Dendrochronological Methods

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"Tree-ring dating" uses the annual growth patterns of wide and narrow tree-rings in wood to discover when and where the parent tree grew and when it was cut down. For most structures, we collect samples to find out when a building was constructed or altered, what species of tree were used, and where the logs came from. The most common species used for construction in New York State prior to 1850 are eastern white pine, a number of oak species, and eastern hemlock. As of May 2020 we have sampled and dated over 60 historic buildings in New York, USA. This paper gives an explanation of the methods used in tree-ring dating.

Collection

During collection, we discuss the history of a building or other structure with the owner and/or contact and take a visual inspection to find accessible timbers with the attributes and potential to determine when a structure was built, whether there was more than one known building phase or addition, and to answer other questions about construction and the general history of settlement and development of the region.

Cellar beams are generally the least-replaced timbers in a structure, and are key to establishing building dates, but beams, posts, and attic timbers in the stories above can be equally successful. Any accessible beams are checked for the presence of bark, a "waney edge" – where only bark has been removed – and the presence of sapwood when bark or waney edge is absent. The first two attributes are necessary to determine the actual felling date of the represented tree, and the third will give a "soon after" date. Also checked during inspection is the approximate number of tree rings in each beam when they are visible, often on a squared surface of the beam or at its intersection with other support timbers. A minimum of 50 rings is essential, and 75-plus is much more successful for accurate dendrochronological dating. The final requirement is whether a beam can be sampled by our collection equipment. To take a core, we use a hollow dry wood borer ~1.5cm in diameter, and obviously thin boards and panels cannot be sampled with this instrument. Occasionally the outer end of an extant timber is exposed so that a cross-section can be sawn off. Cross-section are ideal samples, and when a building is being altered or after alteration, loose timbers, boards, paneling, etc., are often available for collection and significantly add to the results. Even when it is not certain where the loose timbers came from, their tree rings often can be dated, perhaps reveal their usage, and add to our regional tree-ring chronologies for New York State.

Core samples are taken with two kinds of hollow dry-wood borers that produce core samples 0.6 and 1cm in diameter, and up to ~20cm in length. The best timbers for sampling are those with minimal squaring and the presence of bark and/or the waney edge. For squared beams, the edges along the beam are carefully inspected to find a possible waney edge or bark. In either case, samples were taken with the borer by drilling into the timber towards the pith as far as possible, and the core was extracted and stored in a straw. For exposed ends of beams and any loose timbers, a 1 to 2″ sample was sawn, wrapped with cheesecloth or string before or after sawing depending on fragility, and taped up.

Measuring and analyzing the samples

At the lab, core samples are prepared by gluing them onto core holders, generally a long strip of wood about 0.7 x 0.7" (1.5 x 1.5cm) in width and height with a semicircular groove along one side. All samples are sanded on the transverse surface where ring boundaries are clearly visible, with 40- to 300-grit sandpaper and polished when necessary. Species are then identified and rings counted. Ring-widths are measured on a moving table under a microscope with cross hairs, and the widths are measured at 0.01mm accuracy with 3% error.

The presence of bark or waney edge plus any number of sapwood rings or unusual features are noted. Samples that are fragmented or damaged are only measured if the fragments were able to be glued in the same order as they were in the cored timber and/or contain a waney edge, over 50 rings, and are from a key location such as a sill beam that is unquestionably part of the original construction. Samples with less than 50 rings are not measured because the ring patterns in that short a sequence are not sufficiently unique for that length of time, and so cannot be accurately dated with tree rings.

The ring widths of each sample are measured twice and any difference between the measurements reconciled, which creates a sequence of ring-width measurements. The pattern of wide and narrow rings in the sequence of one sample is then compared to those from the other samples of the same species, and when patterns match both visually and statistically, those sequences are "crossdated" – relatively dated to each other - and then combined into a chronology, with this process repeated for all datable samples of each species, with all combined into a final chronology for that species and site. The averaging of the single samples dampens the individual trees' growth idiosyncrasies, and highlights the "common signal" the growth response to climate parameter(s) such as summer rain or spring temperature that affect tree growth and is contained in each tree ring in addition to the idiosyncrasies.

The patterns in the site chronology are then matched to those in calendar-dated reference chronologies that are composed of other historic site chronologies and the forest chronologies used to determine the calendar years of the site chronologies. A successful crossmatch with a reference chronology establishes the calendar dates of the new site chronology and its samples.

Once the calendar date of the outer measured ring of each sequence is established, the outer rings of samples with bark and waney edges or just the waney edge have to be inspected to successfully determine the exact year and even season when a tree was felled. The dates of the sample sequences include only the measured rings, and if there is one or more incomplete or unmeasured rings on the outer end of a sample, that number must be added to the outer ring of the sequence to determine the felling year of the parent tree. For example, if the outer measured ring is a complete ring at the waney edge and the sequence dates end in 1719, then that tree was felled after the growing season ended in September 1719 and before the start of growing season in March or April of 1720. If there is one unmeasured outer ring of a sample with a waney edge, and the measured ring dates to 1719, then the outer ring dates to 1720, and the tree was felled sometime between the start and end of the growing season in 1720. For oak samples with a number of sapwood rings present, the felling year can be estimated from the known average of ~10 sapwood rings, but for other species an average sapwood count is not established or too variable to be used for that purpose and some species such as hemlock do not have a distinguishable heartwood/sapwood boundary. Only a "felled after" date can be determined with samples with no bark, waney edge, and/or sapwood rings.

When multiple samples give the same felling year, the building date is most often within a year of that date for historic buildings in New York west of the Hudson River prior to ca 1850, but the history of the lumber trade in the immediate area, thus possible drying and transport time for the construction timbers, needs to be taken into account if that was possible. If two or more substantially different felling years are indicated, these suggest repair, restoration, two or more building phases, reuse of wood from a previous structure, and other possibilities.

Reference chronologies are both single-site chronologies and regional chronologies that are calendar-dated. Their calendar dates are based on cross-matching between them and the live tree forest chronologies calendar-dated based on the year(s) when samples were collected. Regional reference chronologies are composed of site chronologies that crossdate very well and come from within a geographic region. The Cornell Tree-Ring Laboratory has now established site and regional chronologies from ~60 buildings, Buffalo to Albany, Massena to Waverly, NY. Reference site chronologies include 44 site chronologies of oak, 1448-2006; 42 of hemlock, 1506-2016, 28 of eastern white pine 1543-1856; and 7 of pitch pine, 1551-1783. Additional New York chronologies are available within New York State, especially from the Adirondacks and Catskill Mountains, from E.R. Cook and J. Rayburn. The eastern white pine and pitch pine chronologies are calendar-dated by their matching patterns with several forest and historic chronologies from eastern New York and northern Pennsylvania built by E.R. Cook of the Lamont Doherty Earth Observatory.

Definitions of terms used in tree-ring analysis and site reports:

B	bark present
W	waney edge present, with the outer ring directly inside the bark
+N	A known number of unmeasured rings before or after a measured sequence
v	the outer ring is likely very close or at the waney edge (subjective)
vv	unknown number of rings missing between the outer ring of the sample and the bark

For the statistics in the "pro" sheets (provenance), calculated for the crossdated sequences:

t-score – the Student's *t*-score, statistically significant over 2.56 for 100 year overlap, but generally not considered unless over 3.50 (Baillie and Pilcher 1973).

Intercorrelation: Average of the correlations between each sample and the averaged data from the other samples in a chronology, significant at > 0.328 (Holmes 1983).

Correlation coefficient - Pearson correlation coefficient between chronologies.

Trend coefficient. – percentage of the year-to-year increase or decrease in ring widths that are the same in compared sequences; significant above ~ 60% depending on overlap.

General references

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