A New Tree-Ring Network from Nepal

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Abstract:

46 ring-width chronologies from the highlands of Nepal are presented along with details of these chronologies', over all, performance as proxy-climate, network data. These chronologies represent a collaborative effort by many independent researchers over many years of collecting. Eight Himalayan tree species are represented in this collection Silver fir (Abies spectabilus), Himalayan hemlock (Tsuga dumosa), West Himalayan spruce, (Picea smithiana), Chir pine (Pinus roxbughii), Blue pine (Pinus wallichiana), Himalayan poplar (Populus ciliata) and Himalayan Elm (Ulmnus wallichiana). Initial examination of these data strongly suggests year to year variability is a function of extreme geographical determination, as well as, climatic variability.

The Network:

The initial collection, responsible for the present Nepalese network, originated from the impressive work of Rudolf Zuber. Zuber made 25 collections of increment cores from the highlands of Nepal (Schweingruber 1996). The first dendrochronological examination of ten of Zuber's 25, site collections appears in Bhattacharyya et. al., 1995. In 1996, Dr. Fritz Schweingruber, Swiss Federal Institute of Snow and Forests contributed Rudolf Zuber's entire increment core collection for our use in this research. Dr. Berghart Schmidt, University of Koln contributed six collections and one collection appears courtesy of Dr. Narendra Raj Khanal, Tribhuvan University, Kathamndu, Nepal (Schmidt 1993, Khanal 1998). Between 1993 and 2000, 26 new collections were added to the above contributions and seven, of Zuber's original 25 collections, were updated to the present.

Figures 1(A-I) illustrates the location and distribution of all 46 tree-ring chronologies by species. From this illustration one sees the broad and narrow east/west distribution of the sites. It is also apparent, from Figure 2, that the majority of sites are clustered about Nepal's highest summits. The maps in Figure 2 also give the illusion of a seemingly tight clustering amongst sites. This impression is largely due to the extreme topographic relief of the Himalaya. Two adjacent sites on the maps in Figure 2, a tenth of a degree apart, may have a 7,000 m. peak between them. Orographic conditions on such a scale can create entirely different climatogical conditions within short, distances.

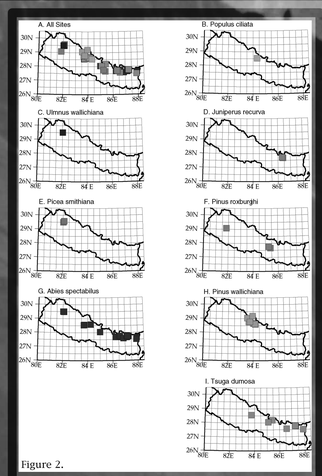

Figure 2.
Locations of all LDEO, and contributed, tree-ring sites from Nepal (A), Populus ciliata (B), Ulmnus wallichiana (C), Juniperus recurva (D), Picea smithiana (E), Pinus roxburghii (F), Abies spectabilus (G), Pinus wallichiana (H) and Tsuga dumosa (I).

The Tree Ring Data

All site chronologies were developed using a double-detrending method in program ARSTAN (Cook 1985). Initial ring-width, standardization began by fitting either a negative exponential or linear growth function to all ring-width measurements, then dividing the measurement values by the suitably chosen, growth trend values. This new increment core, index series was detrended a second time using a cubic spline constrained to preserve 50% of the within series variance at a wavelength of 67 years (Cook and Peters 1981; Cook 1985). Mean site chronologies were derived by averaging all the resulting, double detrended, increment core, index series into a site average (Figure 3). Figure 4 graphically illustrates basic chronology information for six, of the eight, species with two or more chronologies.
These box plots assist between species, chronology comparisons. Each box plot in Figure 4 contains the median value (horizontal line), the 25 and 75 percentiles (top and bottom of the box), the 5th and 95th percentiles (whiskers) and outlying data points (open circles). For many of the same collections and species, as reported in Bhattacharyya et.al., 1995, the range in values of mean sensitivity, mean RBAR, standard deviation, and auto-correlation are the same. These characteristics are consistent with those one would expect from high elevation conifers. The two exceptions being P.wallichiana and P. roxbughiiI, which are exclusively arid-site species. The common signal strength is also strongest amongst the pine species and weakest amongst the Tsuga, Abies and Juniperus. By contrast to all Pinus collections, the Abies, Juniperus and Tsuga collections are from moderately to extremely dense, mixed stands.

Figure 2 shows how the network, site locations correspond to both extant physiographic and climatological divisions of Nepal. Derived solely from observations of plant communities, the majority of sites in this network are located in the "Middle" or "High-Mountain" zones of the Himalaya (Stainton 1972). From a recent examination of 49 temperature and 78 precipitation, station, data records all but two sites are in the "Himalayan" or "Trans-Himalayan" climatic zones (Shrestha, A.B 1999, 200). The two exceptions are sites BKPR (Bhaktapur, Pinus roxbughii) and NGPR (Nargarjun, Pinus roxbughii) located in the sub-tropical, "Middle Mountain" zone. What is most obvious from these illustrations are how physiological divisions parallel climatic divisions.

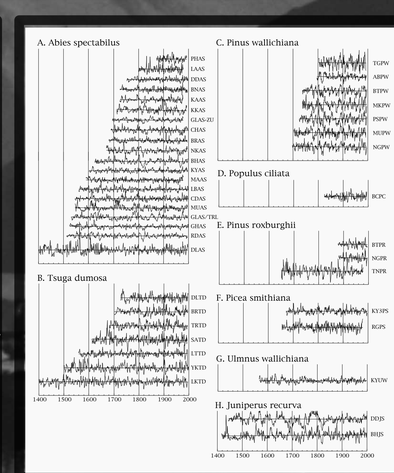

Figure 3.
46, standardized, ring-width, ARSTAN, chronologies from Nepal. The x-axes for all plots are the same. Abies (A), Pinus w. (B), Tsuga (C), Populus (D), Pinus r. (E), Picea (F), Ulmnus (G) and Juniperus (H).

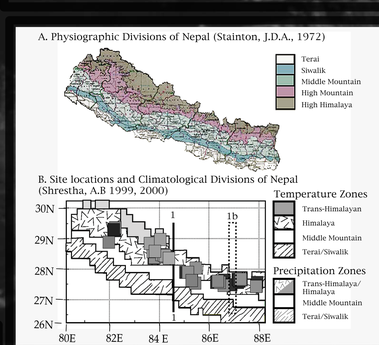

Figure 2.
The physiological and climatological divisions of Nepal, (A) as derived by observations of plant communities, (B) as derived from analysis of modern meteorological, station data.

Conclusions:

Two multi-centennial reconstruction's of February-June and October-February temperatures, from 33, out of the 46 chronologies presented in this paper, have recently been produced (Cook, E.R. et. al., in prep.) This work confirms the existence of meaningful climate information in these chronologies and demonstrates the network's sensitivity to extreme high-and low frequency variability. Further analysis will focus on the study of individual site reconstructions in an attempt to verify the interpretations presented in this experiment.
In conclusion a new, collaborative, collection of chronologies from Nepal represents a significant advance in developing a region-wide network of high resolution, paleo-records from High Asia.

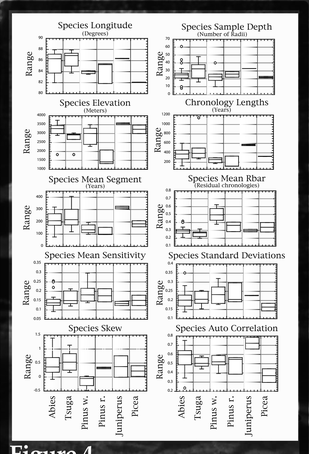

Figure 4.
Box plots summarizing significant chronology and site descriptors. The x-axes for all plots are the same and each box, within a plot, contains the median value the 25 and 75 percentiles the 5th and 95th percentiles (whiskers) and outlying data points (open circles).

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