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STATUS REPORT

LOST AND FOUND: THE BRISTLECONE PINE COLLECTION

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INTRODUCTION

A unique relationship between researchers at the Laboratory of Tree-Ring Research (LTRR) and the bristlecone pine, *Pinus longaeva* (Bailey 1970), has existed for over 50 years. Not only is the bristlecone pine collection vast, samples from the collection have been used by a variety of researchers to investigate many scientific topics over the years (Figure 1). From Edmund Schulman and C. W. Ferguson creating and extending bristlecone pine chronologies and aiding in the calibration of radiocarbon in the early days of bristlecone studies to bristlecone pine phenology studies by Hal Fritts to V. C. LaMarche and D. A. Graybill investigating new sites, soil erosion, frost rings, and carbon dioxide fertilization, bristlecone pines have provided a time machine for researchers. Scientific inquiries involving climate change by M. Hughes and M. Salzer, further extension of bristlecone pine chronologies, and isotopes are some of the more recent studies. During this time, there have been 3 constants: 1) the uniqueness of the collection itself, 2) the increasing number of samples collected over the years, and 3) the need to archive and inventory these specimens.

The importance of the bristlecone pine collection is not just in its immense quantity of specimens, but also the value of the samples themselves. Bristlecone pines have been utilized in many studies, and are often touted as the trees that rewrote history. Early calibrations of the radiocarbon timescale were based on the carbon in these ancient rings for which an exact calendar year can be assigned. Because the amount of radioactive carbon is not constant in the atmosphere, substances dated by radiocarbon were inaccurate. The radiocarbon calibration curve was/is utilized to provide more exact dates for other organic material from all over the world. Archiving these samples is of utmost importance so that when new scientific methods or questions emerge, the actual wood specimens can still be found for future investigations.

CURRENT CAMPAIGN

The collection and inventory continues today as a result of an anonymous donation first received in December 1999. With these funds, the first large-scale collection and relocation of bristlecone pines in the White Mountains, CA, in many years was initiated the following July 2000 and continues today. The one-month per year effort in the field consists of an eclectic group of volunteers and researchers (15 to 45, and growing) from all over the US and the world. During the month of

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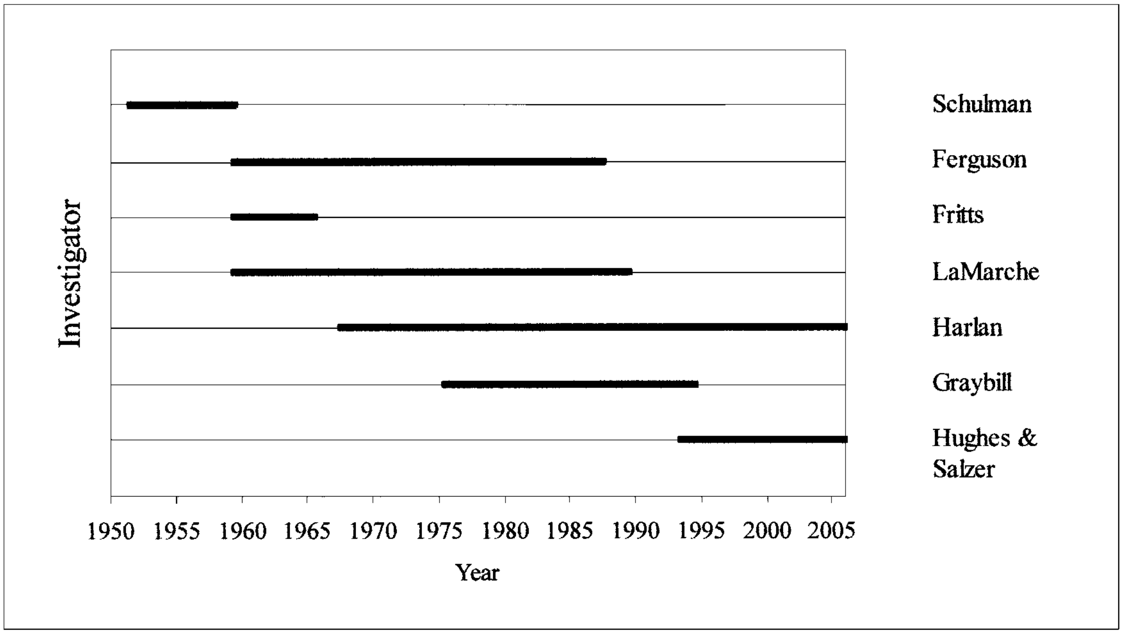

Figure 1. Bristlecone pine researchers from The Laboratory of Tree-Ring Research.

July, we converge on the White Mountains in hopes of finding the piece that will bridge the gap between the dated and floating chronologies, to relocate specimens, etc. New samples are collected from strategically chosen sites while samples found to be over 8,500 years old are often resampled in hopes of finding more rings. From field seasons 2000 to 2005, over 1,500 new samples and a few hundred previously-sampled specimens have been recollected in various sites in the White Mts.

A dendrochronology 'Most Wanted' occurs in the White Mts. every July, not in search of researchers but trees. Because Schulman did not tag trees, volunteers go in search of these trees based on 40+ year-old notes or photographs. Believe it or not, several have been found. Other volunteers gather GPS data for previously-tagged samples and take photographs of the samples *in situ.* A small group downloads temperature data from I-buttons that have collected temperatures at 4-hour intervals for 11 months. Back at camp, wood preparation and crossdating activities occur. These wood preparation and dating activities continue for the rest of the year, as so many samples are collected that they can not all be dated in camp. For one month, dendrochronologists, botanists, engineers, veterinarians, physicists, geologists, teachers, photographers, authors, *etc.,* swarm the White Mts. for elusive bristlecone pine samples. In addition, this eclectic group is very successful in finding new samples, old samples, and collecting vast quantities of data, plus having an enjoyable time in the process.

After collecting all of this data in July, it must be entered into the database and then the archiving of previously-sampled bristlecone pines continues back in Tucson, AZ. Others have tried to inventory specimens, but for one reason or another, those inventories were not completed. In 2000, one of us (T. H.), a retired dendrochronologist, began not the first effort but hopefully the ultimate successful proper archiving of all bristlecone specimens. A database was created that is easily queried and contains sample numbers, collector, date of collection, site location, specimen information, tree-ring dates, radiocarbon dates, and substrate (Figure 2). Also noted in this database is whether a GPS point is associated with the sample, whether an *in situ* photo or a scanned photo of the sample exists, and whether the sample is a core or cross-section. If the sample has been inventoried, then a box number is also listed. This database is vital in the

prefix	specime	Collector	Date	Location	State
2005	730	TPH,ADH	7-29-2005	Methuselah Walk	CA
2005	731	TPH,ADH	7-29-2005	Methuselah Walk	CA
2005	732	TPH,ADH	7-29-2005	Methuselah Walk	CA
2005	733	TPH,ADH	7-29-2005	Methuselah Walk	CA
2005	734	AK, FL, GL	7-29-2005	Methuselah Walk	CA
2005	735A	AK, FL, GL	7-29-2005	Methuselah Walk	CA
2005	735B	AK, FL, GL	7-29-2005	Methuselah Walk	CA
2005	736	AK, FL, GL	7-29-2005	Methuselah Walk	CA
2005	737	AK, FL, GL	7-29-2005	Methuselah Walk	CA
2005	738	AK, FL, GL	7-29-2005	Methuselah Walk	CA
2005	739	AK, FL, GL	7-29-2005	Methuselah Walk	CA
2005	748			Methuselah Walk	CA
2005	749			Methuselah Walk	CA

specimen data
grey partially buried remnant across slopNW of 2005-729
uprooted grey bi-stemmed snag, 8' long, west of 2000-121, same level, long radius
eroded remnant snag, all grey, at foot of large snag, same ridgelet as 2005-731
plank like grey remnant under barely mature BCP, continuing down same ridgelet as 2005-732
remnant 5' by 1', 30' above drainage on edge of terrace, next to a mt. mahogany, 350 rings plotted, no date
remnant, 1' by 5' 20' S of 2005-734
remnant, 1' by 5' 20' S of 2005-734
trunk, 15' by 3' on bench 20' above drainage
remnant, 2.5' by 1' under live tree and two snags, 20' above drainage
secondary drainage, partially buried, 1.5' by 10" remnant
trunk wrapped on up slope side of large BCVP, 30' above creek, 15' by 3'
N and above of 2005-739, 100' above drainage on W slope, remnant 4' by 1.5'
remnant 2.5' by 1', 20' above drainage, W side

Tree ring Dates	inside date	outside date	C14	GPS	Substrate	photo	Digital	Core	section	Box	Lab photo
-1518 to -1300>	-1518	-1300		☑	Dolomite	☐	☐	☑	☐	BCP R 009	☐
-44 to 296>	-44	296		☑	Dolomite	☐	☑	☑	☐	BCP R 009	☐
-3156 to -3000>	-3156	-3000		☑	Dolomite	☐	☑	☑	☐	BCP R 009	☐
				☑	Dolomite	☐	☑	☐	☐		☐
				☐	Dolomite	☐	☐	☐	☐		☐
<-535 to -425	-535	-425		☐	Dolomite	☐	☐	☐	☑	BCP R 024	☑
	-614	-465		☐	Dolomite	☐	☐	☐	☑	BCP R 024	☑
	-3235	-2830		☐	Dolomite	☐	☐	☑	☐	BCP R 009	☐
<-2775 to -2526>	-2775	-2526		☐	Dolomite	☐	☐	☑	☐	BCP R 009	☐
	-1765	-1469		☐	Dolomite	☐	☐	☐	☑	BCP R 024	☑
<-3200 to -3045	-3200	-3045		☑	Dolomite	☐	☐	☑	☐	BCP R 009	☐
-5866 to -5600>	-5866	-5600		☑	Dolomite	☐	☐	☑	☐	BCP R 009	☐
-2743 to -2000>	-2743	-2000		☐	Dolomite	☐	☐	☑	☑	BCP 174	☑

Figure 2. Database layout in three sections.

search to extend the over-8,800-year-long bristlecone pine chronology further back in time. T. H. continues to add information from the inventoried samples and from Schulman and Ferguson's notes and new collections so that currently the database has over 8,700 entries.

Visualizing the bristlecone pine collection is unfathomable unless one has walked through the LTRR storeroom and then the realization of the enormity hits you. Before this archiving project started in 2004, thousands of samples stored under the seats of the football stadium were unevenly organized and not well cataloged. As the result of the untimely deaths of several primary researchers, the location and descriptions of samples were lost. Archiving had been attempted in the past, but none were complete and were by today's standards inefficient. Another difficulty in organization was that each researcher had their own numbering system. Schulman used the 'WHT' prefix with lowercase letters representing smaller sites. For example, WHTb2 was used for samples taken in the Methuselah Walk area of the White Mountains. Ferguson utilized the year plus sample number, 1978-138, so to find the location of the sample one must consult his notes. Researchers from different labs used their own labeling system, for example Henry Michael labeled samples H80-5 with 80 = 1980 and sample number 5.

To sum up, the bristlecone pine collection after many years was in disarray as a result of time and the passing away of researchers. Today the database holds over 8,700 entries (note some samples are present more than once, *i.e.* 2001-682a or 2001-682b) with over 3,600 of the samples from Schulman, Ferguson, and LaMarche inventoried. Currently about 2,400 of the samples are cross-dated, but others are partially dated, dated by radiocarbon, or dated but not in the database. According to estimates, about half of the bristlecone pine collection has been inventoried and added to the database by the current effort. The task of the archiving and field work is enormous, but piece by piece, more organized and standardized data are being compiled and available for further research. The utility of the database and archiving is fundamental to present and future investigators.

TREASURE TROVE

Some of the older pieces of bristlecone pine have not seen the light of day in over 30 years. Until many of the boxes in the LTRR storeroom were opened; some of the so-called 'floaters' existed only on paper as indices or skeleton plots. Bridging the gap between the 13 'floater' specimens (representing about 2,000 years) that cross-date with each other, but do not match the dated chronology is of utmost importance because this match would provide climate information for more than 10,000 years. To solve this problem, the answer is in the wood. To access the wood, the location of these samples must be known. This clearly illustrates the importance and utility of the inventory efforts and the database.

In February 2004, one of us (C. H.) joined the database effort. She has gone through more than 200 boxes and added appropriate information, scanned samples, and re-boxed the samples. An

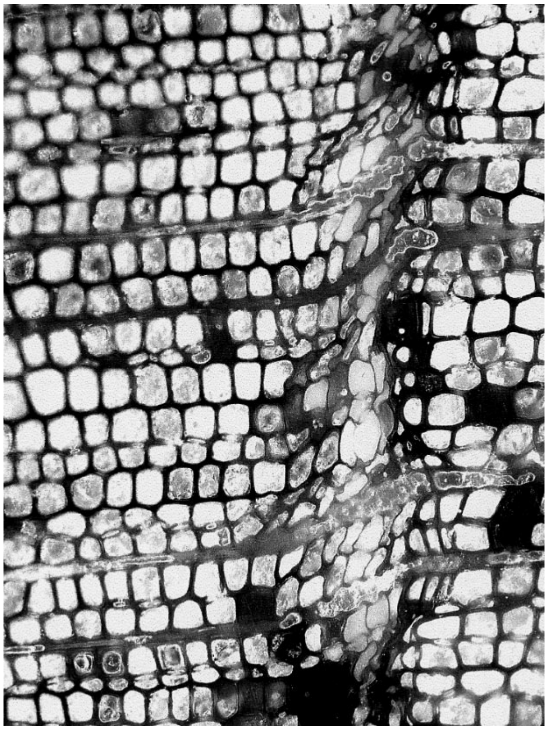

Figure 3. Frost damage in the 1979-138 specimen.

excellent example of the utility and value of the bristlecone pine collection and the inventorying of its samples involved the discovery of a unique physical feature within a sample, a frost ring. Most days are filled with uneventful activities, such as typing, scanning, *etc.*, but this past year an unusual characteristic was spotted in a specimen. While labeling a very old large remnant, she noticed that many of the cross-sections contained a fairly large crack. When the sample was examined under a microscope, she discovered that the crack was a result of deterioration of damaged cells. Because C. H. had studied frost-ring damage in bristlecone pines for her Master's thesis research (Hallman 2001), her observation skills were attuned to recognizing frost rings. In this remnant sample set of TRL1979-138, the damage was a result of latewood frost damage (Figure 3). We promptly crossdated it and realized that TRL1979-138 was in fact the second oldest dated bristlecone pine sample. What makes this discovery doubly notable is that the frost ring dated to −6413 (6414 BC), which is the oldest known frost event. Not only that, but this particular frost event occurred in a sample from Methuselah Walk, White Mountains, California. Although frost rings are fairly common in the White Mts. high elevation sites (11,000–12,000 ft./3,300–3,600 m) like Campito Mtn. and Sheep Mtn., frost rings in low elevation sites (9,200–9,600 ft./2,800–2,900 m), like Methuselah Walk, are exceptionally rare. Sample 1979-138 had been lost in the storeroom and any minimal analysis was conducted about 25 years ago. Not only was the second oldest crossdated bristlecone pine remnant rediscovered, but it had the oldest known frost ring. None of this would have come to light without the current archiving campaign.

For further confirmation of the frost ring, one of us (H. A.) analyzed a cross-section using light microscopy and SEM imagery. As a result of his investigations, he discovered that the 'bending' of the cells is also unique in that the cells are bent in two directions. Arnott also noted 'dark' material in the area of damage. Both the unusual 'bending' and the 'dark' material appear to be unique to this particular frost ring. Arnott's investigations indicated that frost rings were a result of the expansion of ray cells and renewed growth and recovery after the damage occurred. The expansion of the ray cells deformed the surrounding tracheids, resulting in cell injury (Arnott *et al.* 2005).

The presence of this frost ring has a couple of climatic implications. First, climate at the time of the frost event at Methuselah Walk was probably much different from today. Today frost rings are fairly common at higher elevation (above 10,500 feet), but Methuselah Walk is at an elevation of 9,400 feet. So 8,000 years ago, it is possible that climate there was more similar to present day 11,000 feet. Second, LaMarche and Hirschboeck's 1984 paper suggested a relationship between frost damage and climatically effective volcanic eruptions. This −6413 frost ring may be associated with a major eruption, a polar outbreak, or some other sudden cooling event. Possible associated volcanic eruptions include Karymsky, Kamchatka in −5700 with VEI = 6 and Tao-Rusyr Caldera, Kurile Islands in −5550 with VEI = 6 (Simkin and Siebert 1994). Dates given for the above eruptions are in uncalibrated radiocarbon years, which calibrate to *ca.* −6400. VEI (Volcanic Explosivity Index) is a scale from 0 to 8 that measures the magnitude of a volcanic eruption based on quantitative information and subjective observations. One of us (C. H.) is conducting an ongoing search to find more samples that cover the −6413 event. Without the determination to archive the vast bristlecone pine collections, this discovery and discoveries like it would be unrealized in the LTRR storeroom.

Discovering ‘floaters’ and the −6413 frost ring are just two examples of the importance of this gigantic effort to archive the bristlecone pine collection. When new methods or research ideas emerge, researchers can always go back to the wood for answers; therefore, archiving and housing the samples are invaluable for future investigations. The pursuit of the ‘missing link’ that will allow us to discover how climate changed in the last 10,000 years in the White Mountains, continues both in the field and in the storeroom. We often joke that the piece that will bridge the gap is somewhere in the storeroom waiting to be rediscovered.

REFERENCES CITED

Arnott, H., C. Hallman, T. Harlan, and R. Adams
2005 The −6413 frost ring is the oldest in bristlecone pines. *Texas Journal of Microscopy* 36(2):50–51.

Bailey, D. K.
1970 Phytogeography and taxonomy of *Pinus* subsection Balfourianae. *Annals of the Missouri Botanical Garden* 57:210–249.

Hallman, C.
2001 *Spatial Distribution of Frost Events in Bristlecone Pines of Western USA.* M.S. thesis, University of Arizona, Tucson.

LaMarche, V., and K. Hirschboeck
1984 Frost rings in trees as records of major volcanic eruptions. *Nature* 307:121–126.

Simkin, T., and L. Siebert
1994 *Volcanoes of the World,* 2nd ed. Geoscience Press, Inc. Tucson, Arizona.

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