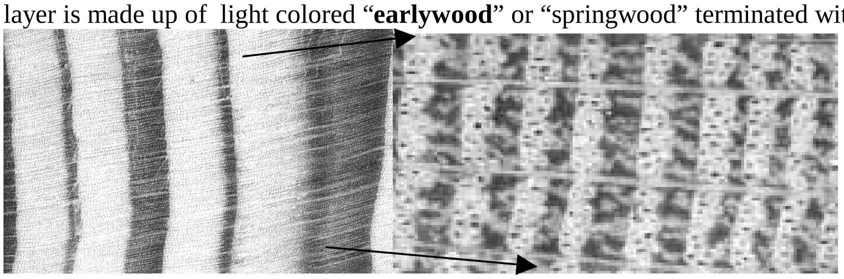
Historical Dendrochronology: Tree-ring sampling of historical structures to determine date of construction or develop a reference or "dating" chronology.

Basic tree-ring anatomy

Many trees and woody plants in temperate regions produce annual layers of woody tissue commonly referred to as "tree-rings". Growth layers in the stems of such plants, when viewed in cross section, form a series of concentric rings – thus the name tree-ring. In coniferous species (pine, fir, spruce) the "ring" or layer is made up of light colored "**earlywood**" or "springwood" terminated with a



Conifer wood (left), and a ring-porous hardwood (right).

dark layer of small, thick-walled cells called "**latewood**" or "summerwood". Hardwoods also produce growth layers or rings, but the tissue is anatomically and visually different than conifer wood. Two broad types of anatomy cover most hardwoods: **ring-porous** and **diffuse-porous** woods. Oak, hickory, and ash are ring-porous while maple, cottonwood and aspen are diffuse-porous, for example. Ring-porous woods have a ring of large vessels that are produced in the spring as the tree leafs out. These cells appear as a light-colored ring in cross section. The rest of the ring is made up of small densely packed cells. Diffuse-porous woods have the large vessels distributed through out the ring and ring boundaries are often difficult to see.

Growth in woody plants can be thought of as a series of cones stacked one upon another, like a stack of paper cups. Once formed, the tissue is immobile: a nail driven into a tree will remain at the point and height where it was driven while becoming slowly embedded in the tree as the stem adds new layers each year. Most wood cells remain alive for a few months before dying and becoming empty tubes used for the transport of sap or water in the stem. Only a thin outer skin beneath the bark remains alive. This skin is known as the **cambium**. A radial sample from the center, or pith, of a tree to the bark will contain a complete series of growth layers making it possible to determine the age of the plant at that height. The longest record, and the age of the tree, can only be obtained at the base of the tree. A radius from high up among the branches will yield a shorter record, as it lacks the early layers of growth produced as the young tree was growing to that height.

Basic Dendrochronology

Tree-ring dating of wood samples relies on matching growth patterns in a sample of unknown date with the pattern in a known standard, or "chronology". Growth patterns useful for dendrochronological dating are produced by yearly variations in climate that favor or disfavor the growth of trees in a region ***in common*** with each other. Variations in growth due to events that only affect an individual (death of a neighbor, loss of limbs or top in a storm for instance) are not helpful and may obscure the common "signal" or pattern. In some cases individual variation may prevent successful tree-ring dating of a sample. Tree-ring chronologies are region specific, and often species specific as well. Conditions favoring the growth of oaks in a valley may not be so favorable for spruce on a mountain top.

For successful tree-ring dating the following requirements must be met:

(1) Annual layers or "rings" present and identifiable.
(2) Growth pattern due to external factors present and identifiable.

(3) A known standard or tree-ring chronology containing the record of typical growth for the region, species, and period of time in question must be developed or already available for comparison.
(4) Sufficient number of rings present in a sample for the pattern to be uniquely identified as belonging to a particular period of time, based on comparison with the known standard.

Number 4 is variable depending on the strength of the common growth pattern. Generally, 80 to 100 years is desirable at a minimum, and the longer the sequence, the better. Dating chronologies are generally developed by sampling living trees in a region of interest using an increment borer. Growth patterns are compared and averaged together to maximize the common pattern and eliminate individual variability. Tree-ring chronologies have been developed for many species in many temperate regions of the world. Some of these are available through the International Tree-Ring Data Bank maintained by NOAA (the National Oceanic and Atmospheric Administration) and are available on the World Wide Web.

<u>Sampling historical structures to provide tree-ring dates</u>

In order to date the construction of a building with wooden elements the following requirements must be met:

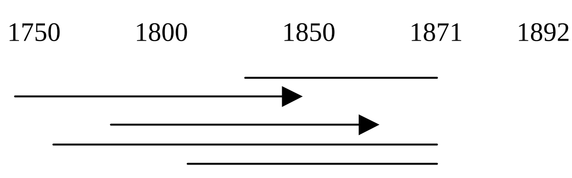
(1) Species used in construction must be suitable for dendrochronological analysis (spruce, hemlock, oak, or ash are some examples)
(2) Local timber must have been used, or the place of origin of the wooden elements must be known.
(3) ***<u>Samples with an intact bark surface must be obtained</u>*** (these samples document the year and season of harvest). Milling by sawing or shaping with an ax or adz will remove the outer rings from some or all portions of a timber or board. At least some samples from the structure must have the bark edge, or "waney" edge as it is sometimes called, in order to obtain a construction date. The bark edge is smooth, often has a distinctive color, may have galleries created by engraver beetles, and may, or may not have bits of bark remaining.
(4) The samples must have a sufficient number of rings to provide a reliable date.

Additionally:

(5) Local construction practices including typical season of harvest and the length of the milling and storage process known (this appears vary from a few months to two years for 19^{th} century Vermont).
(6) Known history of the structure and area should be noted.
(7) In buildings with a history of repair or construction with re-used material the details of construction, milling or shaping, and juxtaposition of timbers should be examined and noted at the time of sampling.

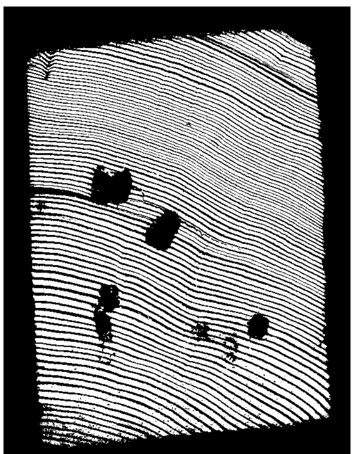
Ideally as many samples as possible should be obtained, each with a large number of rings and the bark edge present, and each a complete cross section of the timber. For a given timber, three samples might be obtained – one from each end to be sure that the maximum number of rings is obtained, and perhaps a third from a point with the bark edge present. Practical considerations will often preclude such through sampling and a single timber. Often a "core" from an in-situ timber removed with a hole saw, with the bark edge present, would be a typical sample. In a well-sampled structure many elements would be sampled, and not all would necessarily have the bark edge present.

In the following diagram the lines represent the time spans of several samples. Those with an arrow had no bark edge present. The rest, save one, had a bark date of 1871 representing harvest in the winter of 1871/72 and construction in 1872. A single sample had a bark date of 1892, representing a repair or later addition to the building.

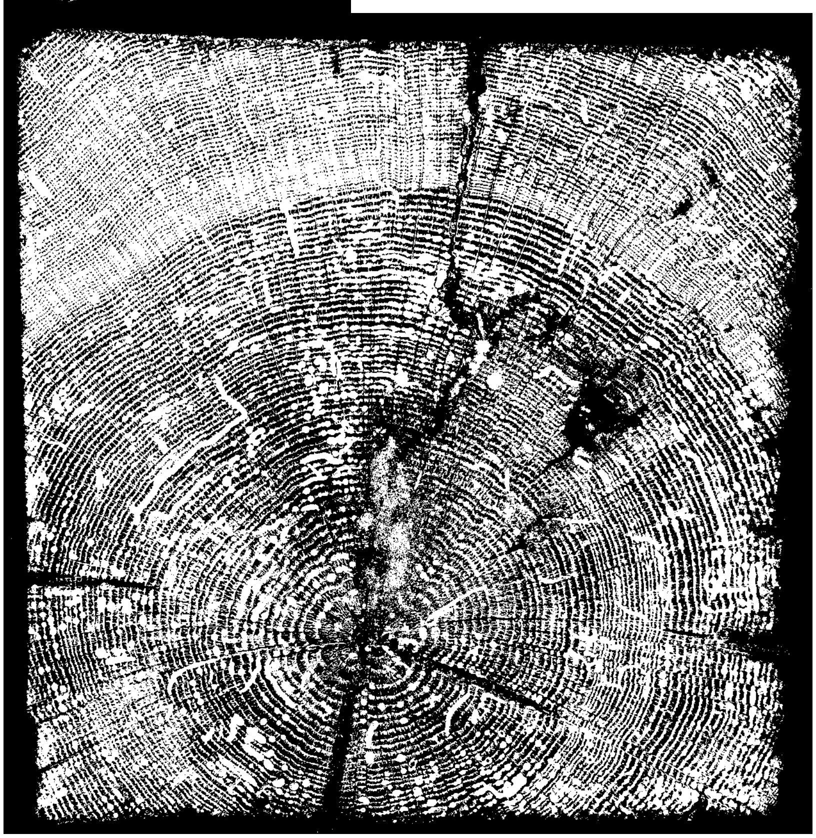


In the above example, all the samples contribute information to the complete picture and bolster the confidence in the date for the structure. The two samples without a bark date bolster the early part of the time line and aid in confirming the growth pattern for the complete set of samples.

Since the maximum number of rings is also a criteria, and local procurement of timber often meant harvest from a single or small number of forest stands, the samples from a structure can be integrated to form a more complete unit. Suitable samples might be obtained from a variety of elements including siding boards, rafters, structural timbers, floor or ceiling joists, etc. As tree size is often poorly correlated with tree age, a smaller element may turn out to have a larger number of rings, and thus be more “datable” than a large timber. This is particularly true of spruce, a common construction wood in 19th century New England. A four-inch board may have over one hundred rings, while a large 12 inch square timber may have only forty.

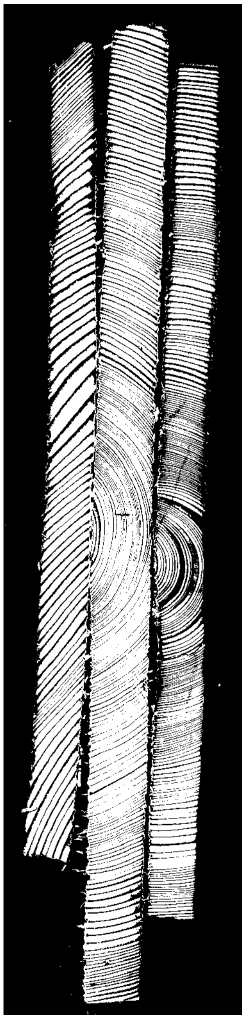


Hemlock brace. This sample has sufficient rings to date and a bark, or waney edge at the upper right that can provide a cutting date.

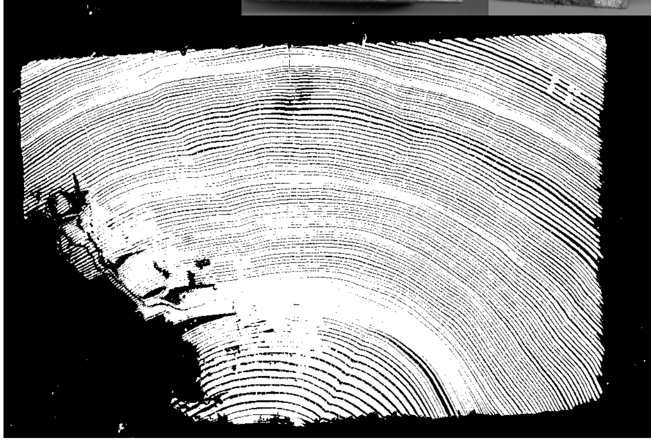


This oak timber also has sufficient rings for dating purposes, over 100, however in the process of shaping all bark surfaces were removed. The sample may contribute to chronology development and provide a minimum date for the structure, but no cutting date can be obtained.

These spruce siding boards, shown with their end-grain polished, provided excellent samples. The one on the far left has a waney edge that gave a cutting date of 1823.



These mounted cores, obtained with a hole saw from exposed beams, provide excellent samples for dating a building.



This hemlock timber from a slow-growing tree had sufficient rings to date, but no bark edge and thus the date of felling could not be determined.

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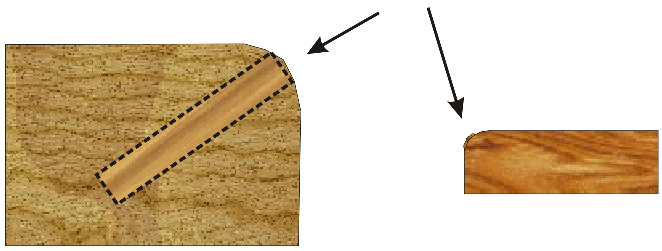
Obtaining a sample from an exposed beam with an electric drill and a hole saw.

Sawn or hewn timbers and boards may retain some of the original bark surface allowing a cutting date to be obtained.

Note the rounded surface of the bark, or "waney" edge in these cross-sectional views.



A core from this timber can be sampled so that the waney edge is included.