Dendrochronology, the Bristlecone Pines and the White Mountains of the Western United States

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Introduction

Dendrochronology is the scientific study more commonly referred to as "tree-ring dating." It is the science of taking samples from trees, living or dead, to create chronologies. While this may seem a rather amusing idea, dendrochronology does, in fact, have many uses in today's scientific world and has helped the scientific community at large in any number of ways. Using the Southwestern United States as an example I will attempt to explain both the processes and the findings of the science of dendrochronology.

The mechanics of tree-ring dating

The first requirement for tree-ring dating is to acquire a tree sample. In years past it was sometimes necessary to cut trees down to obtain these samples. However, for most of this past century a technique called "coring" has been used (Stokes and Smiley, 1968). Using a tree corer an individual removes a small section of the core of the tree, attempting to include in his or her sample the pith, or what would be the "center" of the ring structure in any given cross-section of the tree (Stokes and Smiley). Figure 1 shows a standard cross section. Figure 2 is an individual boring to make a core sample. The sample, which is at this point a long, skinny, cylindrical sample, is transported to the laboratory for preparation. Every organization has its own standards for transporting these cores, and at this point the US Forest Service slides the core samples into paper drinking straws in order to keep them in good shape between the time they are taken and the time that they are returned to the lab at the end of the day (Connie Millar, pers. comm.., 2002). Preparation techniques also vary from organization to organization, but the basic goals of any such preparation is to first, mount and preserve the sample, and second, make the tree-ring patterns visible. In other words, the basic standard is that after the core is dry it is glued into a “slotted mount” and once it is secured and the glue dries it is “surfaced,” often by slicing the core and sanding it (Stokes and Smiley). Figure 3 is a photo of a number of mounted core samples. When this is done, the ring pattern should be fairly apparent and the tree-rings are counted. To simplify later use of this same sample a different number of pinpricks or dots are imprinted directly on the sample every ten, fifty and one hundred years (Stokes and Smiley). These samples are then saved and can be analyzed and referenced in the future.

What makes a tree a good candidate for coring?

There are certain requirements as laid out in Stokes and Smiley’s *An Introduction to Tree-Ring Dating* that help to determine whether any given tree is likely to be of use in creating an effective and relatively accurate chronology (1968). First, the type of tree from which one is considering taking a sample “…must add only one ring per growing season.” Tree species that are generally useful for tree-ring dating include Douglas-fir, white fir, ponderosa pine, post oak, red oak and sugar maple (Martinez 1996). Second, though obviously a wide range of things affect the growth of trees, there must be *one* such factor that dominates the limiting of growth in the given area. Thirdly, this factor must vary in “intensity” over time and result in correlative variances in the width of the rings within the tree. And, finally, these environmental factors must hold true over a large enough area to make extensive coring and study a worthwhile endeavor. Examples of environmental growth-limiting factors could be precipitation in a desert or temperature on the slopes of a mountain.

The analysis of tree-rings

Once a core sample has been prepared it is often analyzed using a method called the skeleton plot (Stokes and Smiley). This process involves plotting on a graph the intervals at which narrow rings occur in a given sample. On every interval that a narrow ring occurs, a vertical line is drawn: the smaller the tree-ring, the longer the line one draws (Stokes and Smiley). This process is repeated for all of the samples for any given region and, since the environmental factors should be basically the same, the samples can be dated relative to each other. Older, dead but "preserved" samples can be overlapped with newer, still living trees; this process is called cross dating. A graphic illustrating the basic idea of cross dating can be seen in Figure #4. As so aptly stated by Leonard Millar, "crossdating is considered the fundamental principle of dendrochronology – without the precision given by crossdating, the dating of tree rings would be nothing more than simple ring counting!" (2002). In other words, the process of cross dating allows the scientific community to compile a long chronologies for a given area that extend back much further than the life span of any individual tree by matching up characteristic patterns in the ring growth in any number of live or dead trees in a given area. At this time the longest "absolutely dated tree ring chronology of a single species" is the chronology of the Methuselah Walk in the White Mountains of California (Hughes and

Graumlich **YEAR**). This chronology based on the cross dating of bristlecone pine samples is almost a full 9000 years long.

Bristlecone pines and dendrochronology in the White Mountains

The bristlecone pine is considered by most to be among the oldest living things on the planet earth by most. Figure 5 is a bristlecone pine. The single bristlecone can easily live to be thousands of years old and thus has helped extend some tree-ring chronologies to the beginning of the seventh millennium BC (Hughes, et. al., 2002). In addition to the longevity of the individual trees, the climate in which they live also contributes to their helpfulness in chronologies. Because the bristlecone pines in the White Mountains live in harsh, cold climates where little else can survive, fallen trees also survive in a dateable form for much longer than they might in other areas (C. Millar, pers. comm., 2002). Now, using the four factors outlining an ideal tree for coring as laid out by Stokes and Smiley, one can see, also, that the bristlecone pine is ideal in terms of these requirements as well. First, the bristlecone pine does add just an annual ring, meaning one per growing season. Secondly, in the bristlecone pine groves in the high altitudes in the White Mountains, there is just one significant growth-limiting factor, precipitation (Hughes, et. al.). Thirdly, the bristlecone pines do live in a "strongly moisture-stressed and variable" site (Hughes, et. al) and, the tree-rings do seem to show correlative variances in width. And, finally, this is obviously a worthwhile endeavor because if these individual trees live for so long then the chronology the have recorded will also be unusually long, and the precipitation patterns in the high altitudes do seem to correlate very well with the precipitation patterns in a wide area, such as those in Mono Lake (Hughes et al.). This Methuselah Walk chronology is presently made up of 285 individual samples whose average length is 748 years, and these samples have all been taken from an area of just around a few hectares (Hughes and Graumlich).

The information that these bristlecone pines have provided to the scientific community has proven invaluable. Perhaps most surprising is the fact that the original chronology prepared using bristlecone pines was instrumental in the re-calibration of the Carbon-14 dating system to the form in which it is used today (Miller 2002). In addition to this very important contribution to the scientific community as a whole, the Methuselah Walk chronology has helped many smaller groups of scientists by serving as another source of historical record to back up conclusions made through other means (C. Millar, pers. comm., 2002). This chronology and others like it can be used in conjunction with pollen information and other information from sediment cores, with archaeological information, with written historical records, or with a wide variety of other records to reinforce conclusions drawn based on that other information (C. Millar, pers. comm., 2002).

What one can actually discern from tree-rings

Tree-ring analysis can be used to draw conclusions about pollution, disease, fire and even temperature and precipitation cycles from the past. For example, Figure 6 is a photograph of a Douglas-fir cross-section that shows evidence of fire damage.

The most significant environmental record that the bristlecone pines have contributed is information about the variability of precipitation (Hughes et. al., 2002). First, the Methuselah Walk chronology contains rings formations that suggest two droughts, both lasting multiple decades, between 900 and 1300 AD (Hughes et. al.). This conclusion and information is consistent with conclusions drawn from geomorphological evidence suggesting low lake levels in Mono Lake at the time. This information is further supported by evidence from studies done in the nearby Sierra Nevada on other tree species (Hughes et. al.). Additionally, these conclusions are supported by evidence from a 1700 year long reconstruction of Southern Great Basin precipitation (Hughes et al.). At this point, it seems obvious that tree-ring dating by itself may, honestly, not mean too much. It can tell one how old a tree is and allow one to draw conclusions that may or may not be supportable. But, coupled with the other sciences, and with the work of other sciences, tree-ring dating proves to be a most helpful tool.

However, in the interest of fair, unbiased presentation, one must make note of the fact that dendrochronology has at times had what most would consider a negative impact on the world around us. Though the methods used to date trees today are said to not harm the trees and representatives of the US Forest Service attempt to stick faithfully to these non-destructive methods, this has not always been the case. In 1964 a young student at the University of North Carolina while doing research on the bristlecone pines apparently broke his only coring tool. In an effort to not delay his studies the young man requested permission to cut down the tree at which he was looking. The US Forest Service granted him permission. The young man cut down the tree and took it to the lab and began to count the rings, the young man realized what he had done. The US Forest Service had granted him permission to cut down a tree that was 4862 years old, and he had done it. This man had killed the "oldest living thing on earth" (Leonrad Miller). To be fair, however, this was decades ago and the science was much younger that it is today. And, on a positive note, this accident brought the bristlecone pines the attention and the protection that they deserved (Miller).

Closing thoughts

The science of dendrochronology has made many great contributions to the scientific world as we know it. Yet, it is amazing to see how many people have no idea what it is. Having been home from a geology field trip in the Eastern Sierra Nevada for two weeks I have had the opportunity to discuss this, my final paper, with a large number of people. Few of these people, not more than one or two, had any idea what dendrocronology is. It would seem to me that as technologies in the sciences continue to improve and analyses become more accurate and conclusions become more concrete, dendrochronology will continue to make great contributions to the scientific and academic worlds as well as to the knowledge of the public as a whole. Perhaps as the importance of dendrochronology as a science continues to grow, so will its public recognition.