

# Climate Change Response of Great Basin Bristlecone Pine in the Nevada NSF-EPSCoR Project ([www.nvclimatechange.org](http://www.nvclimatechange.org))

**Franco Biondi**, DendroLab, Department of Geography and Graduate Program of Hydrologic Sciences, University of Nevada, Reno, NV; and **Scotty Strachan**, DendroLab, Department of Geography, University of Nevada, Reno, NV

**Abstract**—Predicting the future of high-elevation pine populations is closely linked to correctly interpreting their past responses to climatic variability. As a proxy index of climate, dendrochronological records have the advantage of seasonal to annual resolution over multiple centuries to millennia (Bradley 1999). All climate reconstructions rely on the ‘uniformity principle’ (Camardi 1999), which assumes that modern natural processes have acted similarly in the past, and is used to calibrate proxy records of climate against instrumental observations (National Research Council 2006). The possibility has recently been raised that long proxy records of climate could be biased by the presence of periods during which relationships inferred from the instrumental period no longer hold, an issue that can potentially transform the entire discipline of paleoclimatology. One of the best known cases involves high-latitude tree-ring parameters (width and maximum latewood density) that used to correlate closely with air temperature, but have shown a ‘divergence’ from instrumental temperature data during the late 20<sup>th</sup> century (Jacoby and D’Arrigo 1995; Briffa et al. 1998). While multiple explanations have been provided for this phenomenon, they differ between regions and species, and have mostly been based on observational and correlation studies (e.g., Vaganov et al. 1999; Biondi 2000).

Especially for treeline environments in the western USA, the interpretation of tree-ring records has been severely limited by the lack of in-situ observations on hydroclimatic variables, and has had to rely on instrumental records interpolated from much lower elevations, often without the ability to correct for potential bias due to recent urbanization and land use changes. High-elevation Great Basin conifers, such as bristlecone pine, have provided some of the longest annually resolved and continuous records of air temperature (LaMarche Jr. 1978). Individual bristlecone trees growing within about 150 m of the upper treeline limit have reached unprecedented growth peaks in the last few decades (Salzer et al. 2009). This trend is matched by increased air temperature in PRISM data (Daly et al. 1994), which are generated by combining records from stations far away from treeline and potentially affected by various instrumental biases. Recently, a number of NSF-supported environmental observing projects have generated exciting opportunities to improve our understanding of the climatic sensitivity of these pine species.

The Nevada system of Higher Education, including the University of Nevada, Las Vegas, the University of Nevada, Reno, the Desert Research Institute, and Nevada State College have begun a five year research and infrastructure building program, funded by NSF Experimental Program to Stimulate Competitive Research (EPSCoR) with six major components: Climate Modeling, Ecological Change, Water Resources, Cyberinfrastructure, Education, and Policy, Decision-Making, and Outreach. As part of the new infrastructure, two observational transects are going

to be established across Great Basin Ranges, one in the Sheep Range (southern Nevada), and the other in the Snake Range (eastern Nevada), which will both encompass bristlecone pine (*Pinus longaeva* D.K.Bailey) treeline stands. A number of environmental parameters will be monitored at the transect locations, including atmospheric (barometric pressure, air temperature, relative humidity, wind speed and direction, precipitation, insolation, net radiation, snow accumulation, etc.), pedologic (soil moisture, soil temperature, hydraulic head, etc.), and vegetational (stem increment, sap flow, NDVI, phenological changes, etc.) ones.

Specific hypotheses can be tested at the sites, for example on how wood formation responds to climate. Some of the bristlecone pines used by Salzer et al. (2009) are found within the Nevada EPSCoR transects in the Snake Range. We will test the hypothesis that bristlecone growth is a record of mean air temperature by first using detailed field data on soil moisture, sap flow, and stem size to determine what controls the length of the growing season. Radial changes will be measured using point dendrometers to the nearest  $\mu\text{m}$  at half-hour intervals (Deslauriers et al. 2003; Biondi and Hartsough 2010). In addition, repeated microcore sampling can be combined with histological analysis to determine the timing of cambium activity, subdivision, elongation, and lignification of new xylem cells during the season (Rossi et al. 2006). Finally, field experiments could be set up using rainfall simulators (Mutchler and Moldenhauer 1963; Munn and Huntington 1976) to determine how bristlecone pine rings may reflect changes in, for instance, increased summertime precipitation compared to reduced snow cover. The combination of long-term monitoring sites with targeted field investigations is a powerful tool to achieve transformative scientific results in environmental science.

## References

- Biondi, F. 2000. Are climate-tree growth relationships changing in north-central Idaho? *Arctic, Antarctic, and Alpine Research*. 32, 111-116.
- Biondi, F., and P. C. Hartsough. 2010. Using automated point dendrometers to analyze tropical treeline stem growth at Nevado de Colima, Mexico. *Sensors*. 10, 5827-5844.
- Bradley, R. S. 1999. *Paleoclimatology*. 2nd ed. Academic Press, San Diego, CA.
- Briffa, K. R.; F. H. Schweingruber; P. D. Jones; T. J. Osborn; S. G. Shiyatov, et al. 1998. Reduced sensitivity of recent tree-growth to temperature at high northern latitudes. *Nature*. 391, 678-682.
- Camardi, G. 1999. Charles Lyell and the Uniformity Principle. *Biology and Philosophy*. 14, 537-560.

- Daly, C.; R. P. Neilson; and D. L. Phillips. 1994. A statistical-topographic model for mapping climatological precipitation over mountainous terrain. *Journal of Applied Meteorology*. 33, 140-158.
- Deslauriers, A.; H. Morin; C. Urbinati; and M. Carrer. 2003. Daily weather response of balsam fir (*Abies balsamea* (L.) Mill.) stem radius increment from dendrometer analysis in the boreal forests of Québec (Canada). *Trees*. 17, 477-484.
- Jacoby, G. C.; and R. D. D'Arrigo. 1995. Tree-ring width and density evidence of climatic and potential forest change in Alaska. *Global Biogeochemical Cycles*. 9, 227-234.
- LaMarche Jr., V. C. 1978. Tree-ring evidence of past climatic variability. *Nature*. 276, 334-338.
- Munn, J. R.; and G. L. Huntington. 1976. A portable rainfall simulator for erodibility and infiltration measurements in rugged terrain. *Soil Science Society of America Journal*. 40, 622-624.
- Mutchler, C. K.; and W. C. Moldenhauer. 1963. Applicator for laboratory rainfall simulator. *Transactions of the ASAE*. 6, 220-222.
- National Research Council. 2006. *Surface Temperature Reconstructions for the Last 2,000 Years*. The National Academies Press, Committee on Surface Temperature Reconstructions for the Last 2,000 Years. Washington, DC. 196 p.
- Rossi, S.; A. Deslauriers; T. Anfodillo; H. Morin; A. Saracino, et al. 2006. Conifers in cold environments synchronize maximum growth rate of tree-ring formation with day length. *New Phytologist*. 170, 301-310.
- Salzer, M. W.; M. K. Hughes; A. G. Bunn; and K. F. Kipfmüller. 2009. Recent unprecedented tree-ring growth in bristlecone pine at the highest elevations and possible causes. *Proc. Nat. Acad. Sci. USA* 106, 20348-20353.
- Vaganov, E. A.; M. K. Hughes; A. V. Kirilyanov; F. H. Schweingruber, and P. P. Silkin. 1999. Influence of snowfall and melt timing on tree growth in subarctic Eurasia. *Nature*. 400, 149-151.

---

The content of this paper reflects the views of the author(s), who are responsible for the facts and accuracy of the information presented herein.

---