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RADIO TALKS ON SCIENCE[1]

TREE RINGS AND CLIMATE

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IF trees could talk, they would complain bitterly of snowy weather like this, for the cold stops their growth and offers serious chances of injury. But ages of experience have shwon them how to protect themselves by many adaptations, of which one is a change in the character of the growing wood. This altered effect in the trunk appears in the form of annual rings, which thus are really "scars" of the yearly ordeal of cold through which northerly vegetation goes.

Now a scar tells something of its own story, and we might expect the rings to tell us something of the various experiences of the tree. And so they do, and each ring becomes an annual report, not necessarily of the winter, when growth is stopped, but rather of the spring and summer when growth is most rapid. If one growing season differs from another, the difference is highly likely to show in the rings. And in the successive rings of a tree we get its life story. In the east that story depends on many conditions, such as too much other vegetation, competing for every inch of ground, too much water in the soil, and especially such terrible pests

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as the gipsy moth in eastern Massachusetts (I have seen the effect on the shores of Buzzard's Bay) and the chestnut blight; and a tree story here might tell chiefly of such experiences and very little directly of the weather. But conditions in the great pine forest of Northern Arizona are so different that the easterner can scarcely realize them. There the trees are far apart with little or no undergrowth between them: they are miles from any water courses and the ground is dry much of the year. The story in the trees is largely climatic and deals with rainfall and snowfall or, as the botanists say, "moisture is the controlling factor."

This Arizona tree is the yellow pine, much used for lumber. The altitude above the sea, of 5,000 to 9,000 feet, is high enough to make the summer climate lovely and the winter climate cold and bracing, with quantities of snow. So the rings are well marked and very reliable and this tree has proved wonderfully adaptable to this study. Many interesting facts have come out. In the first place, similar sequences of rings are found over very large areas. What that means is this. A heavy winter snowfall in Flagstaff which supplies abundant moisture for the trees there extends over hundreds of miles and supplies abundant moisture in northwestern New Mexico, 225 miles away, or over in the Charleston Mountains near Las Vegas, Nevada, an equal distance west. A dry year in Flagstaff is dry in the other places also. Even at much greater distances the resemblances are enough to enable us to carry dates across. For instance, the yellow pine ring for 1851 is small all the way from Santa Fe, New Mexico, to Fresno, California, a distance of eight hundred miles with nearly four hundred miles difference in latitude. Now this is evidence of a climatic similarity across those great distances and can be used in the study of climatic districts, but I have used it under the auspices of the National Geographic Society in actually determining the date of cutting of certain Spanish beams used in kivas of the Pueblo Indians. It was wonderfully fascinating to make a cutting from an ancient beam in the abandoned part of the village of Oraibi in northern Arizona and find rings that perfectly matched the Flagstaff tree growth and then be able to say that the tree was cut in a certain year a little less than three centuries ago. Fortunately, this society is interested in further research along this line in connection with their excavations at Chaco Canyon under the direction of Mr. Judd.

Another very interesting bit of information has come from these Arizona trees. Since they tell wet and dry years, they can be and are used for the study of drouth. At first I merely compared the trees' growth in given years with statements of famine and flood in the history of Arizona and New Mexico. Then when these seemed to agree I made a more formal search for drouths. This was really

done because various persons interested in reclamation wanted to know how big the reservoirs would have to be in order to take care of dry years. I found easily enough the historic drouths of 1682–6, 1748, 1777–82, 1822, 1879–87 and 1902–4. But I found also a very severe drouth from 1729 to 1741 and a still worse one from 1573 to 1587. Both of these were felt from New Mexico to California. So the trees give us much historical information of value in engineering.

And this brings us to the age of these Arizona trees. My collection includes ten trees whose age is five hundred years and one whose life covers six hundred and forty years. These figures are probably very accurate, for they are reached not merely by a process of ring counting but by a minute comparison between hundreds of trees so that every possible error is avoided. In fact, no tree record is used unless it has been compared with others and found to show minute similarities that can be recognized. The early counting of rings in these yellow pines was later found to have four per cent. of error, due mostly to missing rings which in the outer parts of very old trees may be readily overlooked. These were all discovered by comparing many trees together.

Of course, I have collected sections or cuttings or samples of rings of other trees than the Arizona pines. Of these others the most interesting are the big trees or *Sequoia gigantea* of California which grow at elevations of five to seven thousand feet in the high mountains east of the great central California Valley. My chief collection comes from the King's River country east of Fresno near the General Grant National Park, where much lumbering has been done. I do not like to think of those giant trees being cut down and I hope that no more will be sacrificed, but yet it is the stumps which have supplied most of my material. I have in all thirty-three cuttings from there, two from the grove east of Porterville and this summer five small cuttings from fallen trees in the Calaveras Grove which I obtained by kindness of Mr. Whitesides, who owns the grove. Of course many interesting facts have come out from this study of the sequoias. The rings do not tell quite so accurate a climatic story as the yellow pines and yet on the high and dry ridges it is still a story of moisture. The basins between the ridges have streams flowing through in the summer and the rings are larger and more uniform. There is a great dependence of the growth on the proximity of running water. And thereon lies the blame for overestimating age in many cases. The oldest tree so far found, whose age is absolutely reliable, shows a ring which grew in 1306 B. C. That makes an age which to-day would be over 3,230 years. That particular stump was found by Ellsworth Huntington more than ten years ago.

Now that age was determined by an inter-comparison of some twenty-three trees, mostly over 2,000 years old. That comparison took me a year and after it was done there was a possible error of one year, namely, a possible extra ring which occasionally seemed to show for the year 1580 A. D. So an extra trip was made to the King's River region to settle this question and twelve new specimens were secured which verified this supposed ring as real. So it is probable that the date of the beginning of this tree is correct. I have looked at thousands of stumps and failed to find anything older. In the trip referred to, I looked at some living trees, measuring their size and testing the size of the rings near the outside in sundry burnt places and judging the effect of relation to water, but did not get anything of longer life than this. The General Grant tree may be 2,500 years old. I have not yet seen the General Sherman in the Sequoia National Park. A stump of 25 to 30 feet near the General Grant Park had grown near a stream and had only 1,500 rings. A similar stump in a drier place in the Porterville region has 3,100. It is the stump from which a specimen was taken for the Centennial in 1876. The oldest tree, as mentioned, grew near the Converse Hoist close to the General Grant Park and was only about 22 feet in diameter. The famous Dance Hall stump in Calaveras Grove, mentioned by Mark Twain, was a quick-growing tree and probably did not have more than 1,500 or 1,800 rings. On the whole, the Calaveras trees are not so old as those farther south. The point that proved important at Calaveras was that the rings could be identified with those in the other big tree groves. So that now we know that all the big trees give a somewhat similar story.

Now what is all this for? It is to get all the information we can about climatic conditions in past time and in distant places. Our yellow pines give us the drouth and rain history of five or six hundred years in Arizona: the sequoias give us data for more than three thousand years. We can therefore make extensive historical studies and especially we have a chance to test climatic cycles or recurring climatic conditions by the aid of data which go back far beyond the use of instruments for measuring rainfall or temperature, even though these tree records are not quite so accurate. Yet they are accurate enough to have a very real value. This I became sure of two or three years ago. I had studied the eleven year solar or sunspot cycle in the Arizona trees and found it there for most of the time, but from about 1650 to 1730 or 1740 it disappeared, so that I was in some doubt whether the trees could be reliable. However, I published the facts as I had found them and said that about 1700 the solar cycle flattened out. Three years later,

a letter from the noted English astronomer, E. W. Maunder, of the Greenwich Observatory, said that he had been studying old sunspot observations and that betwen 1645 and 1715 there were none or very few seen and that the trees ought to show this if they were giving real solar history. The dates agreed so well with my time when the trees failed to show the solar cycle that confidence in the tree ring history seemed well placed, and it appeared pretty certain that the solar cycle has been operating since 1400. The sequoias are extending that history farther back. We have constructed an instrument for studying cycles, for the mathematical processes are very long, and we have some 500 curves prepared for analysis. We are beginning to see certain cycles which rather dominate things, and it seems as if they were related to solar changes, but it is perhaps a little early to speak of them with precision.

Finally the study of tree rings will give us further knowledge of the distribution of conditions about this world of ours. Of course trees do not have the same climate everywhere and so show different responses, but making allowance for that we get some knowledge. Thus the pine trees about the Baltic Sea give a very accurate history of the sunspot cycle for the last century. When this study is extended to all parts of the world we shall have certain general information which would be too expensive to get in any other way. In carrying out that idea the Carnegie Institution has assisted in collections from a large number of locations in the southwest.

So Good Night. I thank you.