Change of the treeline ecotone in Khibiny Mountains, Kola Peninsula, Russia, over the last 50 years

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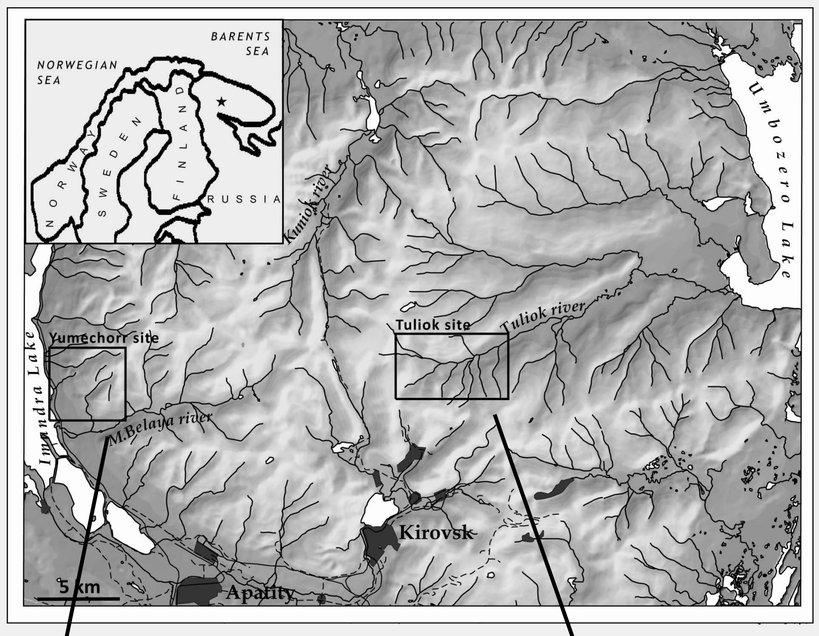
Background

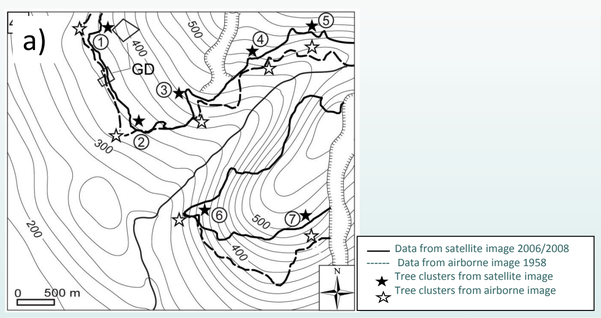
The treeline ecotone stretches around the circumpolar north, linking the boreal forest with the treeless tundra. Ongoing and predicted climate warming are expected to cause swift forest and treeline advance. At a large circumpolar scale tree encroachment of tundra will cause a decrease of regional albedo, amplifying global warming.

Change rate and temporal and species-specific treeline recruitment patterns were analysed using aerial photos from 1958 and high-resolution satellite imagery from 2006/2008 combined with age structure data of dominating tree species (pine and birch) in the Khibiny Mountains.

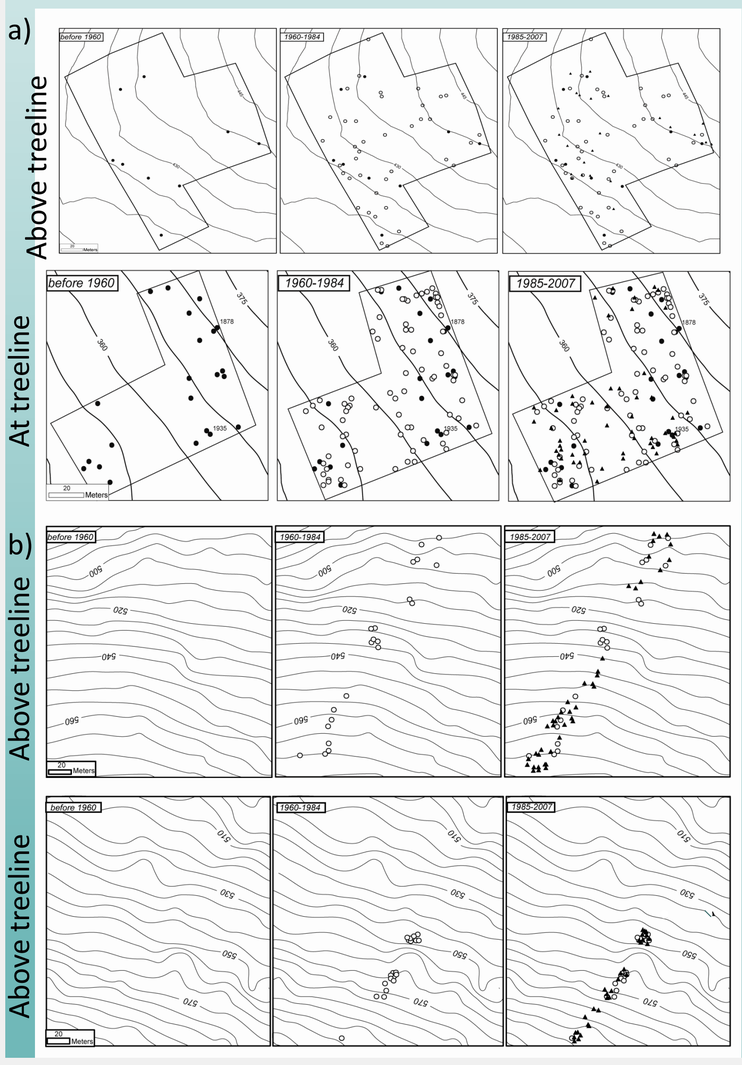
Questions asked

- To what degree has the treeline ecotone in the Khibiny Mountains changed during the last 50 years?
- Can species-specific temporal dynamics be identified?
- How can combined tree community- and remote sensing data strengthen the knowledge about ongoing changes in the northern forest-tundra zone?





*Location of the 1958 and 2006/2008 treelines of **pine** (a) at Yumechorr and **birch** (b) at Tuliok. Gaps in the contour lines are caused by shadow and clouds on the remotely sensed images.*



*Temporal and spatial recruitment distribution of **pine** (a) at and above the treeline, and **birch** (b) above the treeline. Sampling plots at different altitudes were used in the pine study and altitudinal sampling bands for birch. Data was collected in July 2008.*

established before 1960
established 1961-1984
established 1985-2007

Results and Conclusions

The tree community- and remote sensing data identified an apparent infilling process, where new individuals establish and sustain in-between older and taller individuals. A consistent but slow upward treeline movement is recorded and calculated to <1 m/yr. In total a ca 30 m altitudinal advance occurred from 1958 to 2008. The pine colonization was initiated during the 1940s both at and above the treeline, but the recruitment peaked in the 1970s and 1990s. The birch colonization all occurred after the 1960s, with establishment peaks from mid-1980s, but with no temporal altitudinal differentiation.

Pine establishment correlated positively with February and June precipitation, and total winter and summer precipitation, respectively. Birch establishment correlated positively with March temperature and winter precipitation. Winter precipitation increased during the analysed 50-year period and is interpreted as one of the major drivers for tundra encroachment in the Khibiny Mountains.

Combined tree community data and remote sensing data is an efficient method for detailed monitoring and cause-effect revealing. The remotely sensed data gave precise information on the total changes of the ecotone, while the establishment data provided detailed information on the dynamics of these changes and indications of major drivers. This is necessary knowledge for fine-tuning of tundra encroachment scenarios into empirical based predictions at regional to circumpolar scales. Accurate mapping of the treeline ecotone and local/regional causal background is essential when coarser resolution remotely sensed data are used to analyse or monitor the circumpolar extension of the ecotone.

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