Controlling factors on larch growth in taiga-tundra boundary ecosystem

in northeastern Siberia

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[Abstract]

Eastern Siberia is an immense region which is covered by permafrost and larch dominated forest, with ecosystem playing an important role in regulating global climate through changes in water, carbon and energy cycle. Taiga-tundra boundary ecosystem in northeastern Siberia is one of most striking ecosystem not only because it covers an immense region but also because it is very sensitive to environmental change under Arctic amplification. It is therefore important to understand how this boundary ecosystem will change in future. For this better understanding, it is necessary to understand controlling factors on larch trees growth and distribution. Larch growth exhibits difference not only among the sites but also among the years. Among the sites, high soil moisture and low N availability are expected to limit larch growth. Among the years, high soil moisture, cloudiness and high air temperature are expected to limit larch growth. During the growing season of each year from 2009 to 2013, field observations and samplings were conducted to measure photosynthesis, tree size, nitrogen (N) content, and isotopic ratios in larch needle and stems as well as environmental factors including topography, soil moisture and soil N at four sites, different in trees density and

topography level, distributed in the Indigirka River Basin, near Chokurdakh (70°37′N,147°53′E), northeastern Siberia.

Most living larch trees grow on mounds with relatively high elevations and dry soils, indicating intolerance of high soil moisture. Spatial variation of needle $\delta^{13}C$ was positively correlated with needle N content and needle mass, and these parameters showed spatial patterns similar to that of tree size. These results indicate that trees with high needle N content achieved higher rates of photosynthesis, which resulted in larger amounts of C assimilation and larger C allocation to needles and led to larger tree size than trees with lower needle N content. A positive correlation was also found between needle N content and soil NH_4^+ pool. Thus, soil inorganic N pool may indicate N availability, which is reflected in the needle N content of the larch trees. Microtopography plays a principal role in N availability, through a change in soil moisture. Relatively dryer soil of mounds with higher elevation and larger extent causes higher rates of soil N production, leading to increased N availability for plants, in addition to larger rooting space for trees to uptake more N.

Inter-annual variation in needle N content showed similar pattern to that of July air temperature and needle N content in the year was positively correlated with current year stem $\delta^{13}C$ and following year needle $\delta^{13}C$ and needle mass. A positive correlation was also found between July air temperature and sun hours. Year to year variation in needle N content may depend on the uptake and allocation of N. Observed results are interpreted as follows: in the year with high July air temperature, both needle N content and solar radiation are high, which cause high photosynthetic rate and lead to high $\delta^{13}C$ of fixed C. High photosynthetic rate may also cause large amount of fixed C, which is used for stem growth in the year, and high $\delta^{13}C$ of the current year stem. In the following year, this C with high $\delta^{13}C$ is used for needle production with large needle mass. Although the higher air temperature in the year has the potential to limit larch photosynthetic rate, year to year variations in needle and stem $\delta^{13}C$ and needle mass suggest that the limitation of high July air temperature on larch ability of C assimilation in the year is negligible. Wet event was observed in 2011 and continued until 2012. In 2012, low needle N content was observed at all sites with low July air temperature and low photosynthetic rate was also observed at the sites. On the other hand, needle $\delta^{13}C$ decreased from 2011 to 2012 at most sites, however, at the site *K tree wet*, where surface soil was waterlogged in 2011 and 2012, the needle $\delta^{13}C$ increased in 2012. These results indicate that high soil moisture leads to stomata closure, resulting in high $\delta^{13}C$ of needle in the following year.

Future climate changes in July air temperature, solar radiation as well as changes in micro-topography, soil moisture, and N availability would have great impacts on larch distribution and production in this ecosystem.