Treeline Dendroclimatology in the North American Tropics

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Tropical treelines typically occur at the highest elevations among all forest ecosystems. Paleoenvironmental and paleoclimate research in those mountains is particularly needed because of the tropics' importance for the global hydrological cycle, and the scarcity of multi-century, annually resolved climatic information from tropical land areas. Current studies on treeline dendroclimatology of the North American tropics are being conducted at the Department of Geography of the University of Nevada, Reno, in cooperation with the Centro Universitario de Investigaciones en Ciencias del Ambiente de la Universidad de Colima, and the Patronato del Nevado de Colima y Cuencas Adyacentes A.C. Funding has been provided from the Paleoclimatology Program of the U.S. National Science Foundation and of the U.S. National Oceanic and Atmospheric Administration. Research efforts to date have focused on *Pinus hartwegii*, which grows at elevations higher than 3000 m in Mexico and Central America (McVaugh 1992). Wood growth is characterized by very clear, distinct layers, whose variability resembles that of other treeline species, and is high enough for crossdating (Fig. 1). Initial results point to North American monsoon precipitation as the main climatic signal present in a 400-year tree-ring chronology from Nevado de Colima, Mexico (Fig. 2; Biondi 2001). This differs from the prevailing view that dendrochronological records from timberline environments are mostly indicators of temperature changes, but current paradigms on treeline processes have been developed from studies conducted mostly at high latitudes, or at high elevations in mid-latitudes, and may not be applicable to tropical treelines (Lauer 1978).

A suite of geoecological research activities is underway to clarify how environmental factors affect, and can then be reconstructed from,

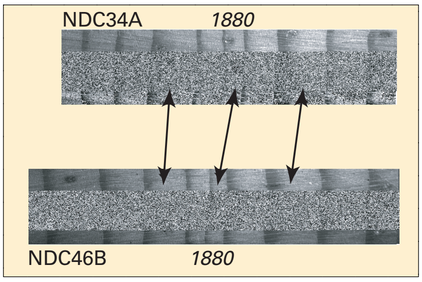

Fig. 1: Crossdating Pinus hartwegii core samples from Nevado de Colima, Mexico. Interannual variability is high enough to match ring patterns across samples, and this, in itself, is an indication that annual ring-width variability reflects climatic patterns.

Pinus hartwegii wood increment. First, a weather station was installed in May 2001 on Nevado de Colima to monitor treeline weather patterns at half-hour intervals (Fig. 3). Second, the length of the growing season, and the relationship between stem growth and climate at daily to weekly timescales, is being investigated at two sites using automated electronic sensors for recording wood increment and environmental parameters (Fig. 4). Sites are within a 1-km radius from the weather station, one at 3790 m elevation, on a 25% slope with west-northwest exposure, the other at 3780 m elevation, on a 58% slope with north-northeast exposure. Sensors at each site consist of 1 phytogram per tree (7 at site 1, 8 at site 2), 3 band dendrometers and 11 point dendrometers, 1 air temperature sensor, 1 PAR sensor, 4 soil temperature probes, and 7 soil moisture probes. One point dendrometer per tree was placed about 1.7-1.8 m above the ground on the south facing side of the stem after shaving most of the bark underneath the sensor. On a few trees, 1-2 more point dendrometers were installed on the north-facing side or without removing the bark or at higher levels to provide comparisons. Measurements began in May 2001, and it will take at least 2-3 years before reliable results will be available. Every effort has been made to involve local researchers, authorities, and forestry personnel to minimize the risk of vandalism on field equipment.

Additional studies being conducted on Nevado de Colima include testing for genetic differences between pine populations at different elevations, and examining

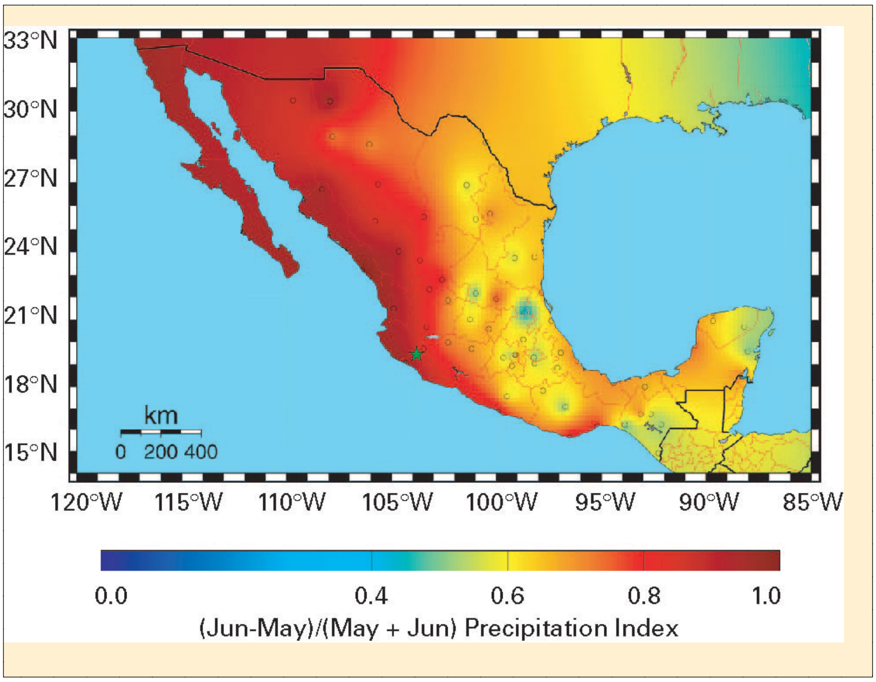

Fig. 2: Map of the precipitation index used to highlight areas in Mexico where monsoon rainfall begins in June, including Nevado de Colima (green star).

tree growth response to the 1913 eruption of the nearby Volcán de Colima (Martin del Pozzo and Sheridan 1993). Field observations have shown that trees at the edge of treeline (about 4000 m elevation) are 2-3 centuries younger than those 200-300 m below, and laboratory analysis has revealed peculiar features in the wood anatomy of upper treeline individuals. Therefore, two sites were sampled for isozyme analysis by clipping a branch terminal shoot from each of 50 trees per site. One site was at about 4000 m elevation, the other was within 1 km of the weather station, at about 3750 m elevation. Sampled trees were at least 25 m from each other, and in good health. Genetic analyses have not shown significant differences between the two pine populations (Constance I. Millar and Robert D. Westfall, Pacific Southwest Research Station, USDA Forest Service, Albany, California, pers. comm.). Spatial information on the impact of the 1913 Plinean eruption of Volcán de Colima on treeline forest growth is being generated by quantifying the 1913-14 wood growth reduction that is clearly evident in most *Pinus hartwegii* tree-ring records. Of 63 dated and measured wood increment cores that included those two years, 22 had no visible ring in 1913, and 8 were missing the 1914 ring as well.

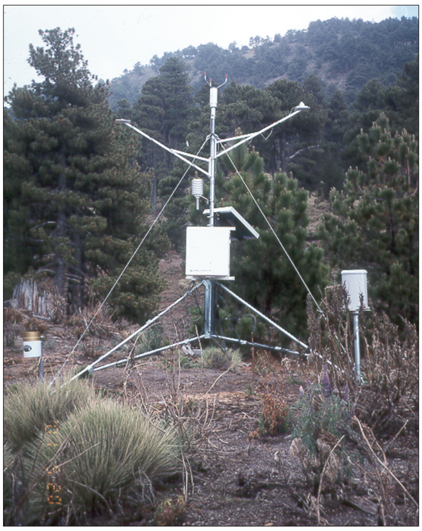

Fig. 3: Automated weather station at 3760 m elevation on Nevado de Colima, Mexico (Photo F. Biondi).

Fig. 4: Phytogram (cable at lower right), band dendrometer (upper instrument), and point dendrometers (middle and lower left instruments) installed on a Pinus hartwegii stem. The point dendrometer in the middle measures radial changes outside bark, whereas the outer bark was shaved underneath the lower left point dendrometer (Photo: P.C. Hartsough).

Other activities are aimed at obtaining a clear representation of North American monsoon patterns in the region. Precipitation and temperature records provided by the University Corporation for Atmospheric Research include a total of about 200 stations throughout Mexico, and the data is being analyzed for spatial and temporal patterns, especially in relation to the onset of monsoon rainfall. Monthly precipitation indices and geostatistical techniques are being used to identify regions characterized by May, June, and July climatological onset of the summer rains (Fig. 2). Future research will concentrate on developing stable isotope and microdensitometry chronologies from *Pinus hartwegii* tree rings. Using Nevado de Colima samples, a preliminary $\delta^{18}O$ time series has been developed for the 1952-97 period, and microdensitometric records have been generated at the Laboratory of Tree-Ring Chronology, University of Arizona, Tucson, using a total of 18 segments from 9 trees. Additional tree-ring records from that site, and from other high peaks of Mexico and Central America, are slated for collection and analysis in the coming year.

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