Role of understory vegetation on net ecosystem exchange of water and CO_2 at larch forest in eastern Siberia

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This study investigated evapotranspiration (ET) and CO_2 exchange over larch-dominated forests in the middle part of the Lena basin, eastern Siberia. Forest ecosystem in this region is characterized by low precipitation, a short growing season, and extensive permafrost. Seasonal thawing permafrost supplies soil water, which is prevented to infiltrating by an impermeable frozen layer, and supports forest development. Recently, expanding summer thawing depth and unusually wet soil layer maintained for a few years at larch forest observation sites caused decline of larch trees (Iijima et al, 2014) and would have affected the water and carbon flux of ecosystem scale (Ohta et al., 2014). To investigate vulnerability of the larch dominant forest faced to too wet condition, we analyzed water and CO_2 fluxes observed with eddy covariance methods inside and over the forest from 2004 to 2013.
The study site is the Spasskaya Pad station (62° 15´N, 129° 14´E) on alluvial terrace near Yakutsk. The mean annual air temperature and mean annual precipitation (1986–2004) at this site were −9 ºC and 256 mm, respectively. In tower site, soil water of active layer is high after unusually high precipitation (compared with the previous 20-year average) in two successive summers, and soil layer close to the ground surface was almost saturated around 2007-2009. The dominant species of the upper canopy is larch (Larix cajanderi), while development of birch (Betula platyphyila) and willow (Salix bebbiana) is remarkable during this decade. The understory was covered with dense cowberry (Vaccinium vitis-idaea). Through the wet period, 19 of 212 larch trees on 2500 m^2 area became dieback, and grasses and shrubs with a high water tolerance have invaded this site.
A decadal observation of hydro-meteorological variables shows inter-annual variability including extreme environmental conditions such as unusually wet active layer, which was maintained for a few years. Some mature larch trees locating poor drainage area suffered wet damage, while young birch and willow trees developed and herbs with water tolerance expanded. Compared to the fluxes of the whole ecosystem, those based on the understory layer changed through the study period due to increase biomass and change of inside canopy environments; plentiful light and soil water, and enhanced turbulent mixing. Evapotranspiration from the understory layer increased and contribution to the whole forest flux reached 60%. Although this layer always acts as CO_2 source in seasonal average through the study period, source strength weaken and changed to temporal sink in the early summer (June). On contrast, contribution of the larch layer, in spite of remaining uncertainty in quantity, decreased in both of evapotranspiration and CO_2 uptake. Interactions between larches and understory vegetation would support this forest ecosystem. Decline of larch contribution is made up by understory growing, resulting in relatively stable whole forest exchange rate at least until this wet event.
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Reference:
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Ohta et al., 2014. Effects of waterlogging on water and carbon dioxide fluxes and environmental variables in a Siberian larch forest, 1998-2011. Agric. For. Meteorol. 188, 64-75.

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