



The response of *Picea crassifolia* forest to climate warming

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Picea crassifolia forest, an endemic genus mainly distributing in the Qilian Mountain of Northwest China, is very sensitive to climate warming. In the present study, the response of treeline, phenological period, and sap flow of *P. crassifolia* forest to climate warming were analyzed through a set of observations and experiments. The result showed: (1) During the past 50 years, the temperature had raised at a mean rate of 0.29°C per decade in this region, especially since 1980s (had increased by a total of more than 1.25°C), obviously higher than increment degree IPCC reported. This resulted in the increase of tree recruitment which was significantly positively correlated with the mean growing season temperature and with the mean minimum temperature in June and in winter. Treeline elevation shifted upward by 5.7 to 13.6 m from 1907 to 1957 and by 6.1 to 10.4 m after 1957. (2) By quantifying the canopy phenology events based on satellite-derived datasets (MODIS-NDVI) from 2001 to 2011, and investigating the correlation with climate factors, a conclusion had been drawn which revealed a 3.7 days/decade advance in the length of growing season. Our results suggested that temperature controlled treeline dynamics and phenological period more strongly than precipitation in the Qilian Mountains. (3) In the case of experimental warming (mean daily temperature was increased 0.83°C, mean daily maximum temperature was increased 4.7°C), the trend for the mass growth of *P. crassifolia* sapling presented a notable increase under conditions of warming, especially for tree height. The data of sap flow showed that warming facilitated the sap flow of sapling in the end of growing season, which indicated the temperature was a major restriction to sap flow rate, especially in the condition of lower temperature.