This information was taken from: Principals of Dendrochronology

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

Principles of Dendrochronology

As with any science, dendrochronology is governed by a set of principles or "scientific rules." These principles have their roots as far back as 1785 (the Principle of Uniformitarianism) and as recent as 1987 (the Principle of Aggregate Tree Growth). Some are specific to dendrochronology while others, like the Principle of Replication, are basic to many disciplines. All tree-ring research must adhere to these principles, or else the research could be flawed. However, before one can understand the principles, one needs to know basic definitions of terms used in tree-ring research.

Definitions

dendrochronology

> (dendron = tree, chronos = time, logos = word = the science of): 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.

dendroarchaeology

> The science that uses tree rings to date when timber was felled, transported, processed, or used for construction or wooden artifacts. Example: dating the tree rings of a beam from a ruin in the American Southwest to determine when it was built.

dendroclimatology

> The science that uses tree rings to study present climate and reconstruct past climate. Example: analyzing ring widths of trees to determine how much rainfall fell per year long before weather records were kept.

dendroecology

The science that uses tree rings to study factors that affect the earth's ecosystems. Example: analyzing the effects of air pollution on tree growth by studying changes in ring widths over time.

dendrogeomorphology

The science that uses tree rings to date earth surface processes that created, altered, or shaped the landscape. Example: analyzing changes in tree growth patterns via tree rings to date a series of landslide events.

dendroglaciology

The science that uses tree rings to date and study past and present changes in glaciers. Example: dating the inside rings of trees on moraines to establish the approximate date of a glacial advance.

dendrohydrology

The science that uses tree rings to study changes in river flow, surface runoff, and lake levels. Example: dating when trees were inundated to determine the sequence of lake level changes over time.

dendropyrochronology

The science that uses tree rings to date and study past and present changes in wildfires. Example: dating the fire scars left in tree rings to determine how often fires occurred in the past.

dendroentomology

The science that uses tree rings to date and study the past dynamics of insect populations. Example: dating the growth suppressions left in tree rings from western spruce budworm outbreaks in the past.

tree ring

A layer of wood cells produced by a tree or shrub in one year, usually consisting of thin-walled cells formed early in the growing season (called earlywood) and thicker-walled cells produced later in the growing season (called latewood). The beginning of earlywood formation and the end of the latewood formation form one annual ring, which usually extends around the entire circumference of the tree.

tree-ring chronology

A series of measured tree-ring properties, such as tree-ring width or maximum latewood density, that has been converted to dimensionless indices through the process of standardization. A tree-ring chronology therefore represents departures of growth for any one year compared to average growth. For example, an index of 0.75 (or 75) for a given year indicates growth below normal (indicated by 1.00, or 100).

standardization

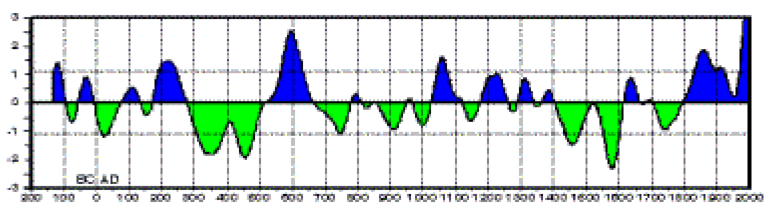
The process that removes undesirable long-term variations from a time series of measured tree-ring properties by dividing the actual measurements by those predicted from a statistically derived equation that relates tree growth over time to tree age. Usually this process tries to remove the growth trends due to normal physiological aging processes and changes in the surrounding forest community.

increment borer:

An auger-like instrument with a hollow shaft that is screwed into the trunk of a tree, and from which an increment core (or tree core) is extracted using an extractor (a long spoon inserted into the shaft that pulls out the tree core). These instruments are quite expensive, normally ranging from $200 to $500.

Principles of Dendrochronology

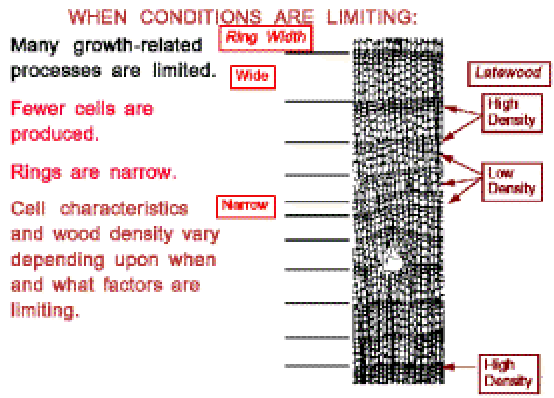
The Uniformitarian Principle



This principle states that physical and biological processes that link current environmental processes with current patterns of tree growth must have been in operation in the past. In other words, "the present is the key to the past," originally stated by James Hutton in 1785. However, dendrochronology adds a new "twist" to this principle: "the past is the key to the future." In other words, by knowing environmental conditions that operated in the past (by analyzing such conditions in tree rings), we can better predict and/or manage such environmental conditions in the future. Hence, by knowing what the climate-tree growth relationship is in the 20th century, we can reconstruct climate from tree rings well before weather records were ever kept.

For example, the graph above shows a long-term precipitation reconstruction for northern New Mexico based on tree rings. The reconstruction was developed by calibrating the widths of tree rings from the 1900s with rainfall records from the 1900s. Because we assume that conditions must have been similar in the past, we can then use the widths of tree rings as a proxy (or substitute) for actual rainfall amounts prior to the historical record.

The Principle of Limiting Factors



As used in dendrochronology, this principle states that rates of plant processes are constrained by the primary environmental variable(s) that is most limiting. For example, precipitation is often the most limiting factor to plant growth in arid and semiarid areas. In these regions, tree growth cannot proceed faster than that allowed by the amount of precipitation, causing the width of the rings (i.e., the volume of wood produced) to be a function of precipitation. In some locations (for example, in higher latitudes and elevations), temperature is often the most limiting factor. For many forest trees, especially those growing in temperate and/or closed canopy conditions, climatic factors may not be most limiting. Instead, processes related to stand dynamics (especially competition for nutrients and light) may be most limiting to tree growth. In addition, the factor that is most limiting is often acted upon by other non-climatic factors. While precipitation may be limiting in semiarid regions, the effects of the low precipitation amounts may be compounded by well-drained (e.g. sandy) soils.

The Principle of Aggregate Tree Growth

$$R_t = A_t + C_t + \delta D1_t + \delta D2_t + E_t$$

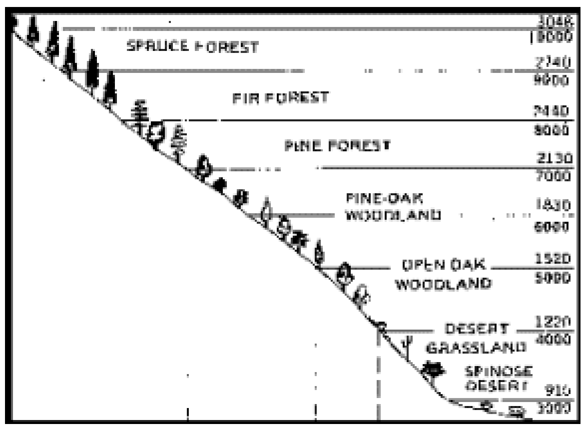
This principle states that any individual tree-growth series can be "decomposed" into an aggregate of environmental factors, both human and natural, that affected the patterns of tree growth over time. For example, tree-ring growth (R) in any one year (indicated by a small "t", where t could be "1" for year 1, and "2" for year 2, etc.) is a function of an aggregate of factors:

1. the age related growth trend (A) due to normal physiological aging processes
2. the climate (C) that occurred during that year
3. the occurrence of disturbance factors within the forest stand (for example, a blow down of trees), indicated by D1,

4. the occurrence of disturbance factors from outside the forest stand (for example, an insect outbreak that defoliates the trees, causing growth reduction), indicated by D2, and
5. random (error) processes (E) not accounted for by these other processes.

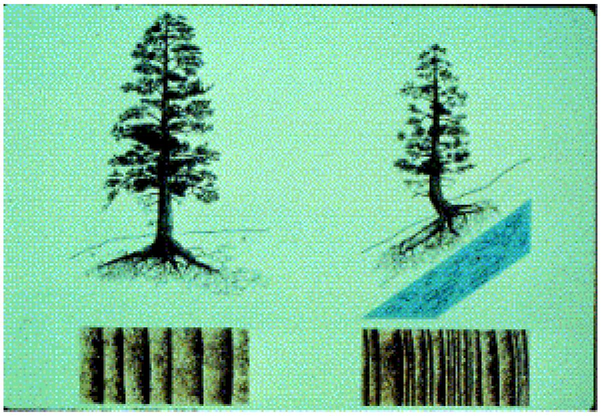
(The Greek letter in front of D1 and D2 indicates either a "0" for absence or "1" for presence of the disturbance signal.) Therefore, to maximize the desired environmental signal being studied, the other factors should be minimized. For example, to maximize the climate signal, the age related trend should be removed, and trees and sites selected to minimize the possibility of internal and external ecological processes affecting tree growth.

The Principle of Ecological Amplitude



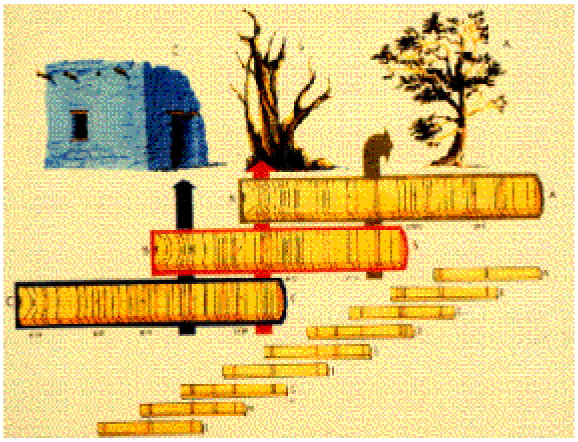
This principle states that a tree species "may grow and reproduce over a certain range of habitats, referred to as its ecological amplitude" (Fritts, 1976). For example, ponderosa pine (Pinus ponderosa) is the most widely distributed of all pine species in North America, growing in a diverse range of habitats. Therefore, ponderosa pine has a wide ecological amplitude. Conversely, giant sequoia trees (*Sequoiadendron giganteum*) grow in restricted areas on the western slopes of the Sierra Nevada of California. Therefore, this species has a narrow ecological amplitude. This principle is important because individual trees that are most useful to dendrochronology are often found near the margins of their natural range, latitudinally, longitudinally, and elevationally. The diagram above shows the different forest types as one increases elevation along a mountainside. To maximize the climate information available in ponderosa pine tree rings, we would likely sample trees at their lower elevational limit around 7000 feet (2130 meters).

The Principle of Site Selection



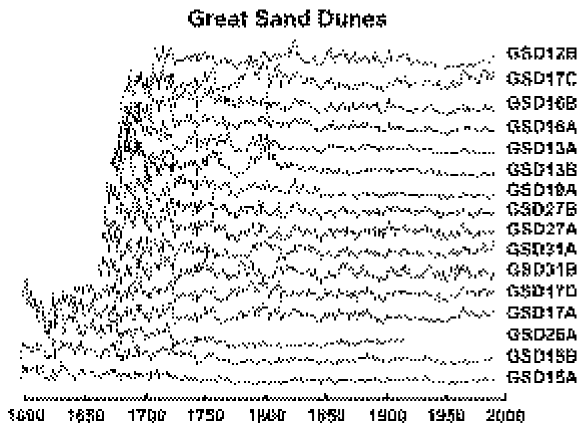
This principle states that sites useful to dendrochronology can be identified and selected based on criteria that will produce tree-ring series sensitive to the environmental variable being examined. For example, trees that are especially responsive to drought conditions can usually be found where rainfall is limiting, such as rocky outcrops, or on ridgecrests of mountains. Therefore, a dendrochronologist interested in past drought conditions would purposely sample trees growing in locations known to be water-limited. Sampling trees growing in low-elevation, mesic (wet) sites would not produce tree-ring series especially sensitive to rainfall deficits. The dendrochronologist must select sites that will maximize the environmental signal being investigated. In the figure below, the tree on the left is growing in an environment that produced a complacent series of tree rings.

The Principle of Crossdating



This principle states that matching patterns in ring widths or other ring characteristics (such as ring density patterns) among several tree-ring series allow the identification of the exact year in which each tree ring was formed. For example, one can date the construction of a building, such as a barn or Indian pueblo, by matching the tree-ring patterns of wood taken from the buildings with tree-ring patterns from living trees. 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!

The Principle of Replication



This principle states that the environmental signal being investigated can be maximized, and the amount of "noise" minimized, by sampling more than one stem radius per tree, and more than one tree per site. Obtaining more than one increment core per tree reduces the amount of "intra-tree variability", in other words, the amount of non-desirable environmental signal peculiar to only tree. Obtaining numerous trees from one site, and perhaps several sites in a region, ensures that the amount of "noise" (environmental factors not being studied, such as air pollution) is minimized.