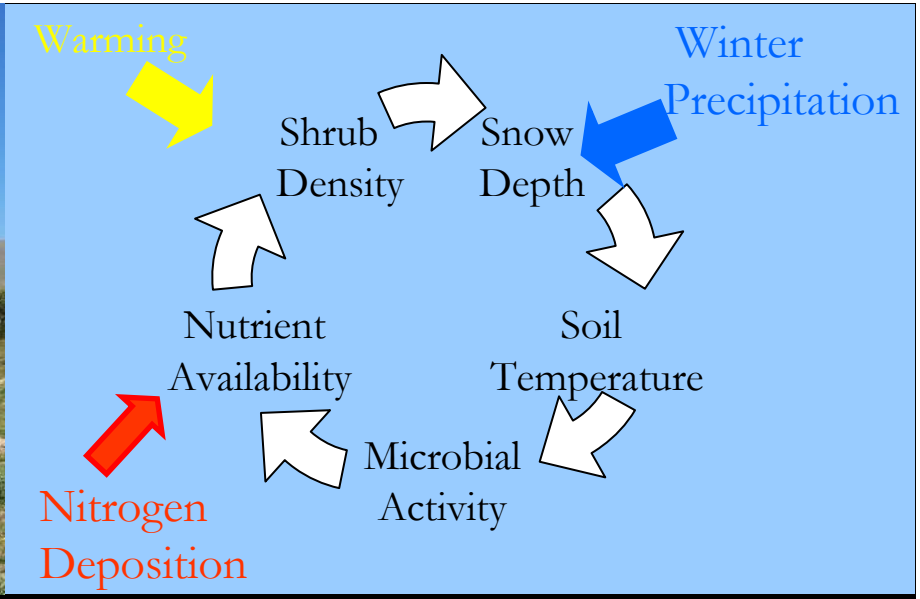
Methods

- 48 1m^2 plots established in 2006
- Added 8 gN/m2/yr
- Snow fence increased 2006-2007 winter precipitation
- Open-topped chambers were used to increase 2007 summer temperatures
- Planted 10 *Salix glauca* seedlings per plot in 2007
- Measured productivity and growth response of tundra vegetation
- Measured growth & survival of *Salix*

Experimental design

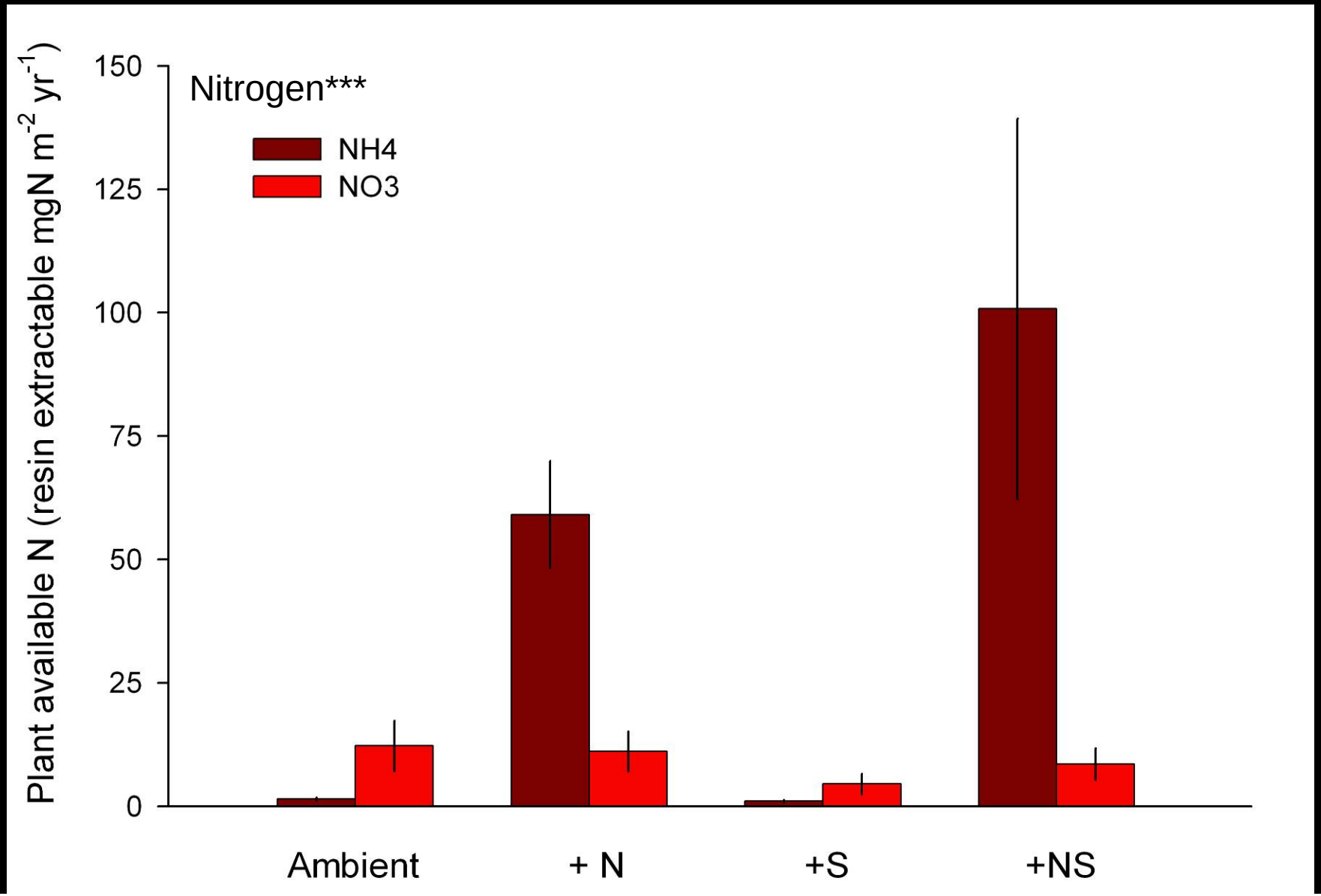


Predications

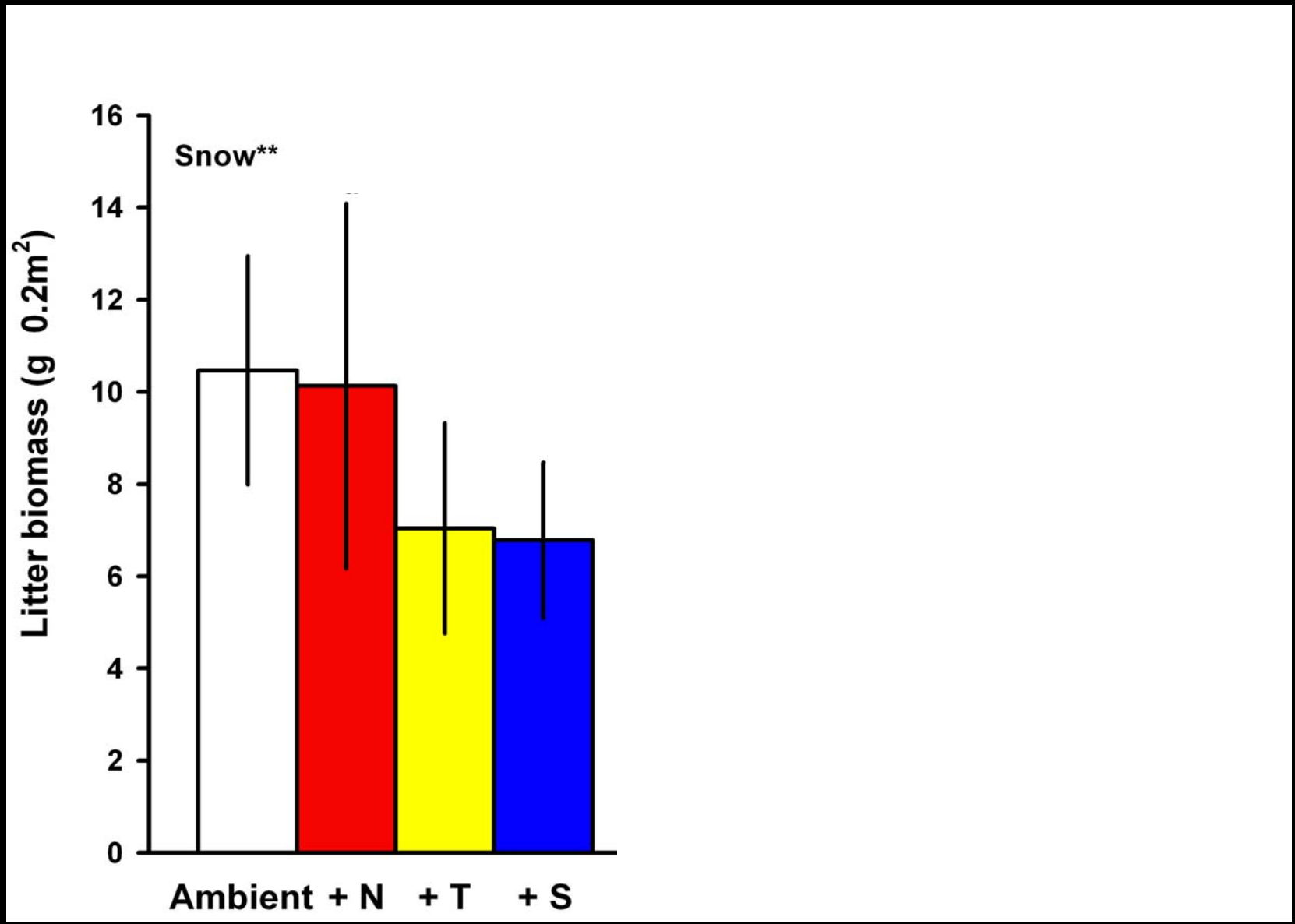


- N deposition, snow & warming increase soil N pools
- Higher soil N increases *Salix* seedling survival & growth rate
- *Salix* response to N is greater than herbaceous tundra vegetation

N addition increases plant available N, but increased winter precipitation does not



Litter biomass is decreased with snow addition



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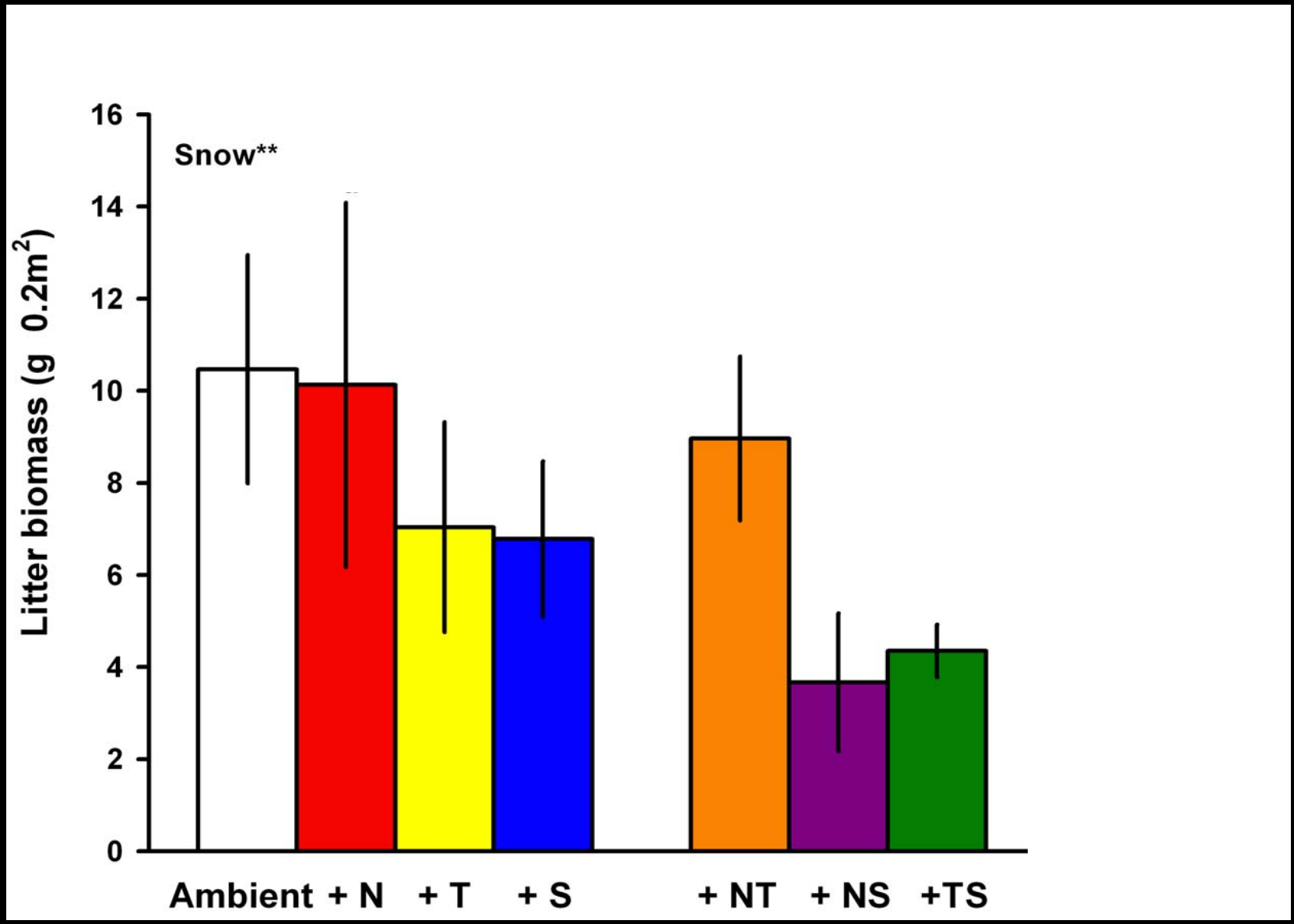

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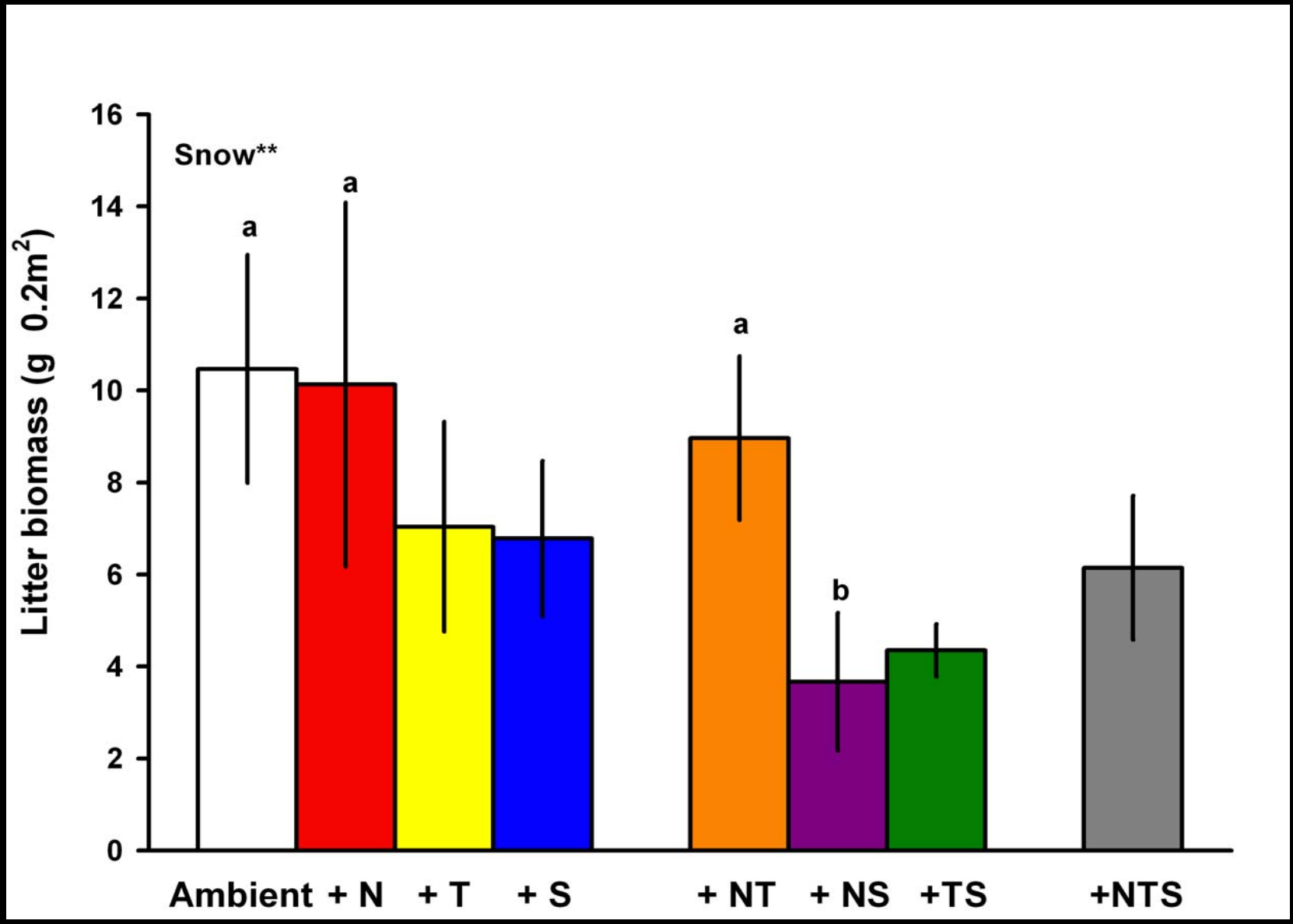
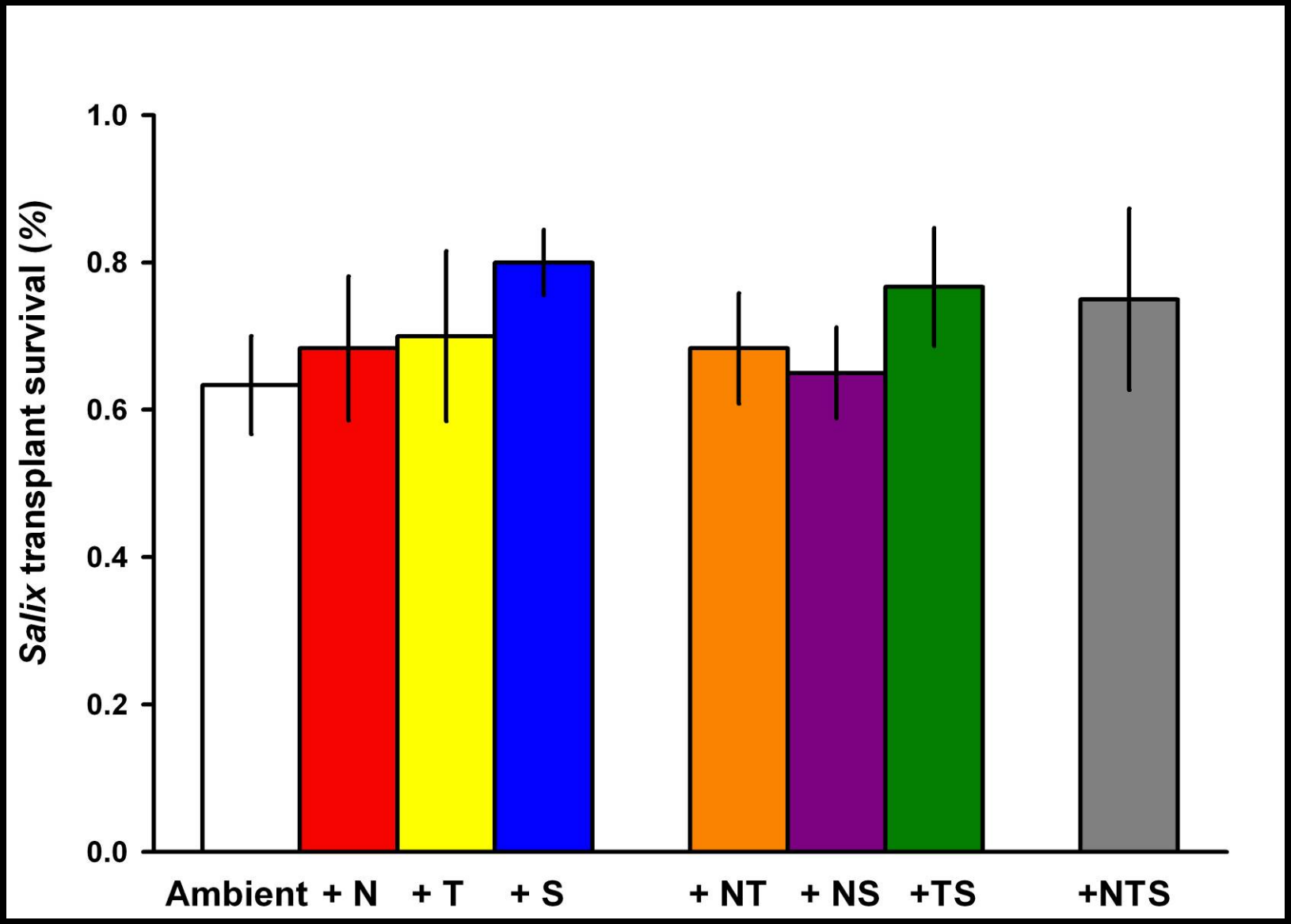
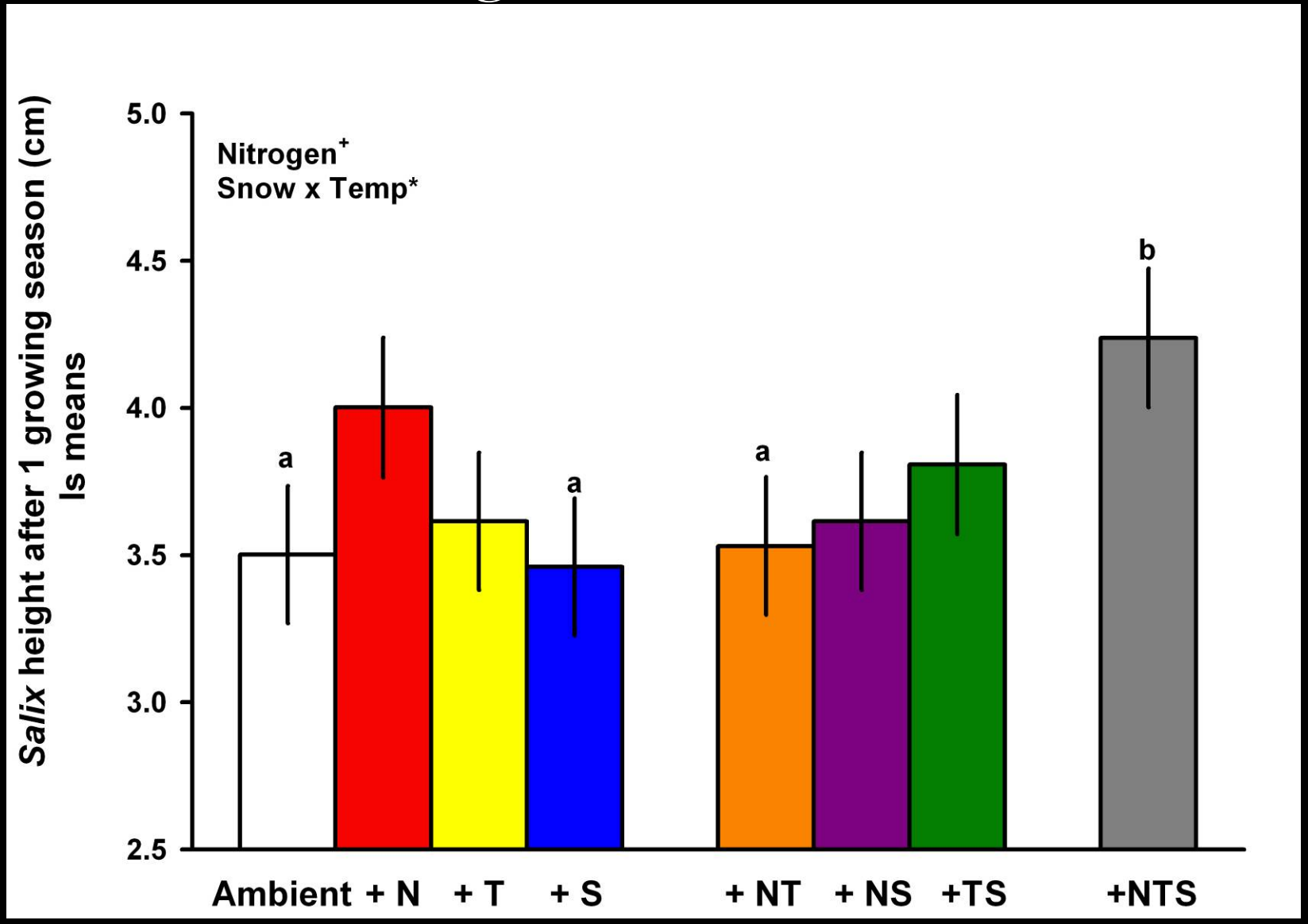


Salix survival is not affected by warming, snow addition, or N addition



Salix growth rate is increased by the combination of warming, snow and N addition



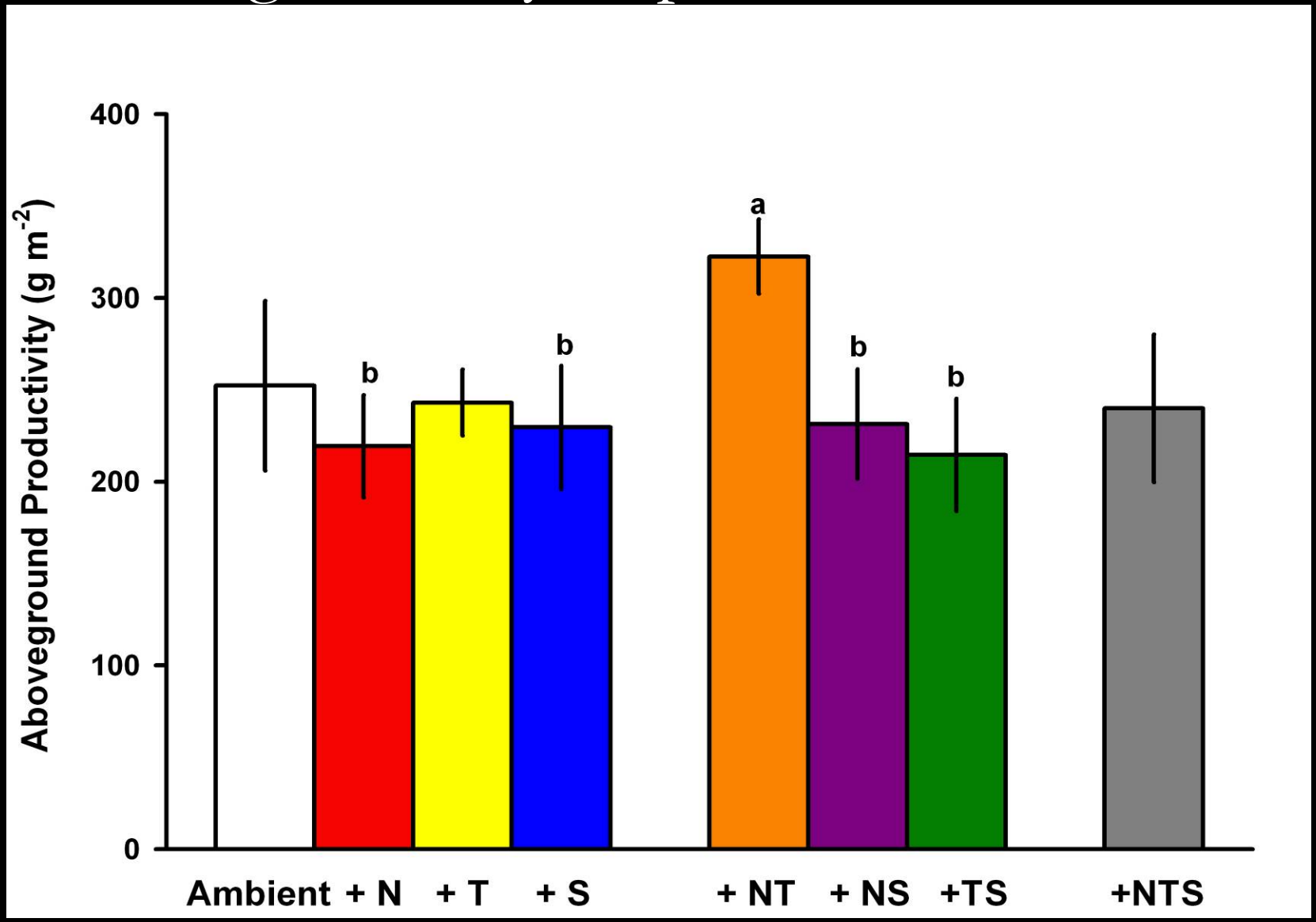
Results

- Snow addition does not increase soil N pools, but loss of litter suggests increased N mineralization

- *Salix* seedling survival rate is not affected by soil N

- *Salix* growth rate increases with a combination of higher soil N, warming, & snow

The growth of herbaceous tundra vegetation does not significantly respond to treatments



Results

- Snow addition does not increase soil N pools, but loss of litter suggests increased N mineralization

- *Salix* seedling survival rate is not affected by soil N

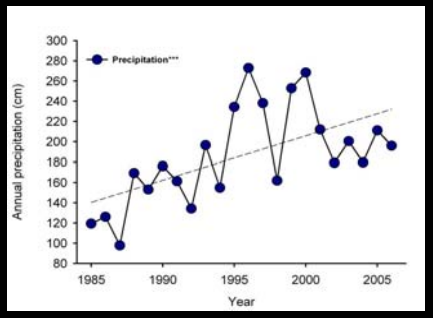
- *Salix* growth rate increases with a combination of higher soil N, warming, & snow

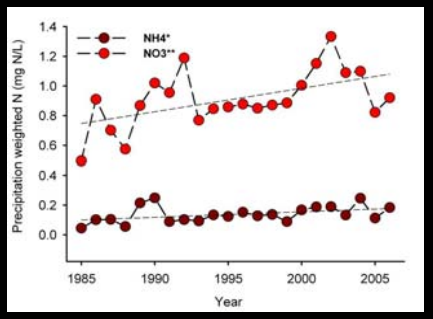
- *Salix* is more responsive to N than other tundra vegetation

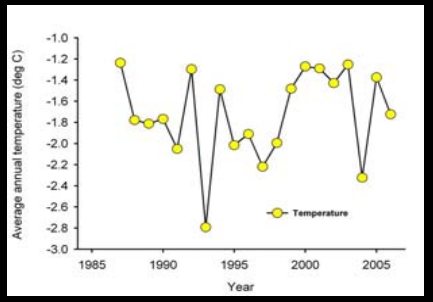
Conclusions

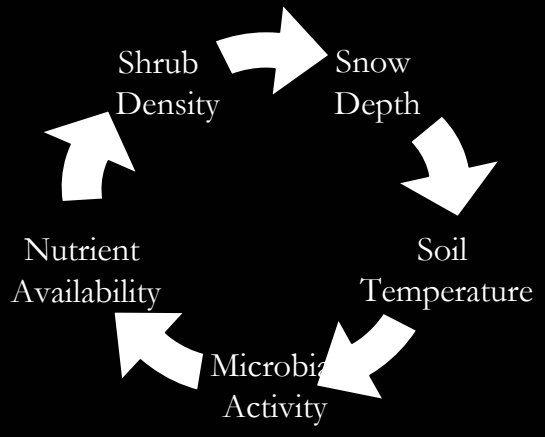
- Increased growth rates, rather than changes in survival rates, are likely responsible for increases in *Salix* abundance

- Nitrogen deposition and interactive effects of N, snow, and warming may facilitate the spread of *Salix*









Implications

Present trends of warming, precipitation, and N deposition suggest that woody encroachment will continue

Woody encroachment may cause changes in local albedo, N availability, and snow pack that will accelerate this process

Acknowledgements

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