Dendrochronology

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Final Paper

June 9, 2006

Abstract:

The Bristlecone pine is an amazing tree that has adapted to the harsh, ever-changing environment of the White Mountains. The adaptability of the Bristlecone pine has aided in their ability to survive. There are Bristlecone pines that have been alive for almost five thousand years. Due to its longevity the bristlecone is very important to the field of dendrochronology. The tree rings allow scientists to determine how the climate has changed during the past ten thousand years. In this paper, I will explain how dendrochronologists are able to track climate and environmental changes by evaluating the growth rings of the Bristlecone pine.

Introduction

Climate has been changing since the beginning of time. In prehistoric times change occurred naturally. In more historic times anthropogenic causes are driving the earth's thermometer higher and higher. Global warming continues to be one of the biggest problems facing the world, and there is an increasing need to reconstruct past climate change. Tree ring dating provides a clear window into the past. Due to its longevity the Bristlecone pine *Pinus longaeva* is a very important specimen in tree ring dating. These amazing trees were seedlings during the time that the pyramids were being built, and can survive for thousands of years and remain preserved for even longer. The bristlecone has even been utilized to calibrate the C 14 carbon dating technique. "Dendrochronology is the science that uses tree rings dated to their exact year of formation to analyze temporal and spatial patterns of processes in the physical and cultural sciences." "Dendroclimatology is the science the uses tree rings to study present climate and reconstruct past climate." (http://web.utk.edu/~grissino/principles.htm) By observing the tree rings of a bristlecone pine, climatic changes including forest fires, volcanism, and precipitation fluctuations can be identified.

Bristlecone pine

Characteristics

The bristlecone is an ancient species of pine that are found in the upper tree line of 6 western states. The oldest trees can be located in the Ancient Bristlecone Pine Forest in the White Mountains of eastern California. The bristlecone is named for the long, hooked spine on the scales of the cones. The trees grow very slowly because of cold temperatures, dry soils, high winds, and short growing seasons. This tree uses many survival techniques to combat these unforgiving conditions. The wood is very dense and resinous which makes it highly resistant to insects and fungi. Bristlecones grow in a highly alkaline dolomite soil, because the soil is so nutrient poor other plants are unable to grow. The light colored dolomite is also important in reflecting the suns rays. This conserves moisture and prevents the tree roots from drying out too quickly. During times of drought the Bristlecone diverts water to keep the main part of the tree alive, this reduces the amount of nutrients that the tree can supply to its tissue and much of the bark and tissue dies. The remaining narrow strip supplies only a few live branches with water keeping them alive. Another adaptation of the Bristlecone is that its needles can live for several decades, therefore the tree does not exert extra energy to add new needles. This helps the tree survive through years of stress.

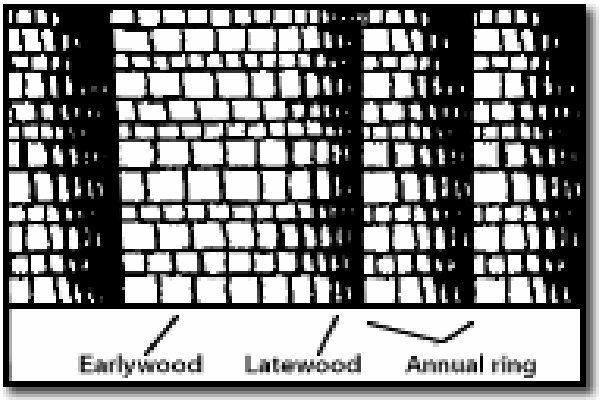
History:

The history of the Bristlecone and dendrochronology started in 1932 when Edmund Schulman began his career observing tree rings. He assisted A.E. Douglass at the laboratory of Tree-Ring research at the University of Arizona. It was here where

Douglass observed the correlation between wet years and wide growth rings and dry years with narrow growth rings. Over the next twenty years Schulman learned that trees growing in the harshest conditions displayed the most sensitive climatic records and lived the longest. Working on a rumor Schulman explored the White Mountains of eastern California and discovered his first tree that was older than two thousand years old. During the next two years he discovered that the oldest trees grew in the 10,000- 11,000-foot elevation range, finding several trees that were older than four thousand years old. In 1957 Schulman discovered the world's oldest tree, "Methuselah" named after the biblical character was four thousand seven hundred and twenty three years old. Still in awe months after his discovery Schulman said "The capacity of these trees to live so fantastically long may, when we come to understand it fully, perhaps serve as a guide post on the road to understanding longevity in general." (http://www.sonic.net/bristlecone/intro.html) In 1964 a geologist broke his coring tool rod while collecting a sample from a tree know as "Prometheus" as a result the U.S. Forest service granted him permission to cut it down. Later they realized that they had fallen the world's oldest tree it was 4,950 years old. (http://www.sonic.net/bristlecone/intro.html) After word of this incident spread, the U.S. Forest Service tightened security around the Bristlecones, and created the Schulman National Forest.

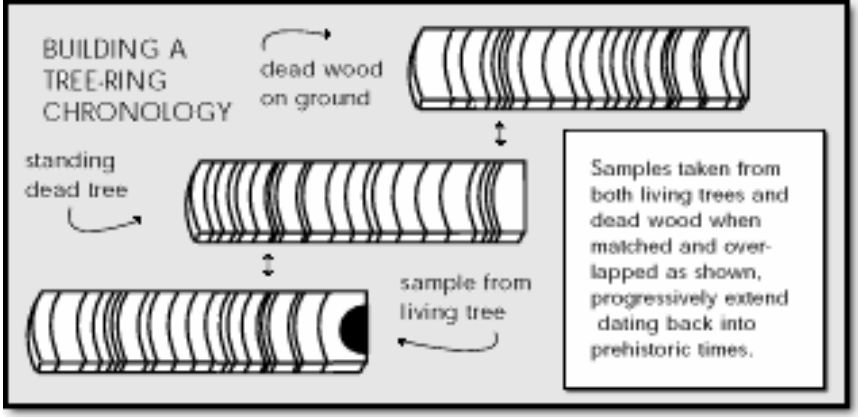
Dendrochronology :

Every year that a tree grows it produces a new ring directly underneath the bark. These rings consist of two layers. First is the thick light colored layer this layer is formed in the late spring and early summer when heat and moisture is most plentiful, this layer is known as early wood. The second layer or the late wood grows slower and is more thin and darker than the first; it is created during late summer or early fall when the temperature starts to drop. Because both of these layers compose one year's growth one can determine how old a tree is by counting the rings. In order to count the rings either a cross section or a core sample is needed. A cross section is obtained by using a saw to cut a section out of the tree, this method is undesirable because it damages or kills the tree. Core sampling is more popular because it doesn't hurt the tree and provides just as much information as the cross section.



Evaluating cores:

The Dendrochronologist can determine many climatic changes while observing tree growth rings. According to M.G.L. Bailli author of Tree Ring Dating and Archaeology there are three techniques that can be utilized when reconstructing climate



change. Average temperature and precipitation can be determined by measuring the width of these rings. Precipitation is measured by the width of one ring (one year's growth). Scientists have compared living trees with known precipitation records to perfect this technique. X-ray densitometry measures density profiles across one ring. Early wood has low density and late wood has high density. Using this technique, researchers in Europe found that in sub-alpine, cool, humid regions maximum density is controlled by summer temperature. Trees living on dry sites have densities related to summer precipitation. By examining trees from both locations summer climate can be determined. Temperature can also be determined by the isotope method it is as follows; the ratios of the stable isotopes of hydrogen and oxygen vary with the air temperature. Prevailing when the ring was formed. Thus each ring should contain an isotope temperature record. Wildfires can be observed by scaring within the ring. "Fire is a keystone ecological process in the Southwest. Recent research has shown that fire frequency and severity is closely associated with not only long and short term variations in climate, but also with the effects of human influences on land us in the Southwest."(University of Arizona)

Obtaining tree ring core samples:

A core sample is obtained from a tree by using a tree borer; this device has a sharp threaded tip with a hole at the end that has a diameter slightly smaller than the

circumference of the rod. While aimed at the center of the tree the borer is screwed into the tree until the center is reached. Then the spoon is inserted into the rod and the sample is removed and placed in a paper straw container, after the sample is numbered and dated it is ready to be examined in the lab.

Limiting factors:

Limiting factors are important to the dendrochronologist because they affect how a tree grows. In semi arid areas moisture is the limiting factor. Because most of the moisture contained in pacific storms falls in the Sierra Nevada mountain range the White Mountains receive less than 12 inches of precipitation annually. In higher elevations temperature is the limiting factor, in elevations exceeding 10,000 feet snow covers most the ground 8 or 9 months out of the year. These are 2 extremes the Bristlecone has endured for thousands of years. Insects, soil nutrient content and drainage, wildfires, and topography are all non-climatic limiting factors. Because there are so many factors limiting growth, many different samples must be taken from many different trees in order to provide a sufficient sample space. While taking samples the dendrochronologist may encounter two different types of trees: Sensitive and Complacent. Sensitive trees are more susceptible to limiting factors and have smaller, more erratic growth rings than complacent trees.

Cross dating:

Trees growing in the same geographic location have a tendency to form the same growth ring patterns. Similar to fingerprints these patterns can be compared and matched

ring for ring with trees growing in the same environment. By matching older trees with unknown age with living trees chronologies can be created. Cross-dating was originally done by manually counting. More recently, computers are used to do the same job only more efficient. To eliminate individual variations in tree ring growth, dendrochronologists take samples from many different trees and take the average of all the growth ring widths to create a chronology. This process is known as replication. A tree ring history with unknown age is called a floating chronology. This floating chronology can be dated by cross dating either the beginning or the end section against the end sections of another sample whose date is known. (http://www.awningz.com/articles/Dendrochronology?mySession) Using these techniques scientists have extended the Bristlecones chronology almost ten thousand years, tracing volcanic activity, weather fluctuations, and wild fires along the way.

Radiocarbon dating:

The following is my interpretation of radiocarbon dating and it's calibration with the bristlecone pine as explained by Archaeology Dendrochronology and the Radiocarbon Calibration Curve. Radiocarbon dating measures the decay of the radioisotope carbon 14. C14 is found in all living things, the radioisotope is absorbed in the early stages of life development. To determine the age of organic remains you need to know the amount of C14 residing in an organism while it was alive, how long it takes for C14 to decay and the amount of C14 that remains in the subject. The rate of decay remains constant, the amount that remains can be measured. The remaining discrepancy lies in determining the amount of C14 that was present in the living organism. C14 is produced when cosmic

rays interact with atoms in the upper atmosphere. This interaction has varied in the past resulting in changing C14 production. Fluctuations in C14 production express the need for radiocarbon dating calibration. Tree growth rings provide the time scale to do so. The Bristlecone is such a valuable tool when calibrating dating techniques because there are trees that still remain that are over eleven thousand years old.

Conclusion:

Thanks to the Bristlecone pine we have a much clearer view on how climate has changed over the last ten thousand years. In order to survive the next ten thousand mankind must learn to cope with global warming and the other climatic problems we've created. We can use the Bristlecone pine to gauge the severity of the climatic changes that we are experiencing today and compare them to historical climate changes.

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