

High Elevation Monitoring in the North American Tropics: Ecosystem/Climate Relationships on Nevado de Colima, Mexico

Peter Hartsough¹, Franco Biondi^{1,2} ¹ Graduate Program of Hydrologic Sciences, University of Nevada, Reno, phartsou@unr.nevada.edu, ² Department of Geography, University of Nevada, Reno, fbiondi@unr.edu

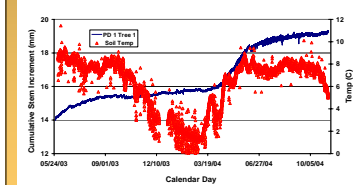
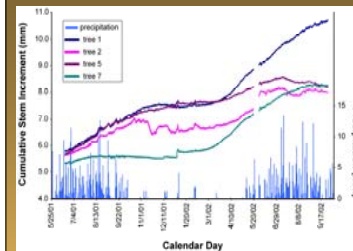


Introduction

High elevation monitoring in the tropics is uncommon. Presented here are the 2001-2004 results of an intensive field study from Nevado de Colima, Mexico. The site is at 3800 m at 19° 34' N, a few hundred meters below tree line. We have been co-monitoring weather and tree growth at half-hour intervals, as well as seasonally averaged stable isotopes throughout the hydrologic/biologic cycle. The site is under the influence of the North American monsoon, which determines a wet-summer, dry-winter climatic regime. Using point and band dendrometers, we have shown the response of high elevation *Pinus hartwegii* trees to changing weather patterns and attempted to pinpoint factors related to onset and cessation of growth in these high elevation tropical trees. Precipitation, temperature and relative humidity are shown to influence stem size at a range of timescales. Along with the stable isotope data collected to date, we hope to build a model of tree growth and stable isotope incorporation into tree-ring cellulose. This will allow a calibrated chemical reconstruction of seasonal growth response to fluctuations in the monsoon over the length of the tree ring record (>350yr). We also had the unfortunate experience of monitoring several of our instrumented trees during a round-headed pine beetle (*Dendroctonus adjunctus*) infestation following an exceptionally dry winter the year before. These data may provide additional insight into tree response to drought stress and physiological response to bark beetle attacks. Long term monitoring provides insight into the complex ecosystem response to global change.

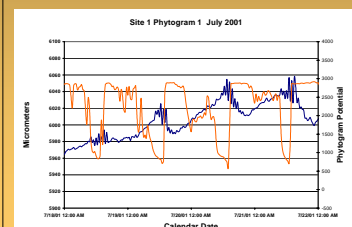
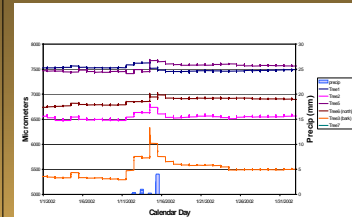


Results from Dendrometers



The dendrometers and phytograms show clear seasonal growth starting in April coincident with increasing temperatures and sustained growth with increased water availability during the Monsoon. Cessation of growth appears to be in October, coincident with the end of the Monsoon and the beginning of the tropical cyclone and winter precipitation regime. We were able to get the better part of three growing seasons of data from the site and had the unforeseen opportunity to collect dendrometer data of the growth suppression and eventual death of the trees due to a bark beetle (*Dendroctonus adjunctus*) infestation. Due to park beetle control efforts, sensors at Site 1, the infested site, were removed in November 2003. Site 2 and the weather station continue to collect data.

Stable isotopic analyses of the waters show a clear signal of different waters being used by the trees in cellulose formation. Early spring (pre Monsoon) is characterized by a low relative humidity and a high evaporation regime at the leaf surface. Results also show the trees using winter precipitation from relatively deeper soils. Post Monsoon is characterized by wet soils, high relative humidity, and very little enrichment at the leaf surface. Xylem samples show water use consistent with shallower soils.



Monitoring Network

The core portion of the monitoring effort was the installation of a weather station and a pair of dendrometer networks just below tree line at 3770 m (12,370 ft) on Nevado de Colima in May 2001. The weather station is measuring soil and air temperature, soil moisture content, RH, barometric pressure, insolation, wind speed and two precipitation gauges. The dendrometer networks consist of point and band dendrometers, phytograms and additional environmental sensors measuring tree growth at the same time scale. Each network consists of 7 instrumented trees in a fenced off plot. Replicate sensors are measuring growth at multiple locations on the same tree and inside and outside of the bark. While the dendrometers have performed well, we have had some problems with electrical activity taking out the dataloggers, leading to their replacement in June 2003.

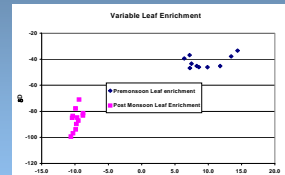
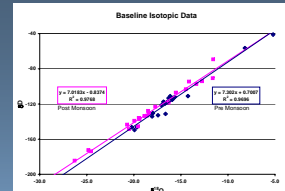
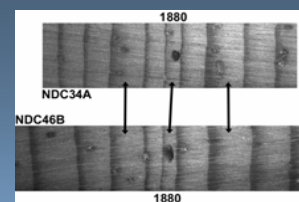
To further characterize the hydrologic and environmental regime the trees are growing under, two additional collectors were installed for precipitation chemistry in early 2003 and collection of spring samples has been going on since 2002. We have also carried out four isotopic characterization events, sampling soil, xylem and leaf water from pre and post Monsoon. Two of the sites are collocated with the dendrometer sites while a third is a comparison site on the west facing side of the mountain. Waters were extracted from soils and tissues using the toluene extraction method. We have also collected weekly and event based precipitation samples tracing the evolution of the monsoon at the Universidad de Colima



Mexico's forests have shrunk to a quarter of the size they were before the arrival of European colonists. The country has one of the highest deforestation rates in the world, losing about 1.5 percent of its forests and jungles -about 1.7 million acres- every year. The forests that remain are vulnerable to drought and insect attacks. Along with the loss of forests comes a major threat to catchments and watersheds. The protected area around Nevado de Colima is in the headwaters for both the America and Naranja rivers, both important drinking and agricultural water sources in the states of Jalisco, Colima and Michoacán.

Further characterization of the monsoon history will lead to more skillful forecasts of future climate scenarios and the associated ecosystem response. A better understanding of plant water relations will allow for the establishment of rainfall records which go beyond the historic record, using xylem anatomy, dendrochronology, and stable isotopes. The combination of different source waters and different evaporation regimes will clearly lead to different cellulose isotopic values at the sub annual level. The ring structure, clear early and latewood bands, will allow seasonal to sub seasonal division of the rings for chemical characterization. Cores will be subdivided into increments representing pre and post monsoon growth. Cellulose will be extracted from ring sub samples and analyzed for ¹³C, ¹⁸O and ²H variations within the yearly growth. It may be possible to reconstruct valuable information such as moisture sourcing and relative humidity. A better understanding of the Monsoon system - both temporal and physical- will be of great value for understanding hydrologic dynamics in the vast region watered by the North American Monsoon.

Future Work and Implications



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