学 位 論 文 内 容 の 要 旨

博士（環境科学）　　氏 名 NOGOVITCYN ALEKSANDR

学 位 論 文 題 名

The effect of the extreme wet event on the larch forest ecosystem in northeastern Siberia
(北東シベリアのカラマツ林生態系に及ぼす湿潤イベントの影響)

Extreme wet events are predicted to be more frequent and intensive worldwide, especially in northern regions under Arctic amplification. The taiga ecosystem in northeastern Siberia, a semi-arid and nitrogen-limited ecosystem on permafrost, has changed under such event in 2007. This study aims to investigate how larch forest conditions varied historically (Nogovitcyn et al., under preparation) and spatially a decade after the extreme wet event (Nogovitcyn et al., 2022).

Observations were conducted at the Spasskaya Pad Forest station (62°25' N, 129°62' E) near Yakutsk, Russia. In the summer of 2018, a transect (60 m × 510 m) with 34 plots (30 m × 30 m) was set. The plots were visually divided into four forest types: typical forest (TF) unaffected by the extreme wet event, and three affected ones in order of a damage level, regenerating forests RF-1 and RF-2, and damaged forest (DF), where all trees died. The forest conditions in the four forest types were determined by a satellite-derived proxy of above-ground production, normalized difference vegetation index (NDVI, a forest greenness) calculated from Landsat images with a spatial resolution of 30 m, and the field-observed measurements. To study historical variations in 1999-2019, seasonal peak TF NDVI in the transect was compared with the ecosystem parameters at TF out of the transect, such as tree-ring width index (RWI), soil moisture water equivalent (SWE), carbon and nitrogen stable isotopes ($\delta^{13}C$ and $\delta^{15}N$) and ratio of carbon and nitrogen contents (C/N) of larch needles. To examine spatial variations after the wet event, seasonal variations in NDVI of the four forest types and needle $\delta^{13}C$, $\delta^{15}N$, and C/N obtained from 105 mature larch trees were investigated in 2018.

Historical variations in NDVI in 1999-2019 showed a large difference among the forest types after 2007, especially between TF and DF, because of a high tree mortality under an extremely high SWE and a presence of water lowering NDVI. The temporal correlations revealed that, before the wet event, needle production in the typical forest (TF NDVI) was positively related with the hydrological conditions (SWE) in the previous summer and current June, and the tree-ring growth (RWI). In this semi-arid (dry) region, larches used the previous-year soil water to make photosynthate (carbon assimilated by photosynthesis) for preparing needles and wood in the current year and used the early summer soil water for elongation of needles in the current year. Besides, TF NDVI showed significant positive correlations with needle N content (or negative one with C/N) and $\delta^{15}N$ in

1999-2006, that was a new finding for this ecosystem. Under a suitable soil moisture condition, the production of soil inorganic N and, consequently, the production of larch needles may be increased. However, after the wet event in 2008-2019, the temporal correlations between the TF NDVI and SWE in the previous summer and current June were shifted from positive to negative ones, while the positive relationship between TF NDVI and needle N content (or the negative one between NDVI and C/N) remained in 2008-2018. During the period, an extremely high soil moisture may had caused an inactive soil inorganic N, anaerobic-stress-induced root damage and/or production of soil phytotoxins, which decreased the nitrogen uptake and plant growth. The needle $\delta^{15}N$ was generally decreasing from 2005, that can indicate that larches used less inorganic nitrogen from deeper soils, which usually has higher $\delta^{15}N$. The needle $\delta^{13}C$ was found to be strongly dependent on the previous-August SWE for the entire observation period 1999-2019.

Spatial variations in NDVI in 2018 revealed that the affected plots had a lower NDVI than the intact plots, resulting from a difference in tree stand density. In addition, the stand density is suggested to be a controlling factor in the spatial variations in the foliar C/N and $\delta^{13}C$ values based on their significant relationships with the NDVI in June. It was concluded that the larch trees from the regenerating forests on the affected areas have a higher nitrogen level and light availability (relatively low C/N and high $\delta^{13}C$) because of the slight competition for resources, owing to a low-stand density.