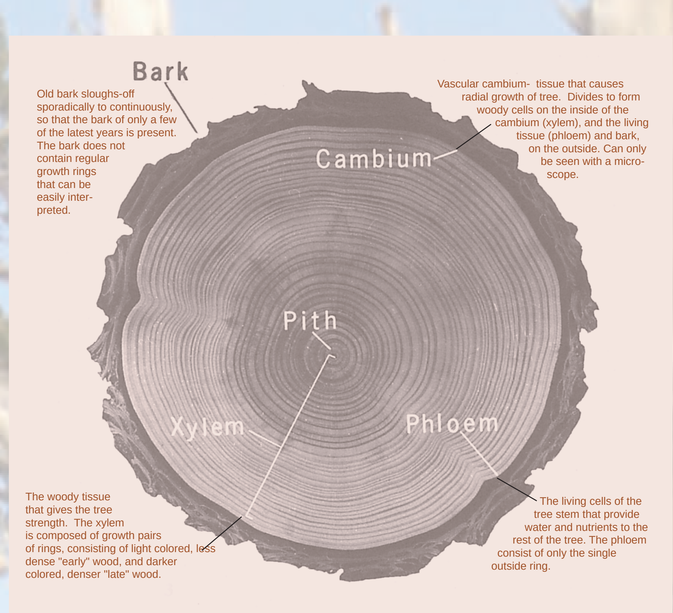
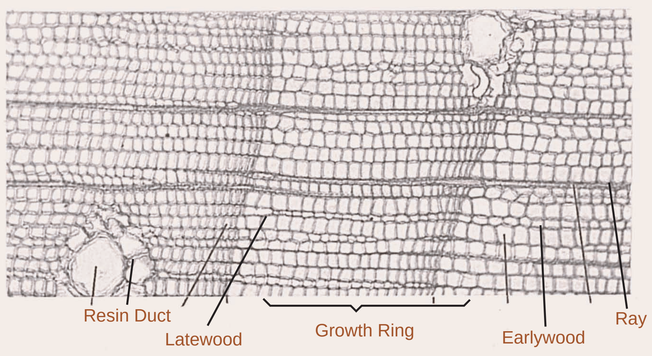
DISASTERS AND DENDROCHRONOLOGY
Using tree ring records to interpret and date catastrophic events and climate change



Cross Section of a Tree Stem (Trunk)

Above is a photo of a slice through a tree stem (or trunk). Inside the cambium are concentric growth rings that mark the growth progress of the tree with time. These rings are alternately lighter and darker in color. The lighter rings are referred to as "early wood", grown in the early part of the growth season when the tree grows fast because of an abundant supply of water, nutrients, sunlight, and favorable temerature. The cells that grow during this early part of the growth cycle are large and less dense than the cells that grow later on in the growth season; the latter cells, referred to as "late wood", are denser, and are thus darker in color. The tree normally grows a pair of such rings each year, a light and dark colored ring. By counting the annual pairs of concentric growth rings, we can calculate the age of the tree. With a log or a piece of cut timber, we can only calculate how old the tree was when it was cut down. When a living tree is cut down or cored, we can calculate both the calendric age of the tree, the year that it sprouted, as well as the calendric date of any ring pair in between. Photo from Stokes and Smiley, "An Introduction to Tree-Ring Dating", the University of Arizona Press, 1996.

Cell Structure within Tree Rings (Xylem)

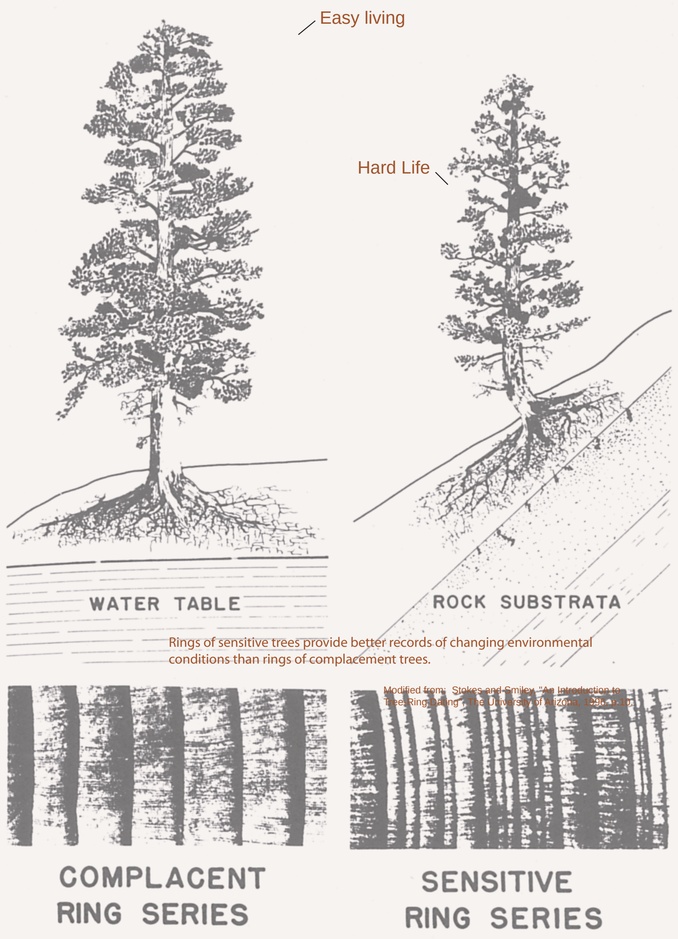


XYLEM: Mixed vascular tissue which conducts water and mineral salts throughout the plant and provides it with mechanical support

From Stokes and Smiley, "An Introduction to Tree-Ring Dating, The Unviersity of Arizona Press, 1996.

Happy and Unhappy Trees:

Trees that grow in an optimum growing environment tend to produce evenly-spaced rings. Such trees are called "complacent". Trees that grow in marginal environments tend to be more sensitive to changes in surrounding conditions. Such trees are called "sensitive".



Rings of sensitive trees provide better records of changing environmental conditions than rings of complacement trees.

Modified from: Stokes and Smiley, "An Introduction to Tree-Ring Dating", The University of Arizona Press, 1996.

DENDROCHRONOLOGY is the study and precise dating of trees and wooden items by accurately counting the annual tree growth rings.

One annual tree ring is comprised of the beginning of earlywood formation to the end of latewood formation.

Earlywood is the lighter colored, thin-walled (lower density) cell tissue formed early in the growing season. Latewood is the darker colored, thicker-walled (higher density) cell tissue formed later in the growing season.

When counting tree rings:

every 10 years is indicated by one dot
every 50 years is indicated by two dots in vertical alignment
every 100 years is indicated by three dots in vertical alignment

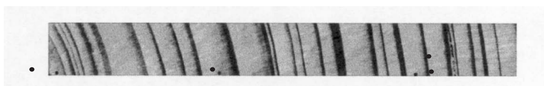


Figure 1. On the tree core illustrated above, decadal tree rings (every 10 years) are marked by one dot and a 50 year tree ring is marked by two vertically aligned dots.

A USEFUL SPECIES FOR TREE RING DATING

Douglas fir (Pseudotsuga menziesii) is one of the preferred tree species for dendrochronology in the western North America. Four reasons are:

1) This tree species has very high circuit uniformity. This means that the rings are usually concentric around the middle.

2) It has well-defined rings; i.e., the earlywood and latewood bands or couplets are sharply defined.

3) this tree species is sensitive to environmental changes and thus shows excellent tree ring variability.

4) Douglas Fir is well distributed from Canada to northern Mexico making it ideal for large scale climate reconstructions.

CROSS-DATING OF THE WILLIAM KENT MEMORIAL DOUGLAS FIR, A NEARBY COAST REDWOOD (MUIR WOODS, MARIN COUNTY, CA) AND A COAST LIVE OAK (SOUTH LEVEE, SAN FRANCISQUITO CREEK, PALO ALTO, CA).

Informal names, scientific names, and counted tree-ring age ranges of studied tree species:

Douglas fir (*Pseudotsuga menziesii*): 1740 to July 3, 1980
Coast redwood (*Sequoia sempervirens*) 1524 to July 18, 1980
Coast live oak (*Quercus agrifolia*) 1884 to November 7, 2002

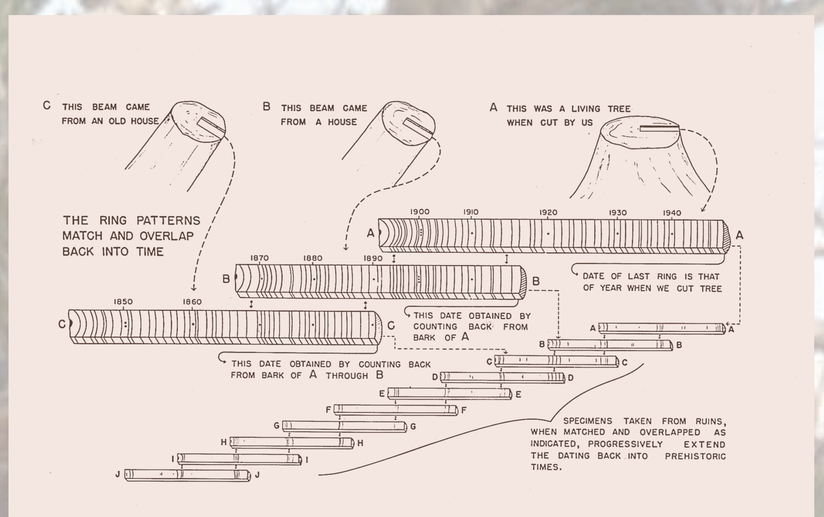
When our specimens are matched and overlapped, our tree dating is progressively extended. The total age range for these 3 tree species is between1524 to 2002, A.D. (or 478 years).

Extracting core from a tree after coring with an increment borer

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 (along spoon inserted into the shaft that pulls out the tree core.

(Modified from: Henry Grissino-Mayer's "Ultimate Tree-Ring Web Pages": http://web.utk.edu/~grissino/)

From Stokes and Smiley, "An Introduction to Tree-Ring Dating, The Unviersity of Arizona Press, 1996.



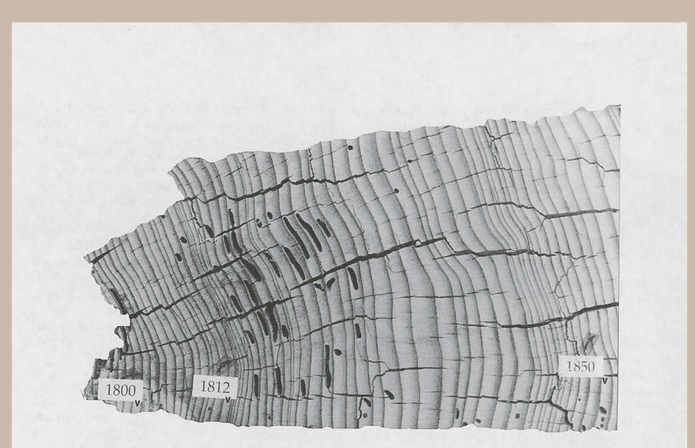
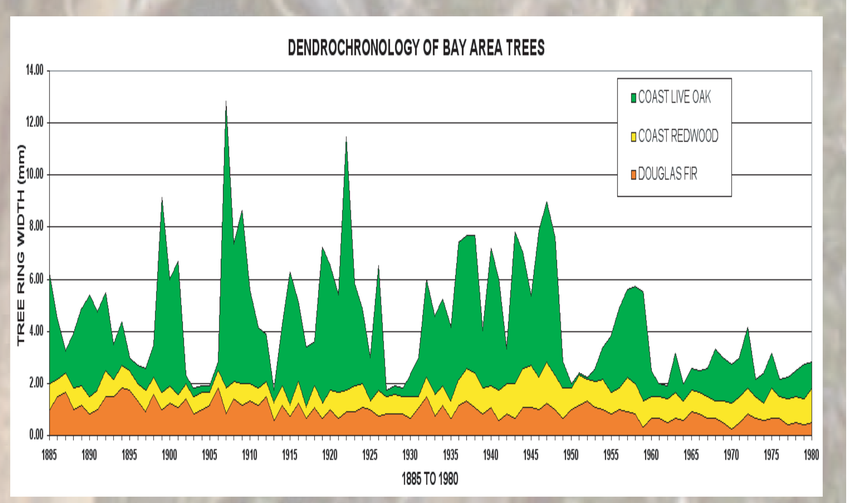


Figure 2. A white fir (Abies concolor) on the San Andreas fault near Wrightwood, California. This section cut from the stump of a tree that died in the 1950's shows effects of the 1812 earthquake. The center of the tree is to the left and the outer part to the right. The 1800 ring is marked with three dots and each decade is marked by one dot. One can see the abrupt decrease in width starting in 1813 and taking four to five years to recover normal growth. 1809 and 1823 were dry years. The elongate dark holes are from wood-boring insects and the cracks are from weathering.

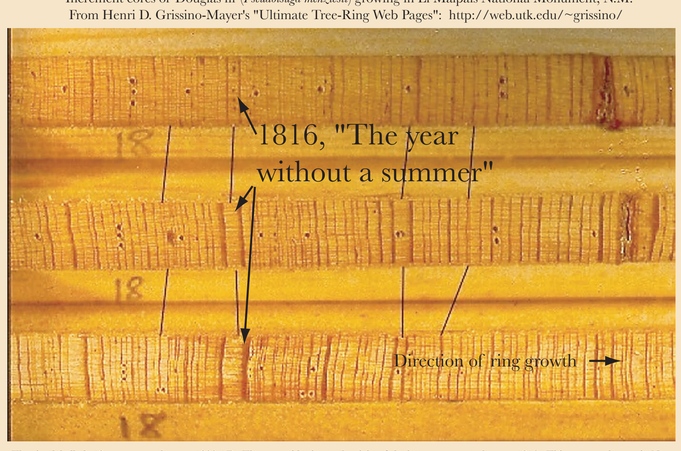
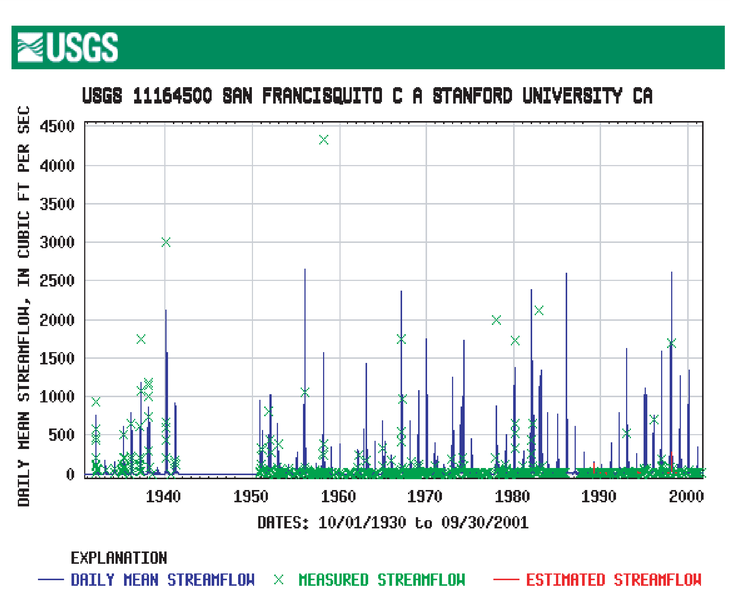
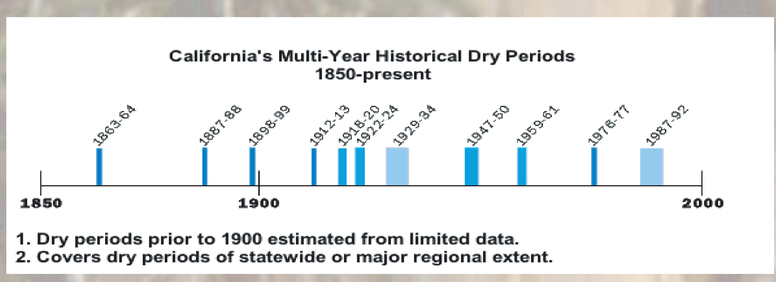
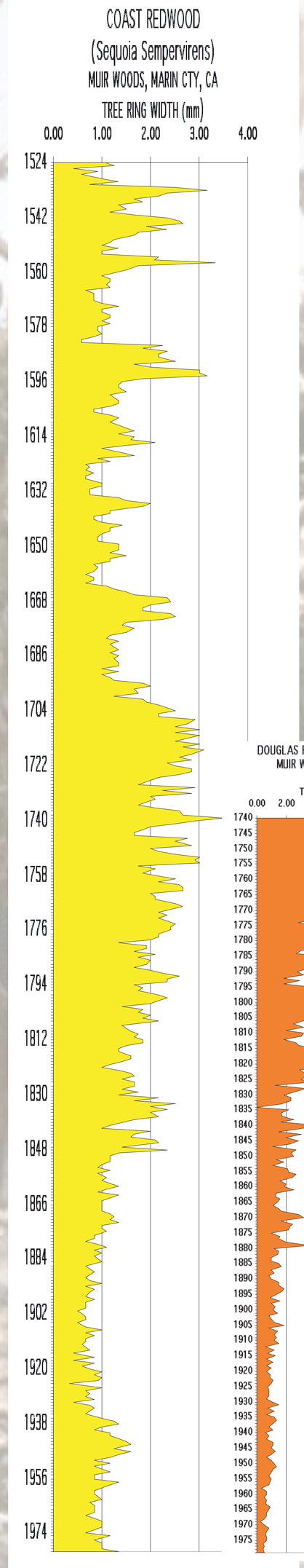
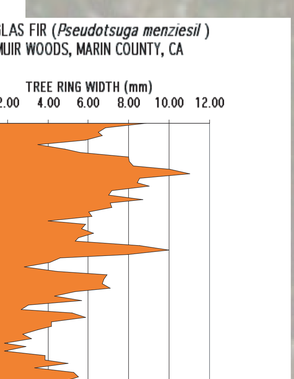
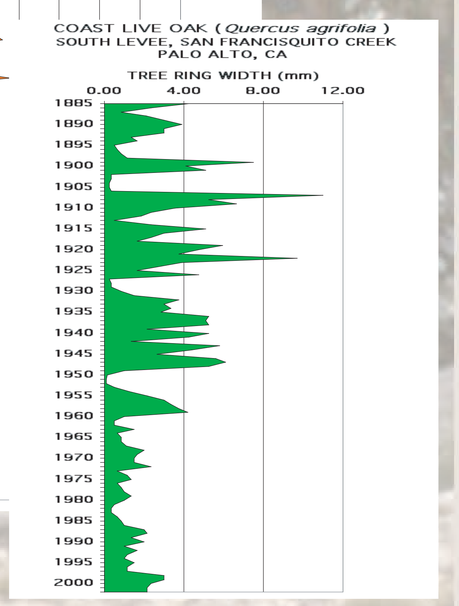


Graph comparing the tree ring widths (in mm) of the coast live oak, coast redwood, and Douglas fir between 1885 to 1980, A.D. High peaks indicate wider tree rings which suggest periods of increased growth rates. Low peaks denote narrow tree rings which suggest decreased growth rate periods. Because tree ring widths also imply favorable or stessful levels of precipitation, temperature, and sun light, they can be used as a substitute or proxy for climate change (wide rings = wetter, milder climate; narrow rings = dryer, extreme climate).

Note the relative peaks and valleys in the curves denoting the trees' reactions to climatic changes. Are the trees reacting similarly and simultaneously to environmental conditons or do any of the tree species lag behind? In the bay area dendendrochronology, many of the shifts in the curves can be correlated to historic records of strong El Nino events and periods of severe drought.

Volcanic Eruptions Recorded in Tree Rings

Increment cores of Douglas fir (*Pseudotsuga menziesii*) growing in El Malpais National Monument, N.M.
From Henri D. Grissino-Mayer's "Ultimate Tree-Ring Web Pages": http://web.utk.edu/~grissino/



The ring labelled "18" represents the year 1800 AD. The very wide ring to the right of the latter represents the year 1816. This year was known in New England and many places around the world as "The year without a summer" because of cold temperatures and frequent frosts that destroyed crops. In 1815, the volcano Tambora erupted near Sumatra. An estimated 150 cubic kilometers of ash were erupted. Fine ash and microscopic droplets of sulfuric acid injected into the stratosphere supressed temperatures worldwide by decreasing the incoming solar radiation. The lowered temperatures, however, also had the effect of increaing effective moisture to these trees because of the lowered temperature, and so increasing the growth rate of the Douglas firs.