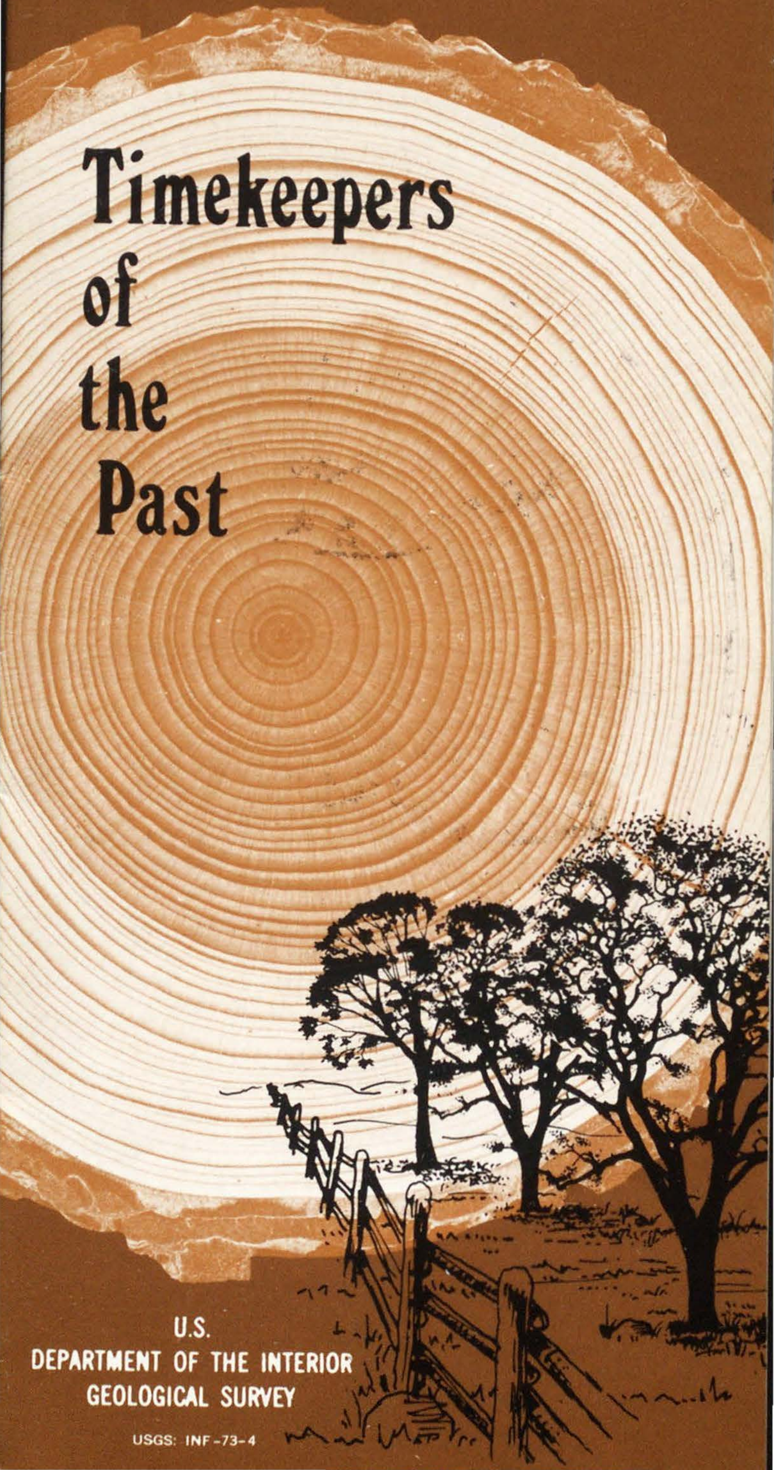
TREE RINGS:

Timekeepers of the Past



U.S.
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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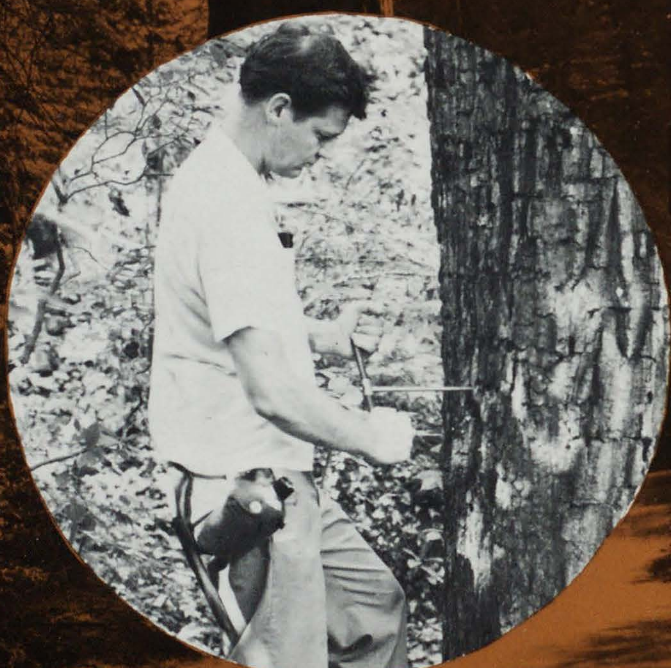


TREES ARE GIANT PLANTS

Perhaps few of us, in viewing a tree, say to ourselves, "I am looking at a giant plant!" It may well be, however, that our fascination with trees, as a subject of esthetic enjoyment, results from our awe and pleasure at their size, vitality, and attractive blossoms as well as from their varied characteristics. Most of us are exposed to trees every day, but we do not tire of them. Indeed, we delight in their nearness, and each year more and more of us turn to forests and woodland areas for our vacations and retirement.

The fascination we feel in viewing trees can be carried a step further, causing us to wonder about and to explore for the record of life forces and events that may be contained in the structure of trees. Seeking such discoveries, botanists and hydrologists have found that trees are nature's timekeepers and historians, providing windows to the past. With this in mind, the Water Resources Division of the United States Geological Survey has been conducting basic research to determine what hydrologic and environmental information is revealed in the growth records of trees. But a tree will not yield this information unless we seek it by looking inside the tree. And herein lies our story.

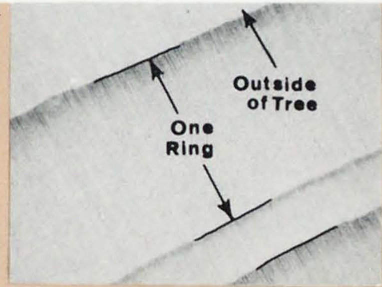
A casual look at the top of a tree stump reveals that it is composed of a series of concentric rings—*tree rings*—that become larger and larger in diameter outward from the center of the stump. Because a single tree ring is usually formed each year, the age of the tree at the time it was cut can be determined by simply counting the rings. If the year of cutting is known, the year during which each ring was formed can be determined by counting backwards from the outside ring. Such "dating" of rings may reveal that rings formed during certain extreme drought years are unusually narrow. This has led to speculation that tree-ring characteristics may indicate a number of things about past water and climatic conditions.

WHAT ARE TREE RINGS?

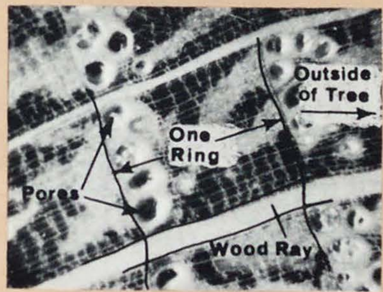
To grow, trees must increase the size of their *xylem* (woody portion exclusive of bark) by adding new tissue between the existing xylem and the bark. Such new growth usually occurs according to a seasonal pattern. Trees in temperate regions typically experience an annual cycle comprising a summer growth period that begins with opening of leaf buds in spring and a winter dormant period that begins with the dropping of leaves in autumn.

Growth, in turn, depends upon the abundance of soil moisture, which follows an annual cycle that normally reaches a peak of availability in early spring and a low in late summer. In response to the cycle, the growing tree forms large thin-walled cells in the early part of the growth season when soil moisture is abundant and forms small thick-walled cells during the latter part of the growth season, when soil moisture is less available.

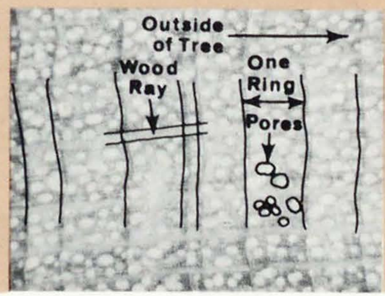
The contrasting rings seen on the cut surface of a stump or log mark the boundaries between small thick-walled cells, produced at the end of a growth season, and the large thin-walled cells, produced at the beginning of the next growth season. The wood between two consecutive boundaries is formed during one growth season and thus is referred to as an *annual increment of growth*, or more popularly, as a *growth ring* or *tree ring*.



NONPOROUS WOOD— Ring boundaries of most trees with nonporous wood (such as in most evergreens) are easily distinguished as the break between a band of darker colored cells (formed near the end of a growth season) and the much lighter colored wood just outside the dark band.



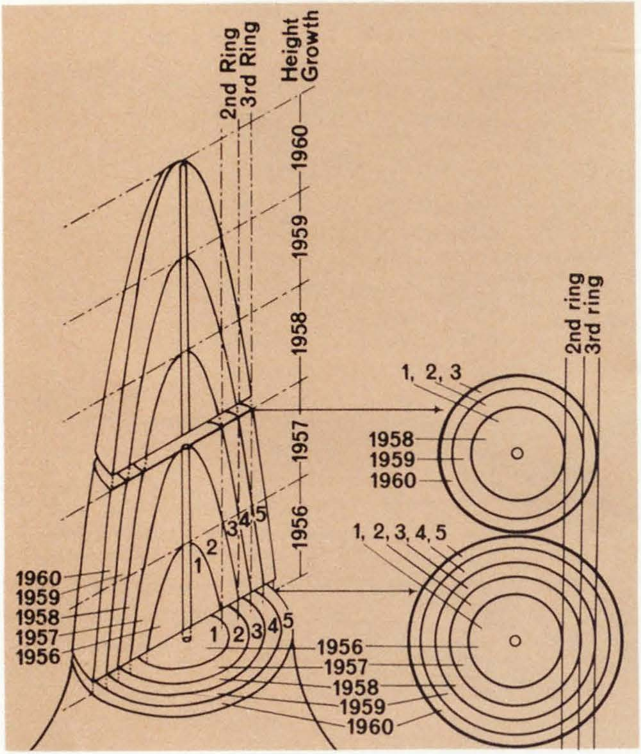
DIFFUSE POROUS WOOD— Although often difficult to distinguish with the naked eye, the ring boundary of diffuse porous wood (including maples, yellow poplars, and sycamores) is the outer boundary of a fine light-colored line formed by very small, thick-walled cells.



RING POROUS WOOD— The ring boundary of ring porous woods (such as the oaks) is readily discernable as the break between small thick-walled cells formed at the end of a growth season and very large open vessels or pores formed at the beginning of the next growth season.

BUILDING A TREE OF RINGS

It may be difficult to visualize from looking at a stump top how tree rings go together to make a tree. Perhaps this is because a tree is a three-dimensional object and a stump top displays only two dimensions. The idea of three-dimensional growth may be clarified by disregarding for the moment the leaves, branches, roots, and bark, and considering only the wood portion of the tree trunk.



The illustrated tree trunk represents a hypothetical situation that would result from growth under average environmental conditions (including no floods, no droughts, and no extreme temperatures). In general, growth begins at the top of the tree and progresses towards the base. Although the width of each ring (the "ring size") decreases from the center, the total cross-sectional area remains the same.

At the end of its first summer after germination from a seed, a tree seedling is composed of one annual growth increment. This somewhat

cone-shaped increment, a fraction of an inch in diameter and only a few inches high, will not grow or change dimensions after the year in which it was formed, but will remain the same size and in the same position as long as the tree exists.

A B

a) Large inside rings formed by a tree that has not been affected by competition from other trees.
b) Narrow early growth rings of a young tree growing in the shade of larger trees.
Both sections taken at 12 feet above the ground.

During the second year another growth layer, or annual growth increment, is formed around and above the first year's increment. By the end of the third year, an increment has been formed around that of the second year, and similar cones of growth are produced in each succeeding year. The growth increment of each year thus increases the diameter and height of the tree trunk; but once having been formed, each increment remains unchanged in size or position during the life of the tree.

If environmental conditions of a non-typical year, such as a year of extreme drought, result in very little new growth, then, during that year, growth may not extend to the base of the tree, and a tree ring may not be formed in the basal section of the trunk. Whether or not a ring is missing can be determined by comparing a section of basal rings with a section from higher in the trunk that contains all growth rings. Such missing rings would then indicate years of extreme environmental conditions.

COLLECTING TREE-RING SAMPLES

Tree stumps, the ends of logs, and the tops of posts provide the best opportunities to examine tree trunks in cross-section. An interested observer can usually find some good tree-rings to examine in his immediate neighborhood and in nearby wooded areas.

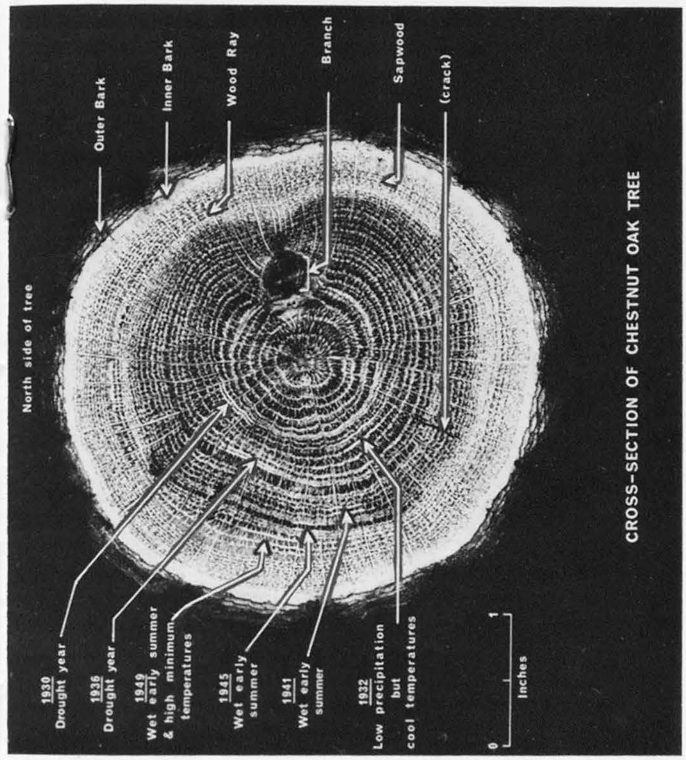
A research botanist removes a core from living chestnut oak tree that dates back to 1595.

Botanists and foresters, who need to examine a great many tree-ring samples and cannot be limited to looking at rings from trees that have been cut down, have devised a tree-boring method to collect tree-ring samples from living trees without harming the trees. This method uses a hollow metal bit, called an *increment borer*, which is twisted into a standing tree to remove a pencil-sized sample, or *core* that provides the needed tree-ring data and can be readily stored for later laboratory studies.

USING TREE RINGS FOR DATING

Counting the rings of a single cross-section, such as a stump top, reveals the number of years the tree grew after it reached that height. By counting backwards from the year of the

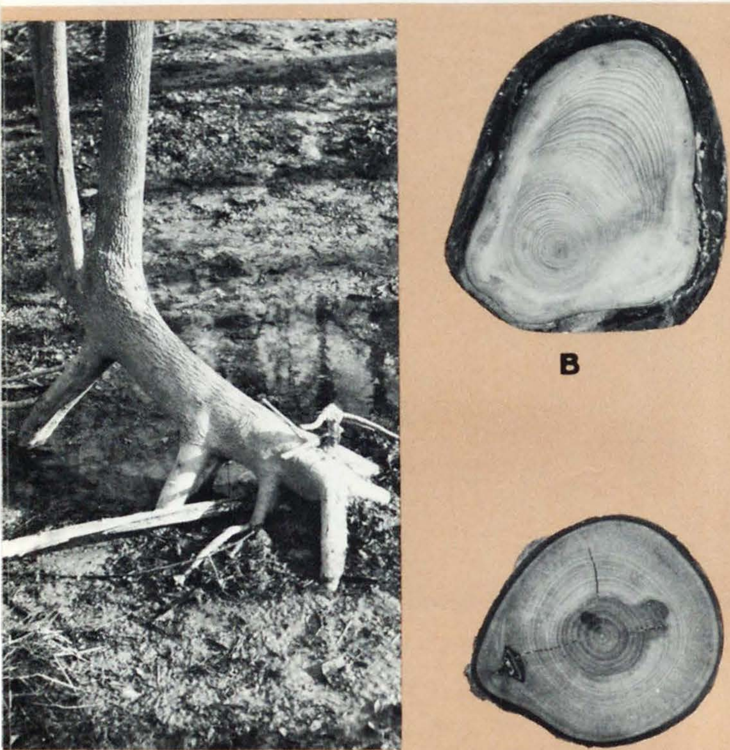
outside ring (year of last growth season before tree was cut), each ring may be labeled with the year during which it was formed. If any rings are missing, then, of course, dating is inaccurate. However, if none of the rings are very small, then rings are unlikely to be missing.



The effect of climatic conditions on the size of tree rings can be checked by comparing weather records to dated sections of tree rings.

Knowledge of the ages of selected trees in an area provides a time framework of reference for conditions or events of historical significance. For example, tree ages can indicate: the minimum time since a land surface first became suitable for germination and growth of tree seedlings; the minimum length of time since farmland was abandoned or no longer cultivated; or the minimum number of years since new land surfaces were created, such as by land fills, road cuts, floods or glaciers.

The specific year during which a tree was damaged can also be determined if the tree rings can be dated. Thus it is possible to date the event or condition that damaged the tree. If a patch of bark has been removed from the tree, killing the delicate growing tissue beneath, the date of such damage can be determined by counting on an adjacent, undamaged, area the number of rings since damage occurred. This method has been successfully used to date and



A B C

Date of damage to tree trunks can be determined by counting number of rings formed after (to the outside of) the damaged ring.

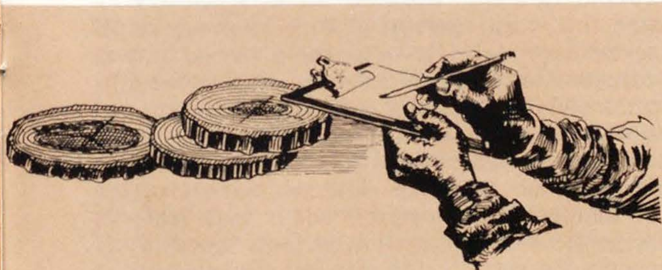
A. Original trunk tipped over by flood.
B. Vertical sprout that grew after tree was tipped over by flood.
C. Root that grew from tipped trunk after the first flood and then was exposed by a second flood.

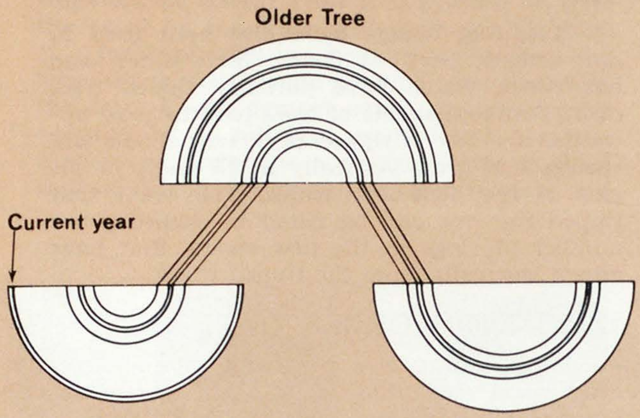
identify such events as forest fires, ice jams on rivers, and the blazing (marking) of boundary trees.

Tree-ring counts have also been used to date events, such as floods, land slides, and hurricanes, which have partially tipped trees over. Terminal shoots of trees tend to grow upwards. If a tree is tipped over, new shoots will emerge and grow vertically at an angle to the axis of the bent-over trunk. The event that tipped the tree can be dated by counting the number of rings in the new shoots that have grown vertically from the tipped trunk.

TREE-RING CROSS DATING

Cross dating is a method of dating long dead wood (including trees, posts, and structural beams) by comparing the ring patterns in the older wood with the patterns in more recent wood. Such dating is based on the fact that there is a variation in ring size from ring to ring. Examination of a number of wood samples from a given area reveals that variation in ring sizes appears to follow a pattern. If the same pattern can be identified in two pieces of wood, one piece of which has been dated, then, by using the pattern common to both pieces, the second piece can be dated—*cross dated*—from the first piece. Use of this method in the Southwest has enabled scientists to establish continuous ring records of more than 6,000 years. With such records, they have been able to determine when trees used as structural beams in ancient Indian cliff dwellings were cut. Cross dating has also allowed historians to date locally obtained wood more than a hundred years old, such as that used for structural beams in buildings constructed by early settlers.





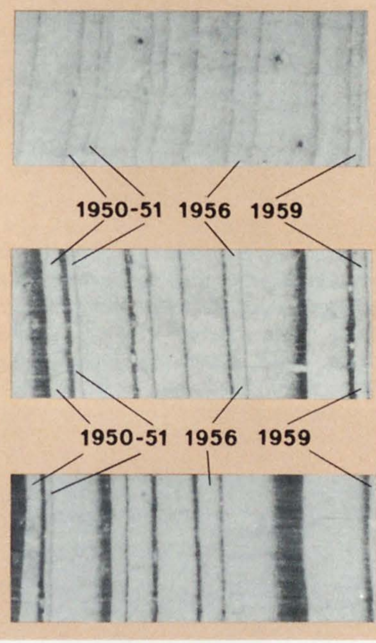
Ring patterns of old, long dead woods can be matched, or cross dated, with younger wood samples to determine the ages of the old samples.

Cross dating can also be a useful tool in working with short records from more recent samples of dead wood. For example, cross dating can be used to determine when a tree was killed by recent but unrecorded floods, fire, or other events. In the case of floods, the position of the dead tree on the stream bank also gives a minimum height for the flood.

THE CAUSES OF RING PATTERNS

Examination of a stump top may reveal an occasional very small ring which, upon dating, is found to correspond to a known year of extreme drought. Further, an occasional very large ring may correspond to a known year of excessive rainfall. Between these two extremes, rings may vary considerably in thickness without correlating directly with any extreme environmental conditions. Obviously, many combinations of environmental factors can result in the same size tree ring. The more complex the environment, the more difficult it is to sort out the particular combination of factors that have produced a certain ring size for a given year.

Cross dating depends on this pattern of variation in ring size from ring to ring. Within a given area, the ring patterns of individuals of one kind of tree may be quite similar. In addition, the patterns found in different kinds of trees in the area may show marked similarities. Thus, the similarities of patterns must be caused by something common to all the trees—environment. However, because each tree grows in a somewhat different microenvironment than its neighbor, parts of its ring pattern are also somewhat different from those of other trees.



Adverse environmental conditions during 1950-51, 1956, and 1959 slowed growth and produced narrow tree rings in three different trees growing at Mesa Verde, Colorado.

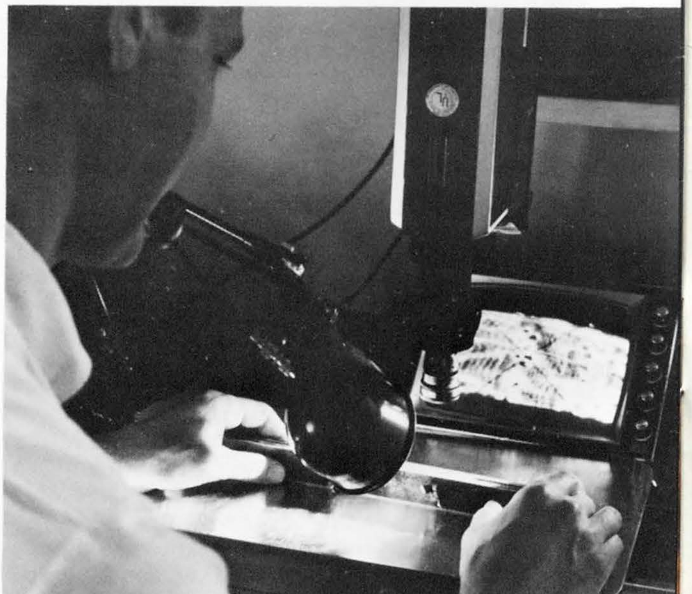
Therefore it is to be expected that similarities in ring patterns among trees in an area can result from those aspects of the areal environment that are common to all the trees. Much research, particularly in the Southwest, has gone into determining what kind of tree and what habitat combine to result in tree-ring patterns that more closely reflect regional environmental conditions rather than local microenvironmental deviations.

PRESENT AND FUTURE USES OF TREE RING STUDIES

Dating *of* tree rings and dating *with* tree rings have been perfected to the point that tree rings may be used to date numerous events and conditions. It appears that such dating is, and for sometime will continue to be, the most practical, reliable use for tree rings in the more humid Northeastern United States. Though still in the experimental stage, greater progress has been made in the semi-arid Southwest in classifying past climate into simple categories such as, cool and wet, or hot and dry.

At present, the Water Resources Division of the U. S. Geological Survey maintains a Tree-Ring Laboratory near Washington, D. C. to measure tree rings and maintain a record of tree ring data. At the same time, research is being conducted to help hydrologists use tree rings to estimate hydrologic conditions both in areas where no other records exist and for periods before records were collected. The research has already proven successful in filling some gaps in our knowledge of past floods and hurricanes.

A television system can be used to help in detailed studies of tree rings.



Tree ring studies have revealed many ways in which changes in various environmental factors affect growth throughout a tree and have demonstrated that much information about past environmental conditions may be reconstructed from tree rings. Thus utilized, trees serve as natural recorders of the environments in which they live. Tree rings are already proving to be excellent historians, but much work remains to be done before we will use fully and see clearly through these windows to the past.

(From material supplied by Richard L. Phipps)

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