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Climate change effects on vegetation in Northeastern Siberian tundra

Shrub growth response to local climate & effects of shrub expansion on permafrost thaw

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- The Siberian tundra is one of the key permafrost regions in the Arctic because of its large spatial extent and carbon-rich soils.
- Permafrost thaw is believed to strongly increase this century, which may impact the global climate.
- Arctic vegetation is responding to climate change, deciduous shrubs, in particular, are expected to benefit from climate warming.
- Experimental evidence shows that shrub expansion may reduce summer permafrost thaw (Blok *et al*, 2010).

Aim: determine vegetation response to local climate conditions, from individual shrub level to pan-Arctic vegetation trends

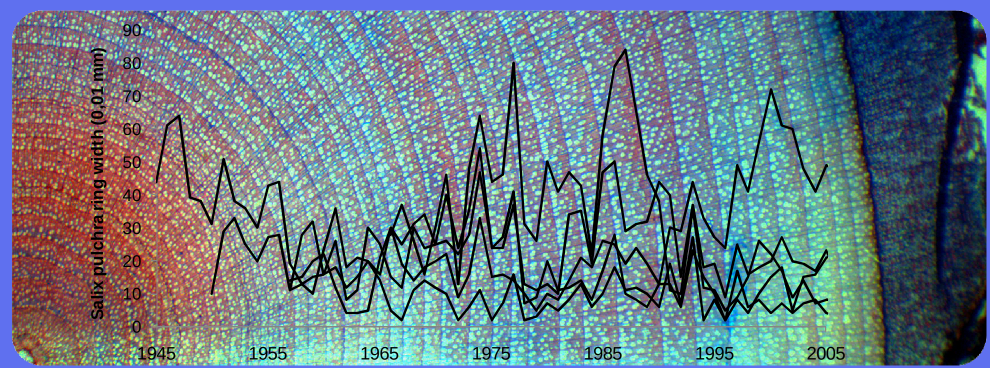
Dendrochronology

We use dendrochronlogy to reconstruct the growth response of tundra shrubs to climatic conditions

Salix pulchra is a widespread deciduous shrub across the Arctic

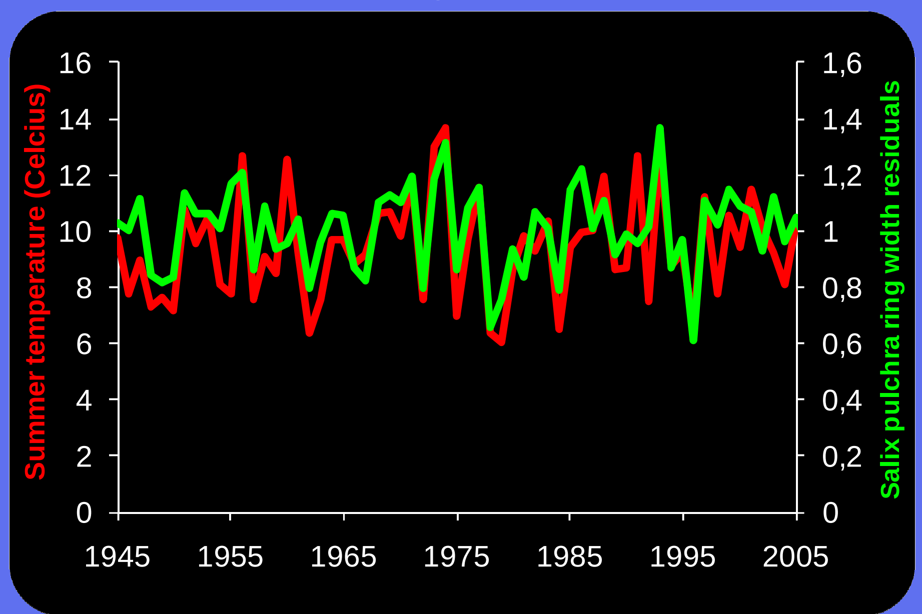
Salix pulchra shrub in Northeastern Siberian tundra

Salix pulchra **ring width measurements**



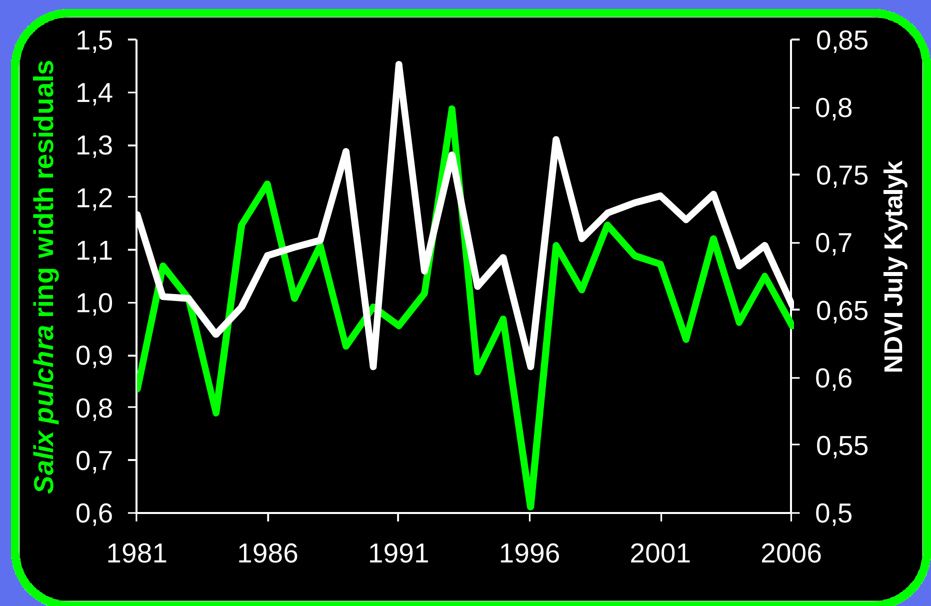
Salix pulchra section sample with raw ring width measurements shown

Salix pulchra **chronology vs. summer temperature**



Salix pulchra chronology is based on the average ring widths of 19 individuals. For each individual shrub, an average of measured ring widths at multiple heights in each shrub is used. Summer temperatures are averages of daily average temperatures for the period day of year 168-200

Greenness (NDVI) vs. shrub growth



NDVI values are based on early July NDVI data from the location of the research site, where shrub samples were collected (four 8 by 8 km pixels)

Salix pulchra shrub growth closely follows summer temperature (Pearson correlation = 0.73; $p < 0.001$)

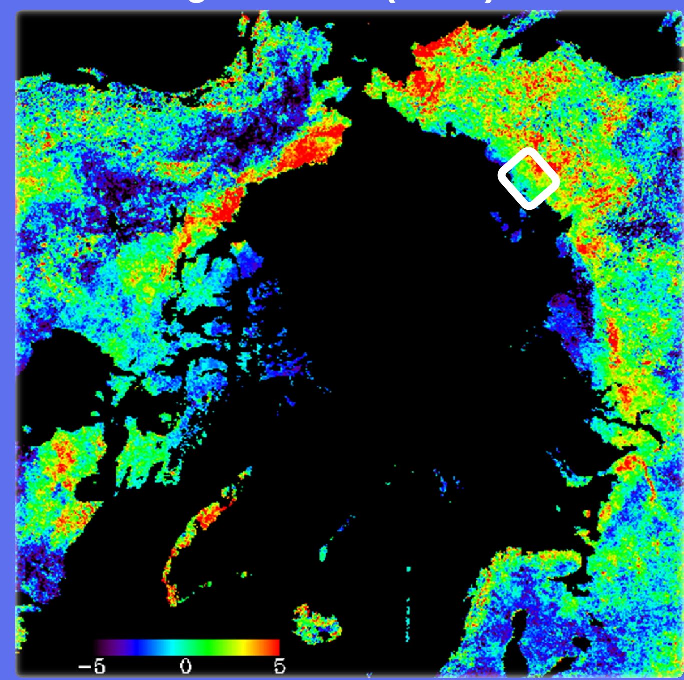
Shrubs most sensitive to period mid June to mid July (day of year 168-200)

Shrub growth corresponds with remote sensing greenness data (Pearson correlation = 0.39; $p < 0.05$)

Remote Sensing

We use remote sensing data to assess the vegetation response to climate change on a large spatial scale

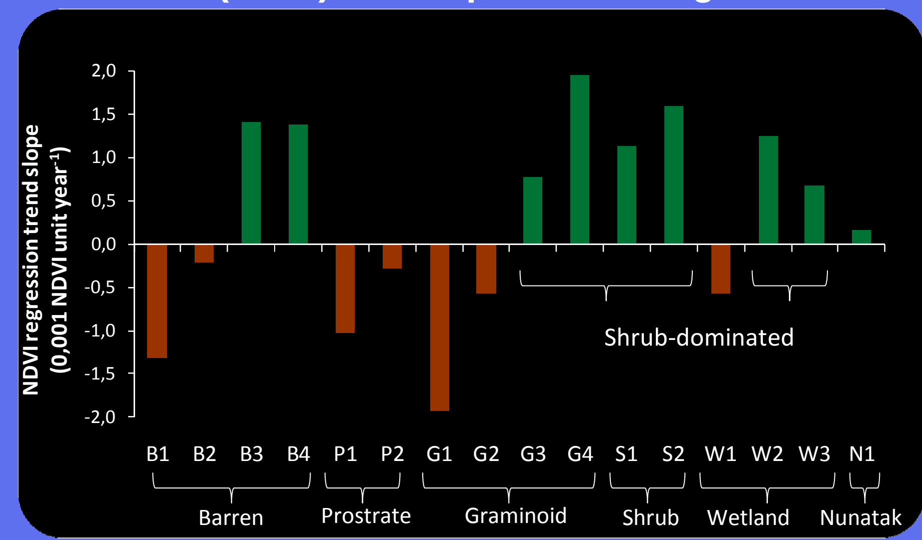
Arctic greenness (NDVI) trends



Per-pixel regression slopes of early July NDVI trends over the period 1981-2006

Stongest positive greening trends occur in shrub-dominated tundra areas

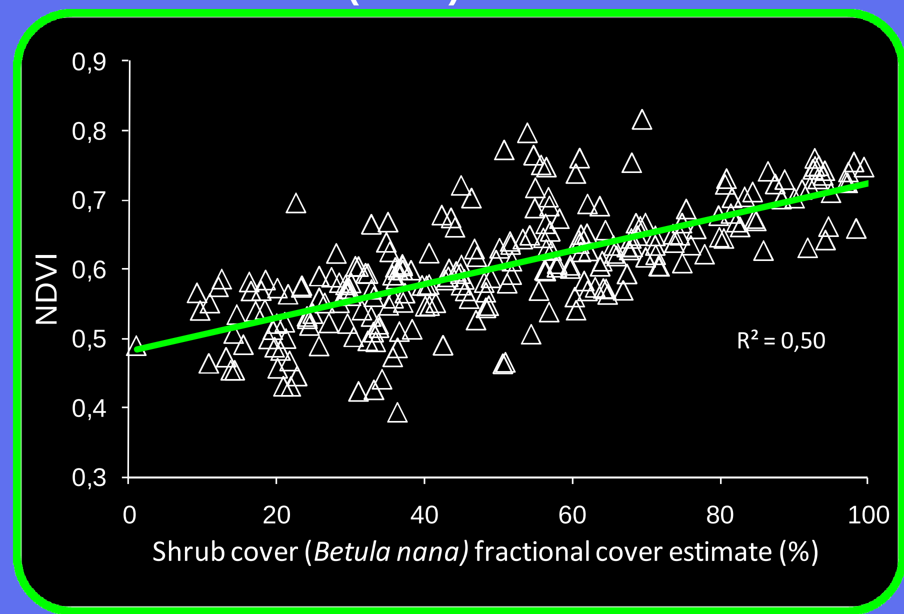
Greenness (NDVI) trends per Arctic vegetation class



Greening trends are based on early July 15-day average NDVI values from the GIMMS AVHRR dataset (Nov. 2008), with a spatial resolution of 8 km. Regression slopes are calculated per pixel, as a function of NDVI change per year over the entire available record period 1981-2006. Arctic vegetation classes: Walker *et al*, 2005.

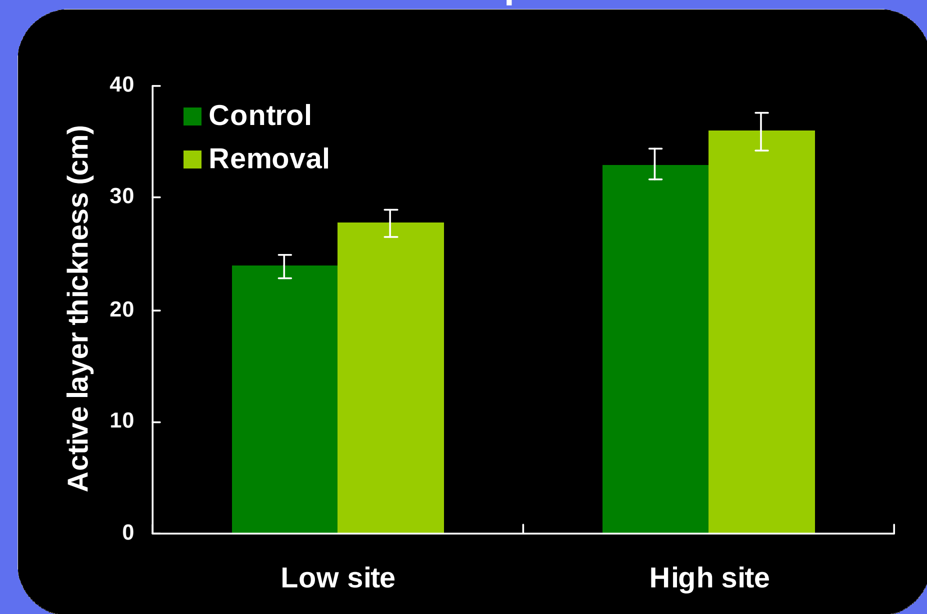
From pan-Arctic to ground level at research site

Greenness (NDVI) vs. shrub cover



Shrub (*Betula nana*) cover estimates are derived from spectral reflectance data, using an unmixing procedure with pure spectral endmembers. NDVI values are calculated from resampled spectral reflectance data.

Effect shrub cover on permafrost thaw



Comparison of active layer thickness (ALT) between control and removal plots. In removal plots, *Betula nana* shrubs have been removed. Data are mean values (n=5 plots ± SE). Blok *et al*, 2010

Spectral reflectance data on the ground show a positive correlation between shrub cover and greenness at the research site in NE-Siberia, 70°N, 147°E (Pearson correlation = 0.71; $p < 0.01$)

Permafrost thaw is reduced by deciduous shrub cover. Effect of treatment: $p < 0.05$; effect of site: $p < 0.01$

Increased shrub cover in the Arctic may partially offset permafrost degradation by climate warming

- Tundra vegetation greenness (NDVI) has generally increased during the last 2 decades, especially in shrub tundra areas.
- Ground-based spectral reflectance measurements show that NDVI increases with deciduous shrub cover.
- *Salix pulchra* shrub growth correlates positively with summer temperature and tundra greenness (NDVI).
- Together, these results suggest that we can expect a (further) increase in Arctic shrub cover with climate warming

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References : Blok *et al*, 2010. Shrub expansion may reduce permafrost thaw, Global Change Biology, **16**, 1296-1305; Walker *et al*, 2005. The Circumpolar Arctic Vegetation Map, Journal of Vegetation Science, **16** (3): 267-282