Tales Trees Tell

Story 1:
The Wisdom of the Ancients

By **Harold C. Fritts**
DendroPower Press
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Tucson, Arizona 85704-3905
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Photo by Donald Graybill courtesy of Gary Funkhouser

Introduction

High in the arid White Mountains of California near the Nevada border you can find the oldest trees in the world, the ancient, gnarled bristlecone pine (*Pinus longaeva*)[1]. The oldest known age of a live bristlecone pine is 4900 years.

The most ancient bristlecone pines are about 20 feet (6 meters) tall yet they are up to 4900 years old.

The exposed contorted wood in this magnificent ancient gradually weathers to a rich reddish brown hue, yet the tree hangs on to life through a single living branch shown on the right.

Just think of this: a century in the life of a 4900 year old bristlecone pine is equivalent to two years for you and me.

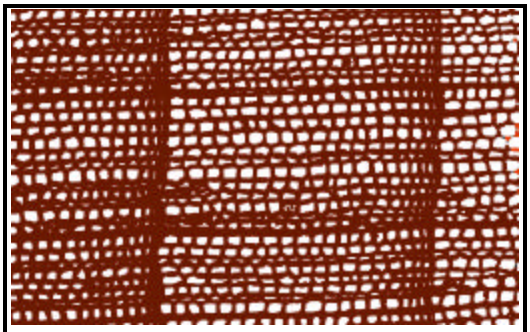
These ancient trees grow in harsh dry mountainous terrain in the rain shadow of the Sierra Nevada. There is little moisture in the air; and not far south lies Death Valley, the driest and hottest land in the United States. The bristlecone pine environment is so extreme

[1]The first time a common name or measurement is mentioned I will also give the scientific name or measurement enclosed in brackets.

that the trees can grow only very slowly for a short duration in summer. The annual growth rings, stem diameter and height are small compared to most trees, but their remarkable age and the sheer majesty of their spiked tops, twisted, gnarled branches, the rich brown color of the weathered wood and brushy green branches makes up for their diminutive size. If you are lucky enough to visit these ancient trees, enjoy their beauty but please don't take souvenirs. It is hard enough to survive to such an old age without people breaking branches, cutting pieces off the bark or collecting cones. It removes much of their beauty and is illegal too!

How to Find the Real Age of a Bristlecone Pine

How can we measure the age of these trees? Many of you already know that trees will produce one growth ring in their stem for each year; and all one needs to do is to count their rings! But like most things in life, the story is not as simple as that. Let me explain.



A tree ring in fast-growing bristlecone pine includes about 20 cells that are large with thin walls when growth begins in late June and smaller and thicker walls when growth slows down in late July. The rings in the ancient trees may have 3 to 5 cells and are much narrower. Photo courtesy of Fritz Schweingruber

I am a scientist, who works with trees and their rings in a field called dendrochronology. "*Dendro*" means tree and "*chronology*" means time. Dendrochronologists work with tree time which provides

considerably more information than simply the age of the tree. Instead of simply counting, dendrochronologists use a procedure called cross-dating to establish the exact year each ring grew from the beginning of the trees life to the time it was sampled. Then by observing and measuring the yearly changes in ring size, structure and density they can learn a great deal about the environmental conditions dated to the very year when each ring grew.

The growth rate of bristlecone pine can be so slow in very dry or cold years, that some trees fail to grow so that the ring is missing at the base of the trunk where they would naturally be counted. If the rings had been counted rather than cross-dated, the tree age would be one year less for every year that the tree did not produce a complete ring.

Two of my scientist friends. John Cardis, on the left, helped me study how the bristlecone pine grow and Wes Furguson, on the right, searched for the oldest trees and developed their long record of past wet and dry years.

The procedure of cross-dating matches the patterns of wide and narrow rings in a large number of trees. A narrow ring can be found in faster growing trees during the same year that the ring is missing in slower growing ancients. When the pattern of

wide and narrow rings is memorized or recorded in some way, it is easy to identify where in a stem a growth ring is missing or when mistakes or other types of problems occur. This allows dendrochronologists to identify the chronology (timing) of every ring to the exact year in which it grew. I will postpone describing more details of this important cross-dating procedure until the next Tale "A Day with the Giants" and get on with this story about the ancient ones.

Dendrochronologists can read the story that is locked in the widths of the cross-dated tree rings. The width tells how well the tree grew each year. In addition the ring may contain a particular kind of scar with charcoal that indicates a fire may have injured the tree in that year. Insect damage can be revealed by certain changes in ring width, frosts leave their mark by injuring cells, chemicals are stored in the wood; and there are other features dendrochronologists can use to read the story from the annual rings.

Of course it is not necessary to cut down a tree to examine the rings. A pencil-thin core can be extracted from the main stem in a way that minimizes the damage to the tree. The tree

A corer is inserted into the tree stem and a pencil-thin core is extracted which contains the story in the form of annual rings.

oozes resin that fills the core hole and in a year or so the wound is completely healed.

The bristlecone pine have a remarkable adaptation to these rocky, arid and cool sites. When the tree becomes too large, branches begin to die, sometimes including the main stem, because of lack of water on the rocky sites. The stems do not rot as they are preserved by the resin in the wood. Even with this gradual reduction in living crown, bark and roots, the tree remains healthy and continues to grow in balance with the amount of moisture available between the cracks of the rocks. The living mass of the tree remains constant allowing the trees to attain a very old tree.

A core is then sanded or cut to obtain a clean surface showing the rings. The width of each ring is measured or the ring is examined, and the feature in question is recorded and analyzed to reveal the story. It is like translating a foreign language into English.

Each of the "*Tales Trees Tell*" is a story of how different trees can write different stories, what the dendrochronology detectives do to read the story, as well as, my sharing with you the sheer beauty, joy and passion one can experience visiting and working with these magnificent beings we call trees. In addition I believe there is a lot of wisdom one can gain from simply being with trees, especially these ancient ones. I will share some of my thoughts and experiences while working

with trees and their annual growth rings.

The Ancient Trees

How can the bristlecone pines live so long? The easiest answer might be that God created such a tree to live in the harsh dry and cold environment high in the mountains. From one point of view this may be true. However, scientists want to understand the mechanisms that allow such trees to come to be, or be created, if you want to say it that way. Scientists have offered a number of ideas, called theories or best inferences, as to why these trees can live to such a ripe old age. Some people suggest "*adversity breeds longevity*" or to say it in simple words: "*when things are tough in the world, we can learn to cope with the difficulties."* This learning is called wisdom, which people can use to heal themselves and grow throughout their lives. If we become wise enough, we know how to live well and can become a very old but healthy man or woman like these ancient trees.

That is certainly one important message the bristlecone pines can tell us, but there are lots of old bristlecone pines, not just a few ancients that may have learned such wisdom. Scientists have another theory which they believe has been proven to be most likely or true. It is called "*Evolution*". The following paragraphs describe how these ancient trees could have evolved over a long period of time. The process we call evolution is stated in very simple terms.

Evolution of the Ancients

These are not ghost trees but a close relative of our bristlecone pine in the clouds over Mt. Evans, Colorado Rocky Mountains.

Many, many years ago some ancestors of bristlecone pine growing in warmer and more moist places produced offspring (children) who were able to live in somewhat drier and higher sites than their parents could. This probably occurred at a time long before the ice ages when the climate in this region was cooling and becoming drier due to the gradual rising of the Sierra Nevada Mountains. As these pines produced offspring, some were like their parents and could not cope with the somewhat drier and cooler conditions so they died before they created new offspring. Some offspring were produced that could cope very well with these increasingly adverse conditions. They lived longer and had their own children that could survive and grow to a somewhat older age. Some of their children were able to grow in even drier and higher places than their grand parents and great grandparents could. The offspring that could not cope with the cold and dry conditions never survived. This was repeated for many many generations until they evolved into the bristlecone pine of today. Some scientists describe this process as "*survival of the fittest*" and the slow process of changing as evolution.

Today, the closest relative is the Rocky Mountain bristlecone pine (*Pinus aristata*) growing in more moist habitats in the Rocky Mountains of Colorado and New Mexico. Just across the valley from the California White Mountains are the high Sierra Nevada where we can find the next closest relative, the foxtail pine (*Pinus balfouriana*). The foxtail pine also grow high on the mountain slopes but require more moisture and are not as old as the bristlecone pine. Long ago these trees probably originated from the same parents as the bristlecone pine, but this population became separated from the bristlecone pine in the White Mountains. When populations are separated and isolated in this way, each population can evolve in slightly different directions because the forces of nature that controlled success or lack of success of offspring were slightly different in each habitat.

The Extreme Sites Occupied by Bristlecone Pine

On clear winter days one can see the Sierra Nevada Mountains west of the bristlecone pine in the White Mountains. Bristlecone pine cannot grow there but a relative called foxtail pine grows on the highest slopes.

What must it be like to live in these high, dry, cold and rocky mountains that are much higher than most of us are used to. The oldest bristlecone pine grow at the lowest elevations that bristlecone can grow at about 9500 feet (2896m), but bristlecone pine can grow to the upper tree line, about 11000 feet (3353m). The trees at the upper tree line are larger but not as ancient as the trees at the lower forest border below them.

It is interesting that the lowest and highest bristlecone pine not only reach different maximum ages, but the width of the rings tell different tales. To understand why, it is helpful to know that trees, like all living things, require food and water to live and grow. Without at least some water they could not live more than a few days unless they were frozen during the winter. Without water they would dry up and die of drought. If there was no source of new food, the trees might live for a few years on food stored in their cells, but they would eventually die of starvation.

The largest bristlecone pine, the Patriarch, is found near the upper tree line. It's trunk is 3394 feet (103m) in circumference; the crown spread is 41 feet (12.5m); and it is 47 feet (14m) tall. It is not as old as some of the smaller strip-barked trees near the lower forest border.

You also know that you will not grow as much if you have little food and water. If you have enough, but not too much, you might be skinny, but could grow strong and live a long time if you eat the right kinds of foods. The same is true of trees. If they have enough food or water, but not too much, they will grow slowly with narrow rings, be stunted, strong and able to become very old. As the young trees grow older and larger they exhaust the soil space in which the roots grow. Soil moisture becomes more limiting during times of drought. The most exposed branches dry out and die along with the connecting bark and associated roots. Those branches that remain alive are still connected to living roots by long strips of bark. What were once circular rings become growth layers formed under the strips of bark.. With the passing of time the main stem of the tree loses its circular shape although the mass of the living tree remains relatively constant through time.

Under adversity, parts of the living bark die, but the tree remains healthy and new rings grow under the remaining bark. These are called strip-bark trees.

As long as you have food and water, your body stays warm. In cooler weather you put on a coat to help keep your body from losing its heat. Your body uses much of the food you eat to keep you warm. Trees cannot make heat and keep warm, so if they are bristlecone pine, they must be able to live and survive the low temperatures in winter. They do use food simply to keep alive when temperatures are above freezing. Also trees can grow only when temperatures are consistently above the freezing point.

The green tissue (chlorenchyma) in the needles carry on photosynthesis in the presence of light making sugar that is used to make other foods and cell parts in the living bristlecone pine. The brown structures are pollen producing cones.

Trees, like all green plants, cannot eat food. They make their food beginning with sugar, in a process called photosynthesis, which requires carbon dioxide, water, light and the green tissue, called chlorenchyma, found in leaves, needles and some stems. All the other foods and structures are made from this sugar with the addition of minerals and rearrangement of the carbon, oxygen and hydrogen molecules of the sugar.

Animals and some plants that are not green must get their food from plants or other animals that in turn eat plants. Both you and I, along with other animals, must have plants for the food and energy that our body needs. Trees, like all green plants, also use the carbon dioxide from the air to make sugar and release the oxygen that you must breathe in to live, but that is a more complicated story which I will explain in a later tale.

The Lower Forest Border Bristlecone Pine

Let us continue with the stories that the bristlecone pine tell. We will start with the lowest and oldest trees. Because they are living lower on the mountains, the winters are not as cold and the summers are warmer and drier. The trees thaw out sooner with the warmer temperature and begin making sugar earlier than the trees at higher sites.

As the weather gets warmer, the trees can begin to grow if they have enough food and water. The bristlecone pines at the lower forest border sites also lose water rapidly because of warmer temperatures. As the roots absorb water the soil becomes drier. If there is little moisture in the soil from a lack of winter snow or rain, the tree may become so dry that both growth and photosynthesis slow down and even stop. As we said

A typical open stand of bristlecone pine near the lower forest border. Each tree requires a lot of space in order to have enough water to remain alive and grow.

before, in extreme drought, growth may never start at the base of the slowest growing trees.

The trees also have “learned” in the evolution process that they should stop growing before it becomes too cold and killing frosts can occur. The bristlecone pines start growth when it is warm enough, grow for about 45 days, and then the growth stops even though the weather is still warm. They may continue to make sugar in the presence of light if water is still available in the soil and it is not too cold. This sugar may be used to make pine cones and seeds, or it is stored in the living tissues until growth begins the next year. If there is plenty of moisture in the soil from the winter snow or from spring rains, they make lots of sugar, grow very rapidly and make very wide rings. If there is little moisture, with little sugar stored from the previous year, growth is slow and the rings are not very wide. The width of the rings in the ancient trees at lower elevations tell us about wet years and dry years for as long as they have grown. Very narrow or absent rings in the slower growing trees indicate years of sever drought.

The old trees become twisted and gnarled and when they die they leave beautiful brown twisted contorted shapes showing the effects of former drought, wind and blowing winter snow.

The wood of dead trees lasts a very long time in this harsh and dry environment. One can examine the rings in this wood to extend the tree ring record further back in time.

Even the dead trees in this ancient forest can tell the same kinds of stories in their rings. The wood remains firm as it is filled with protective resins, and under the dry climate some of the wood lies on the ground for thousands of years. When the rings in this wood are cross-dated with old living trees, dendrochronologists can extend the record of drought well beyond the age of the oldest living trees. The record of past droughts extends backward 8700 years, and there are some older undated fragments that will eventually extend this record even further back in time.

People have measured rainfall and snowfall for little more than the last 100 years. The ring widths in these ancient

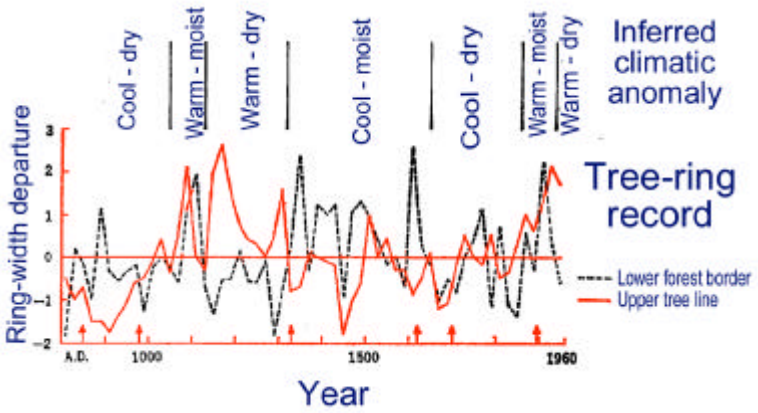
The bristlecone pine at higher elevations are larger and not as old. Their rings tell a story about warm and cool years.

The ring widths in a very old tree near the upper tree line record warm and cold years. More than half of this tree is dead on the windward side but the remaining half remains healthy and strong.

trees can be correlated with this 100 year record and used to extend this snow and rainfall record over 8700 years which is an increase in length of record by 87 times.

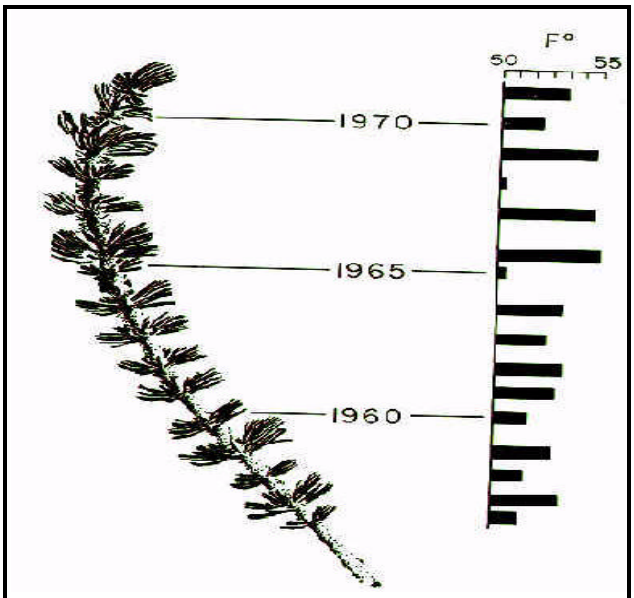
The Upper Tree Line Bristlecone Pine

What about the ring widths in the bristlecone pines higher on the mountain? What tales can they tell? I must explain something about mountains that you may not remember or know. The higher you go up a mountain, or the higher an airplane flies, the colder it is outside. The bristlecone pine trees growing higher in the mountains cannot make food as early in the year as the trees that are near the lower forest border. When they do grow the temperatures are cooler too. If the weather is very cold, the tree cannot make much sugar; and a narrow ring is formed or it is missing if it is really cold.



20-year mean growth at lower forest border and upper tree line and the climatic conditions inferred from the average tree-ring width. Arrows show dates of glacial moraines in the nearby Sierra Nevada. All but the youngest moraines formed during cool climates and glacial advances of the early 1300's and early 1600's coincide with unusually wet periods. From V. C. LaMarche, Jr., 1974.

In warm years, plenty of food is made and the rings are wide. In addition, the needles that grow in the warm years are longer and there may be more of them. With long and many needles the trees can make more sugar than in years when there are shorter and fewer needles. The trees can keep their needles for as many as 20 to 30 years. This helps them survive during long periods of cold and cloudy weather. When it gets warmer, it may take a number of warm years before there are enough needles to produce sufficient sugar to grow very wide rings. The tree rings tell us about both occasional cold years and very long-lasting cold spells in the past.



The number and size of needles from trees on cool sites increase and decrease as temperatures during the summer change, as shown in a graph on the right. From V. C. LaMarche, Jr., 1974.

The ancient bristlecone pine at the upper tree line tell us about past temperatures during the years the rings grew. The trees at the lower forest border tell us about past snow and rainfall during the years the rings grew. My friends, C. W. Ferguson, V. C. LaMarche, Jr., Donald Graybill and Gary Funkhouser were the scientists that extended the records of past climate from both the high and low elevation bristlecone pine thousands of years back in time to 6700 BC. Val LaMarche made graphs of these records from A.D. 800 to 1960 to infer the changing climate including both temperature and precipitation for 1160 years. Then he compared these inferences about cold and warm years to the geological evidence for climatic changes.

Remnants of old trees growing higher than the upper tree line of today told LaMarche (1973) that the climate was warmer 2500 years ago.

The upper tree line in the White Mountains showing many dead fragments above today's tree line corresponding with past centuries when the climate was warmer than today.

LaMarch also studied and used fragments of old trees lying on the ground at

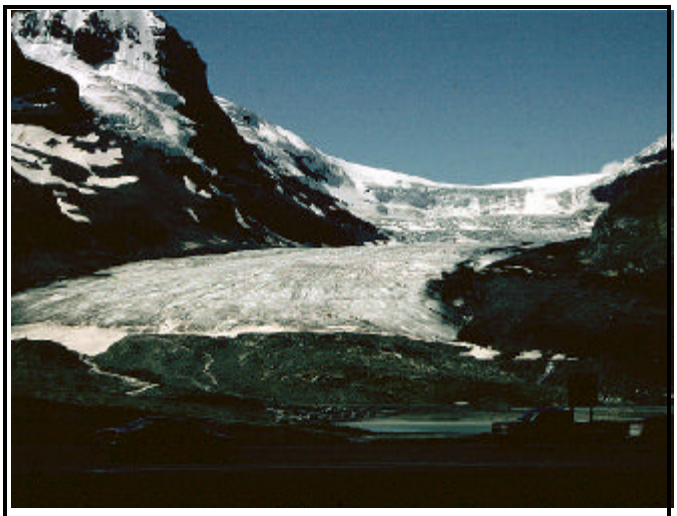
elevations above the existing upper tree line. He found that there were long periods of warm temperatures when the trees were able to grow much higher than they grow today. This warmth was followed by cooler temperatures that killed the highest trees leaving the fragments of these trees that lie there today.

Scientists have shown that some of the coldest years were caused by great volcanoes that exploded, throwing masses of ash into the sky. There was little sunlight and temperatures became cold especially during the summers. They also tell us that during very long cool times, when there were lots of volcanic eruptions, glaciers, the great walls of ice and snow, grew larger and many crops froze that man had tried to grow on cooler sites. These were periods when many people suffered because there was not enough food to eat. Diseases were common; many people were sick. Farms were abandoned and people migrated to warmer places. Historians describe these years as times of famine. In Ireland a disease favored by damp cool weather killed the potato crop. Many of these Irish people abandoned their farms and migrated to the United States where their descendants live today. If you are Irish, your great great grandparents were probably part of this great migration.

Great volcanoes sometimes exploded, throwing out great plumes of ash and dust into the sky. Here is the Mount Saint Helens eruption of may 18, 1980. Dust clouds from some volcanoes were so thick that sunshine was reduced causing colder weather around the earth. The cold years from earlier volcanoes are recorded by the bristlecone pine growing on the highest sites and on other high mountain ranges. Their rings were narrow and sometimes damaged by summer frost. Photograph courtesy of USGS/Cascades Volcano Observatory

One important tale these ancient trees repeatedly tell is that sometimes the sun shines brightly and life can be good and sometimes clouds or drought prevail making life hard and difficult for people, especially if they live in the high mountains or in dry marginal lands. But these people have learned, that when life does get tough, to have courage, do their very best with what they have, adapt to the changes and learn what they can. Eventually the sun will shine again, good times will return and they can be wiser and stronger than they were before, like the ancient bristlecone pine.

Strong winds can carry ice and may trim our branches, bringing great changes into our lives, but we can adapt, still go on growing and learning as we go.



Glaciers, like this Athabaska Glacier in Canada, grew larger in cold wet years and melted back in warm dry years.

Remember that the bristlecone pines adapt by losing part of their bark, leaves and roots when conditions are severe. This reduces the amount of moisture they may need to survive. They keep on growing and living with what they still have. They endure these hardships, become “wise”, very old and remain healthy beautiful trees with lots to tell us about the place where they have lived and the conditions in which they grew. We can learn about our own inner growth and strength from the example of our beautiful friends, the ancient bristlecone pine trees.

With inner strength and knowledge of their beauty we can be challenged to create our own bright future. It can be our choice to be happy with who we are. Remember the many good things we already possess and enjoy. Don’t forget the many good qualities we may have, qualities that we can use to create abundance now and in our future. We can choose to grow stronger and wiser like the ancient bristlecone pine. We can care about each other, our earth, the beautiful trees, crops and animals that support our life. Yes, we can choose to be a looser and complain about what we don’t have, if that is what we want to be. However with the higher choice of being a winner, with caring, loving and working for good along with others that have made this

same choice, we can create a better future and change our world. **Yes we can!** That is what these ancient and beautiful trees tell me.

References and World Wide Web Pages about the Bristlecone Pine

Cohen, M. P. 1998. *A garden of Bristlecones: Tales of change in the Great Basin*. University of Nevada Press. 308pp. (For the mature reader)

Ferguson, C. W. 1968. Bristlecone pine: Science and esthetics. *Science* 159:839-846.

LaMarche, V. C. Jr. 1974. Paleoclimatic inferences from long tree-ring records. *Science* 183:1043-1048.

LaMarche, V. C. Jr. 1973. Holocene climatic variations inferred from treeline fluctuations in the White Mountains, California. *Quaternary Research* 3:630-660.

Muench, D and Lambert, D *Timberline ancients*. Charles H. Belding. Portland, Oregon. 128pp. (Photographic treatise)

http://www.sonic.net/bristlecone/intro.html

http://web.utk.edu/~grissino/

The future can be better for all of us if we choose it to be.