CANADIAN FORESTRY SERVICE

fact sheet

WHAT TREE RINGS TELL US

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We can walk into a forest in many parts of Canada and see living trees that were growing long before we were born. Douglas-fir trees still stand in British Columbia that were centuries old when the New World was discovered by Europeans. We know all this from the well-defined growth layers or "tree rings" found within the stems, branches and roots of many species of trees.

Tree rings, however, tell us much more than just the age of trees. The history of the events and conditions that affected a tree's growth during its lifetime are recorded in these rings — general conditions like soil type, elevation and latitude; climatic factors such as temperature and precipitation; human activities like logging, road construction, air pollution; and natural events such as landslides, floods and forest fires. The quality of wood also can be assessed by studying the width and density of the annual rings.

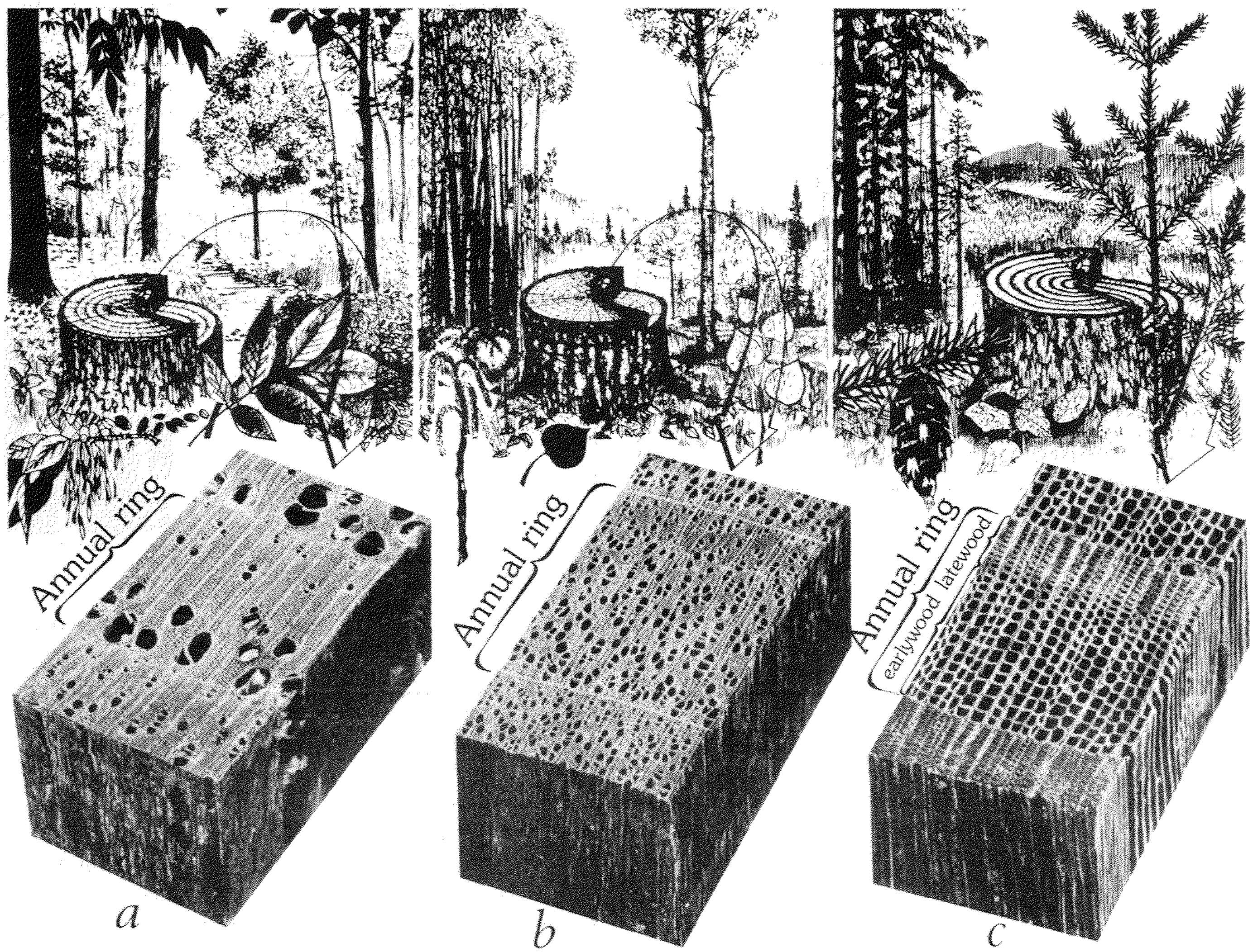

Fig. 1. Scanning electron micrographs reveal the structural differences of various tree rings: a) the ring-porous hardwood, ash, b) the diffuse-porous hardwood, aspen, and c) the softwood Douglas-fir. Earlywood and latewood are evident in the Douglas-fir section.
Credit: R. W. Meyers and A. Bramhall.

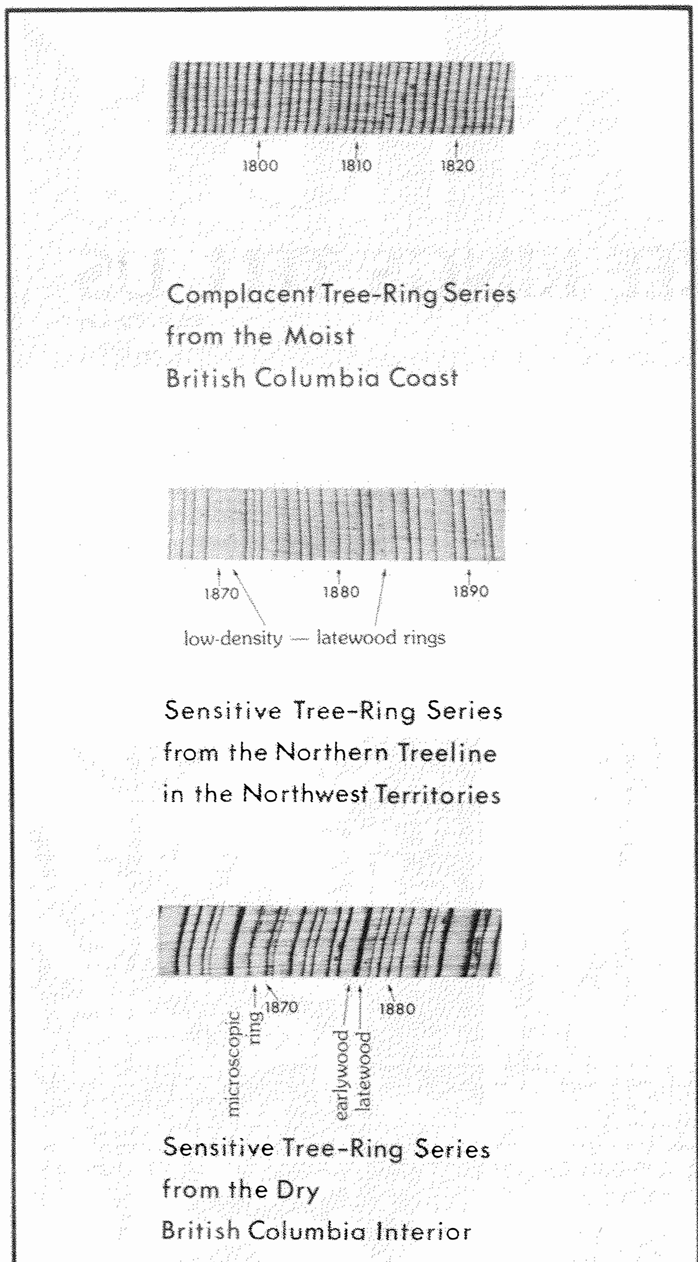

Fig. 2. Complacent ring series from trees on the moist British Columbia coast have rings that are more uniform in width than are the rings of the sensitive chronologies of trees from the province's dry interior or the Northwest Territories.

structure of tree rings

Tree rings are the concentric rings of alternating light and dark coloured wood that appear across the top of a fresh stump or on the end of a log. The outermost ring, directly under the bark, is the tree's annual growth layer formed during the last growing season. The innermost ring contains the pith at its centre. By counting the annual tree rings on a single cross section like a stump top, we can determine the number of years the tree grew after it reached stump height.

The structure of the rings is different for each species of tree. Although tree-ring analyses have been conducted on such broadleaved species as aspen and oak, most studies have related to the conifers — the pines, spruces, firs, etc.

In the conifers all the annual rings contain "earlywood", consisting of large-diameter cells with thin walls, formed in the early part of the growing season, and "latewood", made up of a small-diameter, thick-walled cells which form in the latter part of the growing season. This structural difference between earlywood and latewood allows us to discern the annual rings well enough to count them and measure their width and density.

matching patterns

Tree-ring analysis, or dendrochronology, involves matching the patterns of wide and narrow rings between trees as well as the patterns caused by variations in the density of different parts of the rings. The year during which each ring was formed is determined by counting back on the tree-ring sample from the outermost ring. A tree-ring record or chronology can be produced by noting the width and density of these rings for each year of the tree's life.

In one geographic area, several trees of the same species will exhibit similarities in their ring patterns. These ring patterns usually result from variations in environmental factors like temperature and precipitation that affect the growth of all the trees in an area. A chronology is considered "sensitive" if there is a wide fluctuation in ring width or density from year to year; it is "complacent" if there is little annual variation. Trees growing in the northern regions of Canada, for example, produce sensitive tree-ring chronologies; variations in ring growth in those areas are determined mainly by differences from one year to the next in summer tempera-

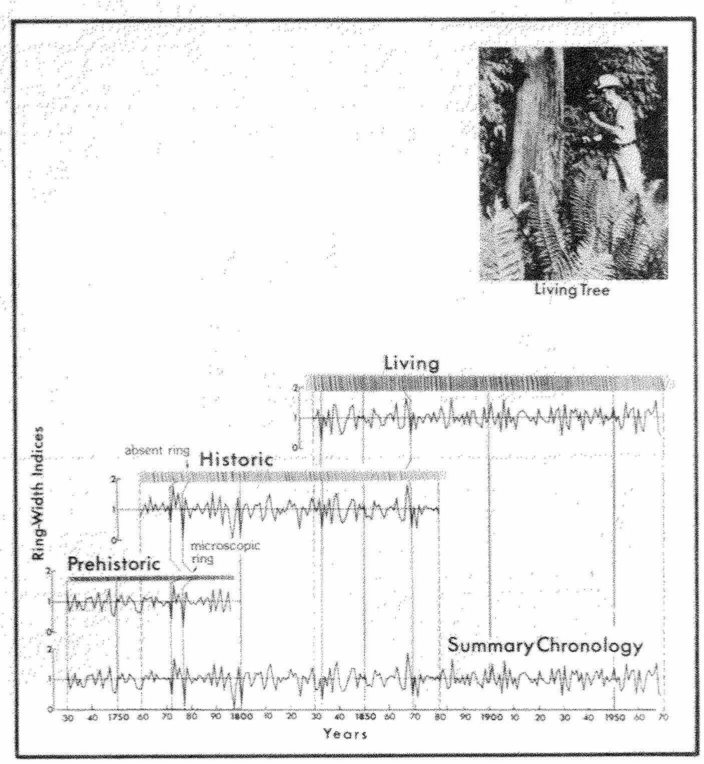

Fig. 3. Historic and prehistoric wood structures can be dated by matching their ring patterns against those found in living trees of known age. An increment borer, a hollow metal bit, when screwed into a standing tree extracts a pencil-sized tree-ring sample without harming the tree.

tures. In dry regions, ground moisture is the major factor determining annual variation in ring growth, and ring series are sensitive. Trees in mild, moist coastal regions where there is sufficient moisture and proper temperatures for rapid growth, usually produce complacent ring series.

These patterns can be used to study past climatic conditions. Those measured in trees cut at a known date can be crossdated with patterns found in dead trees, forming a basis for dating past events. Tree-ring chronologies also can be influenced by injuries to trees caused by man or natural events, enabling us to assess the time and magnitude of these events.

development of dendrochronology

The concept that there is a relationship between time and diameter growth of trees goes back at least to the time of Theophrastus, a student of Aristotle. Many early scientists, including Leonardo da Vinci, understood that tree rings formed annually and speculated that their growth might be affected by weather conditions. Dendrochronology, however, was not established as a scientific discipline until early in the 20th century by the astronomer A. E. Douglass.

Douglass was interested in sunspots and weather, and he attempted to determine their relationship to annual tree rings. He developed a system of crossdating the rings of contemporary trees of known age with those of successively older and older dead trees. Dendrochronologists now call this method "chronology building".

uses of dendrochronology

Dendrochronologists are interested in old trees because they hold an important key to extending climatic records into the past and to dating prehistoric wood samples.

Wood taken from extensive Indian ruins in the southwestern United States, for example, has been dated by the tree-ring method and archaeological tree-ring chronologies have been developed that extend to before the time of Christ for that area. In the same part of the United States, ring chronologies extending back 8,000 years have been constructed for the oldest known tree species, the bristlecone pine. For the giant sequoias chronologies reach back 3,200 years.

In Canada, chronology building has traced the life of a Douglas-fir on Vancouver Island back to 680 AD. Other studies have included ring counts to determine the age of certain trees growing in British Columbia and Alberta in areas recently occupied by glaciers, helping scientists establish an approximate rate of glacial retreat. Trees collected along the proposed MacKenzie Valley pipeline route also have revealed flooding, ice jamming and landslide activity in that region. Annual rings characterized by compression wood (see Fig. 4), which forms when a tree is forced into a leaning position by a land movement, were used to date the landslides. Floods and ice jamming, which scar trees along the banks of rivers, were traced by counting the annual rings back to the injury (see Fig. 5).

Fig. 4. The dark compression wood dates two landslides: the first in 1908 that forced the tree to lean to the left and the second in 1944 that forced it to lean to the right.

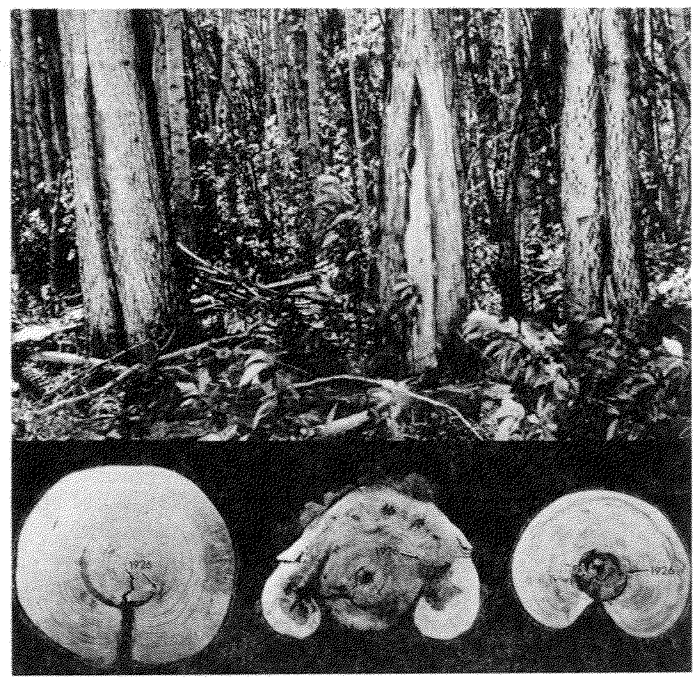

Fig. 5. The scars on these three tree sections indicate the year in which flooding or ice jamming occurred along the river where the trees grew.

Tree-ring analysis has been used around the world to date volcanic eruptions, earthquakes, forest fires, past lake levels, sand dune movement, formation of river terraces; and to assess the effects of fertilization, thinning, pollution, insects and other conditions influencing the health of trees. It has been used to determine rates of sedimentation, erosion, stream migration; to calibrate radiocarbon dates, to determine the elevation of past timberlines, the rate and nature of plant succession and to verify the dates of historic structures or trees marked by surveyors.

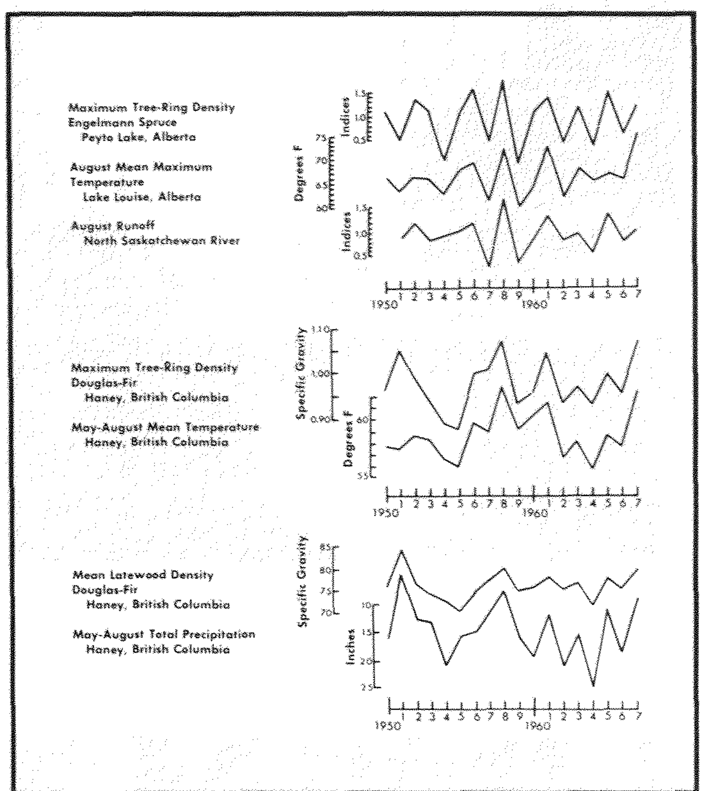

Fig. 6. Tree-ring density of the high-elevation spruce is shown to be closely related to August temperature and river runoff. The two lower graphs show the close relationship of May through August temperatures and precipitation to tree-ring density in the British Columbia coastal Douglas-fir.

new methods

Laboratories concerned with tree-ring research are being established in more countries every year. Today, many new and improved techniques are being used in dendrochronology, including modern statistical methods and computer technology. Of great significance over the past decade has been the development of radiation densitometry of wood. This has particular application in geographical regions where ring width patterns are complacent but ring density patterns are sensitive. In Canada, this situation is found with high-altitude or high-latitude spruce and also with coastal Douglas-fir. Variations in ring density patterns observable with radiation densitometry compensate for lack of information derivable from the relatively stable ring width patterns. By establishing valid relationship between density and climatic factors, it is possible to learn more about such things as precipitation, flooding, and temperature in past ages.

future in Canada

Although tree-ring research has not been conducted extensively in Canada, this country offers a good potential for many dendrochronological projects. Canada's forests extend from the Pacific to the Atlantic oceans and from the prairie grasslands to the arctic tundra.

Some of the oldest and largest trees grow on the West Coast. Very old samples of dead trees, some interglacial, are preserved along the seacoasts and in bogs. All hold important clues to this country's past. As well, an understanding of the impact of air pollution and the effects of silvicultural practices, like fertilization and thinning, are of growing economic importance.

The information is there. What the rings will tell us depends on our ability to interpret the relationships between ring growth and the environment — on how well we can decipher the tree-ring code.

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