Collecting *Pterocarpus erinaceus* samples from Senegal for dendroclimate analyses

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Introduction

Dendroclimatology is an important tool for extending instrumental records of climate back in time. Africa has very few published paleoclimate records, particularly with an annual resolution like those obtained from tree rings. However large portions of Africa are particularly susceptible to the deleterious effects of projected changes in rainfall variability and would benefit greatly from a detailed paleoclimate perspective. Senegal is situated just north of the equator in western Africa along the southern edge of the Sahara desert (Figure 1). As such it is in a highly vulnerable location with regards to shifting rainfall regimes. We propose to develop a dendro-climatology/ecology project in Senegal based initially on *Pterocarpus erinaceus* (Figure 2) for the study of past rainfall variability for the past 2 centuries or more. *P. erinaceus* is a close relative of *P. angolensis* which has been successfully used to reconstruct rainfall from Zimbabwe by Therrell et al. (2006) (Figure 3). Both species produce highly prized lumber and are therefore being increasingly exploited. In March of 2007 we supplied funds to a Columbia University student, Demetri Blanas, who was conducting fieldwork in Senegal for his senior thesis (supervised by Dr. Matthew Palmer), to collect *P. erinaceous* samples to evaluate for dendroclimatology. Mr. Blanas returned to the TRL on April 20 with 7 cross sections from recently felled trees that quite clearly exhibit ring formation to the naked eye (see Figure 2). He also collected a single cross section from a tree in the family Combretaceae, a family shown to exhibit ring formation in some species from Southeast Asia, and core samples from four other candidate species that have yet to be analyzed. Through his prior efforts in Senegal, he has connections with local foresters that enable him to collect samples from throughout this forested region. He also speaks fluent French and both local dialects, and will be spending a full year based in the region commencing in August of 2007. We propose to take advantage of this connection and Demetri's lengthy stay to collect additional samples of *P. erinaceus* from multiple locations and to monitor the species response to local climate, as well as record phenological information, over the upcoming year.

Research Plan

Therrell et al. (2006) found *P. angolensis* to be rather perplexing to work with due to the "camouflaging" of the rings when polished and under magnification, though they were able to successfully use this species after careful analyses. *P. erinaceus* appears to present similar challenges under magnification and we propose several low-tech solutions to working with these samples. We have begun experiments using image analysis on un-polished sections, and X-ray densitometry of microtome thin-sections in order to better identify ring boundaries in this species. Both methods show promise in this very early stage and we are fully equipped at the TRL for conducting these analyses. Senegal's forest resource, as is the case in many tropical locations, is rapidly being destroyed by

over-exploitation. We feel an urgent need to collect samples while we still can. While the most expeditious approach for this study is to cut sections from trees that are being exploited, we also wish to discourage the cutting of living trees. We therefore will try to core living trees where possible. Over the course of 21 days in August we plan to have Sarah Butler and Demetri Blanas sample as many sections of *P. erinaceus* as possible, and have S. Butler return to New York with them. We then hope to arrange for Mr. Blanas to continue sampling when possible, and to install temperature/RH loggers and an automatic rain gauge for monitoring climate over the upcoming year to compare with tree growth. We hope to leverage results from this pilot study into a full research proposal for a much more involved study.

Budget Request

Budget: $ 5,978	
Airfare (1 RT New York to Dakar, Senegal for S. Butler)	$ 1,650
21 days Per Diem x 2 people @ $50 per person per day	$ 2,100
Transport from Dakar to field sites and return	$ 500
Daily fee for 2 workers @ $20 per person x 21 days	$ 840
Temp-RH logger ($199) and Rain logger ($389)	$ 588
Shipping charges for wood samples	$ 300
TOTAL	**$ 5,978**

Budget Justification

We are requesting funds of $ 5,978 for this project, for travel to Senegal by TRL Research Assistant Sarah Butler to join Columbia University student Demetri Blanas to collect samples of *Pterocarpus erinaceus* from southeastern Senegal. We estimate per diem costs at around $50 per day, based on the experiences of Mr. Blanas on previous trips, including the costs of lodging and food from the time of arrival in Dakar to time spent in the field near Kedougou. We request funds for 21 days during the month of August 2007. We are requesting $500 to hire a vehicle and driver for the 16 hour drive from Dakar to Kedougu and return (see Figure 1). We also request funds for a logger that records temperature and relative humidity ($199), and an automatic rain gauge logger ($389) for recording daily climate near the site for the full year of Mr. Blanas' stay. We will use this information, along with phenological and other data collected on site, as leverage in a future proposal to continue this research. Finally, an additional $300 is requested for shipping samples back to New York, subsequent to S. Butlers return near the end of August.

Results from prior Climate Center Funding

Buckley, B.M. and Z. Cheng, 2005, $4,900.
Using X-Ray Fluorescence (XRF) for Rapid Dendrochemical Analyses: A Complement to ring Width and Density Chronologies for Studying Climate Variability?
We sent Paul J. Krusic, a Research Assistant in the Tree-Ring Lab, to Sweden to analyze

samples of several species with XRF technology on the current state of the art equipment for tree ring analyses in Hakan Grudd's lab in Stockholm. Due to time and money constraints for this pilot project, Paul was able to analyze three species, all from Thailand: *Tectona grandis, Pinus kesiya* and *Toona ciliata*. In the latter case we analyzed radii from three heights from a single tree that had fallen earlier in the year in west-central Thailand, to see if results were consistent in different parts of the stems. The aims of these test runs were to confirm two things; 1) could chemical signatures distinguish between true ring boundaries and "false" intra-annual bands? and 2) would any chemical signatures have meaning for possible paleo-climate applications. The results from this pilot study were encouraging in the former case, but for the second question we didn't have enough data to answer this question. We presented this work at the 7th International Conference on Dendrochronology in Beijing in June 2006, and we currently have a working manuscript in progress. We also used these results to help justify a request for an MRI proposal fronted by Dr. Cheng from Brooklyn College to purchase our own XRF system from Cox Analytic, that is an updated version from the one in Sweden. We await word on this proposal.

Buckley, B.M. and Z. Cheng, 2004, $5,300.
An exploratory study of arsenic in annual tree rings at an EPA superfund site in Vineland, New Jersey.
A summer internship (Beth Katz) was awarded in summer 2004 for this project. A manuscript is now in press (Cheng, Z., B.M. Buckley, B. Katz, W. Wright, R. Bailey, K.T. Smith and A. Van Geen (2007). Arsenic levels and radial profiles in tree rings from a historically contaminated site. *Science of the Total Environment*, doi: 10.1016/ j.scitotenv. 2007.01.074). Our summer intern assisted with the chemical analyses on tree ring samples from the arsenic contaminated superfund site at Vinelands, New Jersey, to look for chemical signatures in the annual rings of trees. We were able to successfully detect elevated levels of arsenic from trees in the contaminated soils, compared with trees from control sites that were not contaminated. This work has led us to pursue further dendrochemistry research, to analyze uptake from sites with contaminated soils and to better understand the pathways of transport in living stem tissue. To this end we have been collaborating with a renowned physiologist and pathologist from the USFS in New Hampshire, Dr. Kevin Smith, who was co-author on our paper and has conducted much research on dendrochemistry. This project also led us to the conclusion that wet chemistry techniques are not practical for this type of research and therefore led directly to the XRF proposal listed above and a whole new avenue of research.

Buckley, B.M. and G. C. Jacoby, 1998/99. **$ 3,300**
Re-sampling birch trees from southern Greenland for dendroclimatic analyses.
We sent a graduate student, Matt Arsenault from the University of New Hampshire, to southern Greenland to sample birch trees that had been sampled in the 1980s. Matt was working in Greenland with the Climate Change Research Center at UNH, so we sent him to sample for us. He had lots of trouble with weather and transport into the region, so the samples brought back, while adequate for updating the chronologies to the present, were of marginal use for our dendroclimate work. However the chronologies have been built and are archived in our internal TRL database of global tree ring chronologies.

Figures:

Figure 1. Map of Senegal (center) and it's relationship to Africa (left) and the rest of the globe (right). The red line shows roughly the route of travel overland from Dakar to Kedougou that requires hiring a vehicle and driver and takes about 16 hours. The red circle denotes the primary area of sampling trees for analyses.

Figure 2. Two views of a section of *Pterocarpus erinaceus* from Senegal collected in March 2007 by D. Blanas showing visible ring structure.

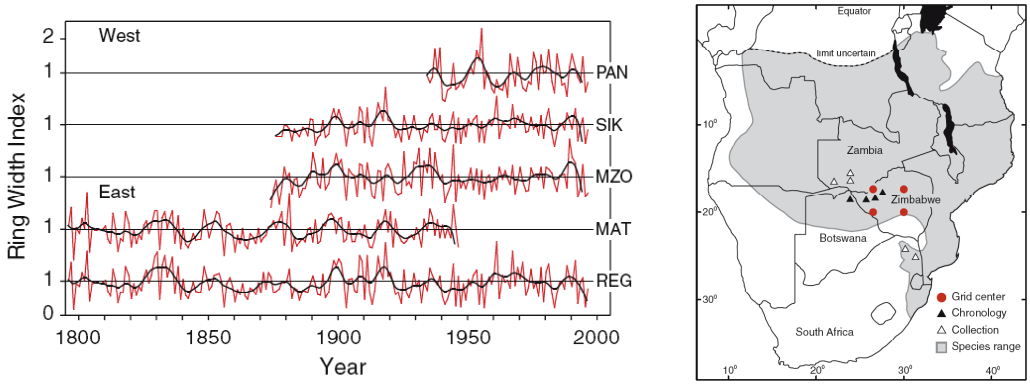

Figure 3. *Pterocarpus angolensis* chronologies (left) and map of sampling locations (right) from Zimbabwe from Therrell et al. (2006).

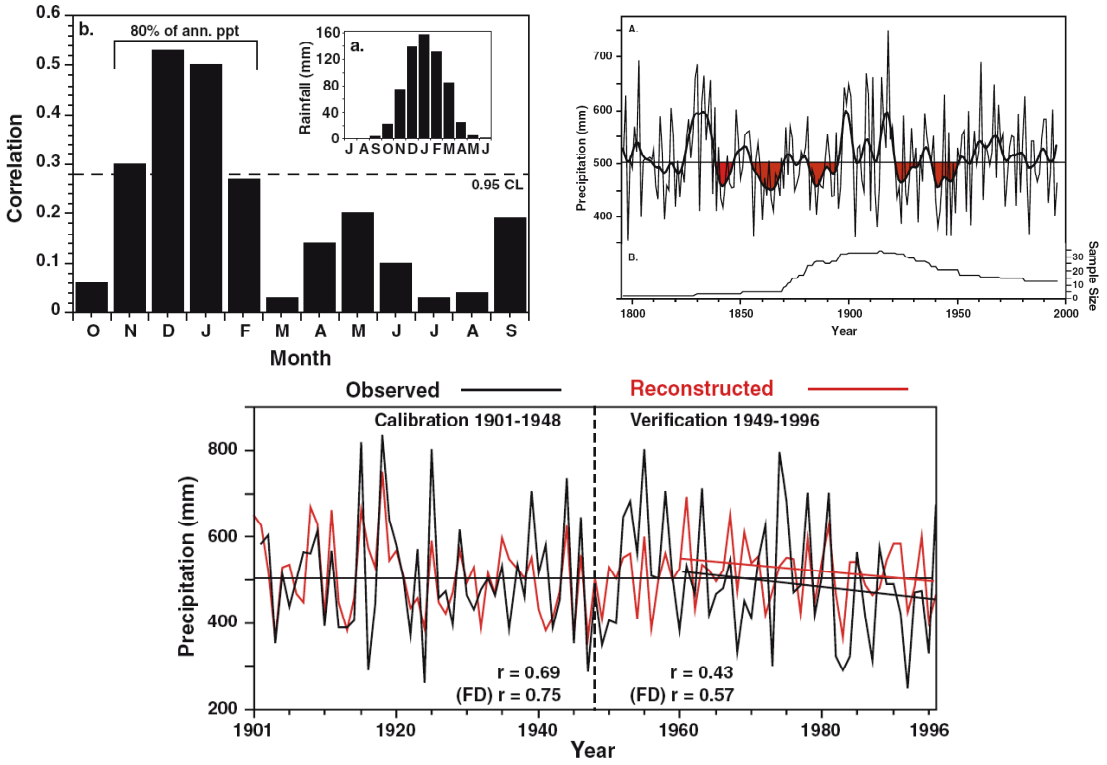

Figure 4. Plots from the Therrell et al. (2006) study on *P. angolensis*, showing the correlation functions with monthly rainfall (top left) and a calibrated and verified reconstruction of rainfall (top right) that explains XX% of the variance in the instrumental record. The bottom plot shows the split calibration-verification for the rainfall reconstruction based on the total period of 1901-1996.

References:

Therrell, M.D., D.W. Stahle, L.P. Ries and H.H. Shugart (2006). Tree-ring reconstructed rainfall variability in Zimbabwe. *Climate Dynamics*, 26: 677–685, DOI 10.1007/s00382-005-0108-2.