# 学 位 論 文 内 容 の 要 旨

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# 学 位 論 文 題 名

## Controlling factors on larch growth in taiga-tundra boundary ecosystem in northeastern Siberia

## 北東シベリアタイガーツンドラ境界生態系のカラマツの成長量規定因子に関する研究

Eastern Siberia is an immense region which is covered by permafrost and larch dominated forest, playing an important role in regulating global climate through ecosystem water, carbon and energy cycle. Taiga-tundra boundary ecosystem in northeastern Siberia is one of most striking ecosystem because not only it covers a larger area but also it is very sensitive to environmental change under Arctic amplification. It is important to understand future changes of this boundary ecosystem. For this better understanding, it is necessary to understand controlling factors of larch trees growth and distribution. Larch trees growth varies not only in spatial distribution but also in year to year, and high soil moisture, low N availability and cloudiness as well as high air temperature are expected to limit larch tree growth. To understand spatial and inter–annual response of larch tree growth to environmental change, field observations and samplings collection were conducted for 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, which are different in trees density and topography level, in the Indigirka River Basin, near Chokurdakh (70°37′N,147°53′E), northeastern Siberia, from 2009 through 2013 during the growing season.

In spatially, most living larch trees are found on mounds with relatively high elevations and dry soils, indicating intolerance of high soil moisture. 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 high photosynthetic rate, 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, suggesting that the soil inorganic N pool indicated N availability and reflected in needle N content of the larch trees. Microtopography plays a principal role in N availability, through changes in soil moisture. Relatively dryer soil of mounds with higher elevation and larger extent causes higher rate of production of soil N available for plants in the soil, and also provides larger rooting space for trees to uptake N. In conclusion, high soil moisture restricts larches on elevated mounds and N availability explains differences in C assimilation among the sites.

In year to year variation, similar patterns of stem $\delta^{13}C$ and needle $\delta^{13}C$ that lagged of one year were found at the sites, indicating that C in needle is derived from assimilated C in previous year. Needle N content, current year stem $\delta^{13}C$ and July air temperature that as an indicator of solar radiation displayed nearly the same patterns of year to year variation, which indicate that higher July solar radiation in the year contributes to higher N availability for larch, and that both higher N availability and higher solar radiation are necessary for larch to have higher productivity. Although the higher air temperature in the year limited larch productivity in some extent, this negative effect, however, is negligible during 5 years study. Waterlogging due to wet event occurred at the sites resulted in high soil moisture, which caused not only low needle N content but also low rate of photosynthesis, while needle $\delta^{13}C$ showed higher value and needle mass showed either higher or lower value, indicating that soil moisture increase complicates the use of needle $\delta^{13}C$ and needle mass in assessing larch productivity. Instead of needle $\delta^{13}C$, year to year variation in needle N content seems consistent with larch productivity. Finally, year to year variation in larch needle N content reflects changes in not only N availability for larch but also larch productivity, with both are controlled by changes in solar radiation and soil moisture.

Tree mounds with lower soil moisture are necessary for the survival of larch trees. In northeastern Siberia, permafrost with high ice content or pure ice is frequently present below tree mounds. Much higher air temperature and higher precipitation are anticipated for Arctic. If this ground ice melts, surface subsidence is likely to occur, which will lead to expansion of wet areas and to a possible reduction in areas supporting larch trees. Even if subsidence is limited to areas around tree mounds, reduced mound area may reduce rooting space and therefore cause decreased N availability, resulting in a decline in larch productivity. If tree mound subsidence does not occur, the counteracting effects of higher July solar radiation and higher July air temperature on larches, and competition for soil available N between larch and soil microbes and other plants would determine larch trees productivity.