Moisture Controls Growth of Birch at Upper Timberline in Southern Himalayas

Birch (*Betula*) trees and forests are widely distributed across much of the temperate and boreal zones of the Northern Hemisphere. Despite being an ecologically significant genus, it is not well studied compared to other genera like *Pinus*, *Picea*, *Larix*, *Juniperus*, *Quercus*, or *Fagus*. Prof. LIANG Eryuan and his colleagues from the Institute of Tibetan Plateau Research (ITP), Chinese Academy of Sciences have been using the widespread Himalayan birch (*Betula utilis*) in the southern Himalayas to study the controlling factors over its growth.

A series studies supported that low growing-season temperature limits tree growth at arctic and alpine timberline and controls timberline formation, so called "the growth limitation hypothesis". "As precipitation in the Nepalese Himalayas decreases with increasing elevation, we hypothesized that the growth of birch at the upper timberlines between 3,900 and 4,150 m above sea level is primarily limited by moisture availability rather than by low temperature," Prof. LIANG said.

To verify this assumption, Prof. LIANG and his PhD candidate Binod Dawadi, facilitated by the Key Laboratory of Tibetan Environment Changes and Land Surface Processes and the Third Pole Environment Kathmandu Center, have conducted a wide range of survey along the southern Himalayas to take tree rings from a total of 292 increment cores from 211 birch trees at nine timberline sites for dendro-ecological analysis (Fig. 1).

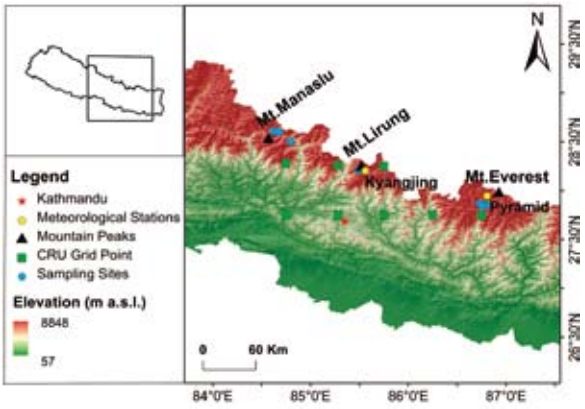

Fig. 1. Location of Himalayan birch sampling sites, CRU grid points as well as high-elevation meteorological stations at Kyangjing in the Langtang valley and at Pyramid in the Mt. Everest area in the Nepal Himalayas.

Taking tree-ring cores from birch in the Sagarmatha National Park in May 2012.

Tree ring patterns showed the synchronous occurrence of narrow rings and the high interseries correlations within and among sites, which evidenced a reliable cross-dating and a common climatic signal in the tree-ring width variations. The researchers found a stronger control of precipitation during spring (March-May), when all nine tree-ring width site chronologies showed a strong positive response to precipitation, and negative to temperature in March-May (Fig. 2).

They also compared the tree ring patterns with the instrumental meteorological record (from 1960 to the

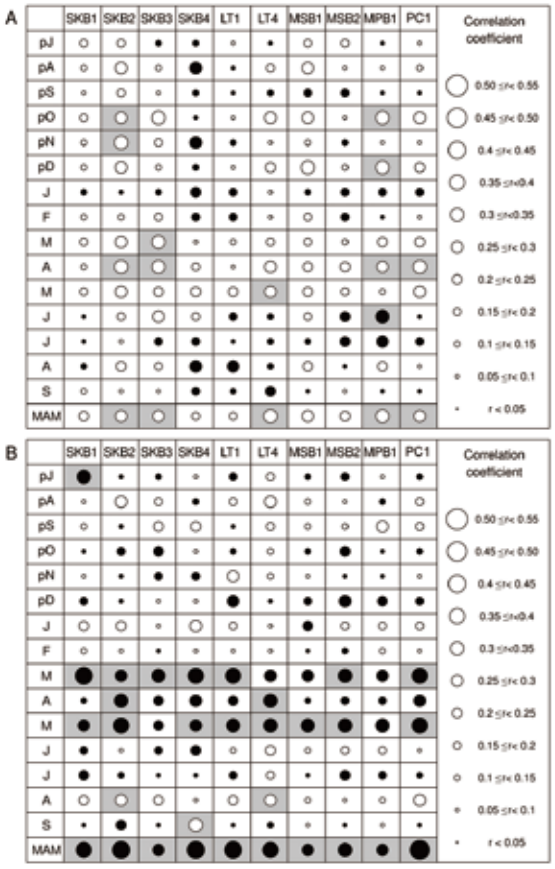

Fig. 2. Correlations between nine standard ring-width chronologies, their first principal component (PC1), and monthly mean temperature (A) and monthly sum of precipitation (B) from July of the previous year to September of the current year. pJ-pD signify July-December of the previous year; MAM means the mean temperature and the sum of precipitation from March to May in A and B, respectively. Black circles indicate positive and empty circles negative correlations. Background shading represents significance on the $p < 0.05$ level. The circle size shows the strength of correlation whereby the smallest circle denotes $r < 0.05$ and the largest circle denotes $0.50 \leq r < 0.55$, with an interval of 0.05.

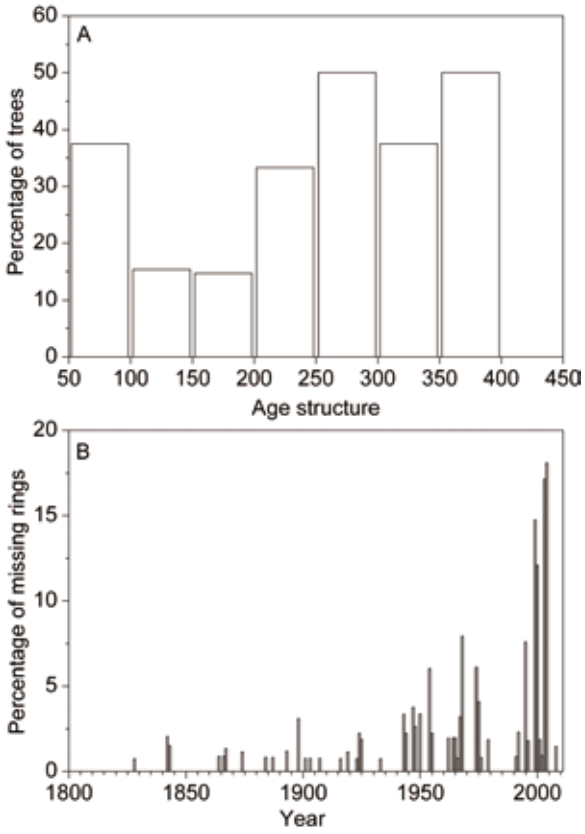

Fig. 3. Percentage of trees with locally missing rings in 2004 in different age classes (A), and frequency of locally missing rings since AD 1800 at the nine study sites (B).

present), and found that years with a high percentage of locally missing rings coincided with dry and warm pre-monsoon seasons (Fig. 3). Thus, Himalayan birch at its upper distribution boundary is increasingly at risk of survival and down-slope range shifts in response to global-change-type droughts. Besides, periods of below-average growth in birch were in phase with well-known drought events over monsoon Asia. Both evidences thus pointed to a new understanding that Himalayan birch growth at the upper timberlines is persistently limited by moisture availability. This study questions the general validity of the growth limitation hypothesis and allows the development of a more differentiated view of the causes of global alpine timberlines than was possible until now.

This study has been accepted by the Ecological Society of America for publication in *Ecology* (http://dx.doi.org/10.1890/13-1904.1).

Typical abrupt treeline of Himalayan birch in the Sagarmatha National Park. (Photo courtesy LIANG Eryuan)