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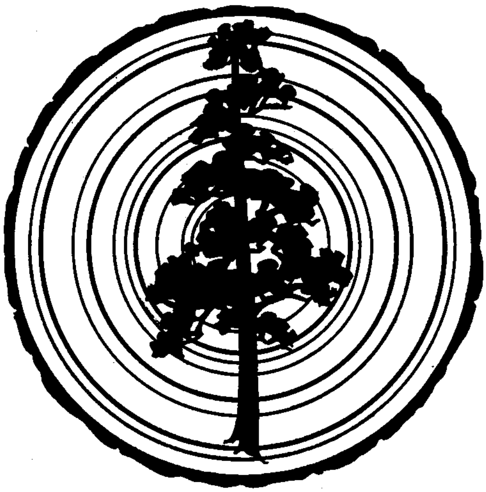

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The Tree-Ring Bulletin will publish papers resulting from original research in tree-rings in relation to climatology, archaeology, and other fields. For reports of projects in tree-ring dating, a tabular form as in Vol. 6, No. 1 is suggested. Until funds are available authors will be requested to pay the cost of illustrations. Each contributor will be given twenty-five copies of the Bulletin in which his article appears.

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TREE-RINGS AS A RECORD OF PRECIPITATION IN WESTERN NEBRASKA

HARRY E. WEAKLY*

The material used in this study is entirely Eastern red cedar, *Juniperus virginiana*, from Lincoln County, Nebraska. For tree-ring study, this species leaves much to be desired. Perhaps one cross-section in four is of sufficient symmetry to be usable. This is the only softwood available; hardwoods have thus far proved of little value.

Numerous sections of logs which had been used in some of the buildings at Fort McPherson and also a number of specimens from old log houses erected by some of the early settlers of this territory have been studied. Also, some specimens have been uncovered in old fills in the bottoms of a number of canyons. Some of this old buried material has given very readable ring sequences, but as yet it has been impossible to assign actual dates.

The material that has been dated so far gives an unbroken sequence back to about 1480 A.D. Settlement of this section of the country began about 1860. The early settlers, tie cutters for the Union Pacific railroad, soldiers, and immigrants who passed along the old California and Oregon trail, cut practically every tree of any size in the country, so that very few of the cedars now growing in the canyons along the edge of the Platte Valley exceed 75 or 80 years in age.

The larger trees cut by the early settlers ran from about 175 years to over 200 years old. The buried trees predate these by many years, as in some cases they have been found beneath a substantial fill in old gully or canyon floors with the stumps of 200-year-old trees in place in the soil many feet above them. At the level of the tops of these old buried trees there is a three to six inch layer of charcoal, and all those observed by the writer or reported to him show evidence of having been burned off at the old level of the earth fill about them. This charcoal bed is present in practically all the canyons in this vicinity and lies at depths varying from one to as much as six or even more feet below the surface. The material below it is largely aeolian in nature, whereas that above is both colluvial and alluvial in its general aspect.

The amount of wind-blown material in the lower portion of these canyon fills would indicate a drought period of considerable duration and severity.

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The annual rings on the buried wood from these localities indicate a period of over 30 years with deficient moisture. Apparently this drought period contributed very largely to the death of these trees.

The correlation coefficient between ring width and the annual rainfall for 63 years at North Platte is 0.63±0.05. An occasional lag effect is observed.

The recorded droughts of 1856 to 1860, 1869 to 1873, 1893 to 1894, and the one culminating in 1910 are all reflected in tree growth very faithfully. The periods of 1676-84, 1765-70, 1795-1800, 1820-24, and 1839-43 were also apparently deficient in precipitation. The period from 1820 to 1824 is of special interest because of the apparently extreme severity of the drought and the fact that it was extraordinarily widespread, being a matter of record in the diaries of several persons in the New England States and showing in the growth of trees studied by Douglass at Flagstaff, Arizona.

The above study has been in progress for about five years; a complete report on it is in preparation.

PROBLEMS IN DATING RINGS OF CALIFORNIA COAST REDWOOD

EMANUEL FRITZ*

In this brief note are described several anomalies in growth rings of California redwood (*Sequoia sempervirens*) which the tree-ring analyst must consider when working on redwood as a possible means of dating past climatic events.

Discontinuous growth rings.—In leaning redwoods all growth rings will not completely encircle the tree. On the side toward the lean, they take an abnormal width and their anatomy is that of compression wood. On the opposite side, diameter growth is dormant for most of the period of the lean, with occasional years producing very narrow rings. One tree example may be cited. This tree stood on a slope that had slipped apparently 161 years before cutting. When felled, it showed a long diameter of 102 inches and a short one of 45. The radius of the side toward the lean was 82 inches but only 20 inches on the opposite side. There were 472 rings on the 82-inch radius and 363 on the 20-inch radius. There were 161 rings of the new type, but of these only 109 appeared also on the 20-inch radius. Thus 52 rings failed to be formed completely around the trunk. Since the time of the slide that slanted the tree, diameter growth on the long radius was 58 inches but only 4 inches on the short radius opposite. A tree-ring analyst would hardly spend much time on a leaning tree, but the observation is nevertheless of interest.

Discontinuous rings are very common in vertical and apparently normal old-growth redwood trees. At this time no reliable explanation can be offered. It is almost certain that in large and very old trees the ring count on any one radius fails to add up to the age of the tree. Several radii must be counted and then, for greater accuracy, the area between the radii must be studied intensively for evidences of "lost" rings. For example, tree section no. 1596, measuring 37 inches in diameter one way and 43 inches at right angles, gave the following ring counts on five separate radii: 268, 290, 348, 363, and 397. In this case it was possible to make a single count to obtain 397 by counting on the 268-year radius until discontinuity was noted and then moving circumferentially to other radii and continuing the count to the outer edge. Another section, no. 1546, with a diameter of about 10 feet, and cut about 20 feet above the ground, gave the following radial counts: 1755, 1809, 1901, 1911, 1941, 1984, 1995, 2015, and 2079. Later, the area between the "oldest" radius and the neighboring radii was examined and an additional 98 rings were picked up.

Discontinuous rings are found also in young trees and in the accelerated-growth portions of trees that have been released from long suppression[1]

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Spiralled compression wood.—Frequently associated with discontinuous rings in coast redwood is compression wood. In the case of leaning trees the rings formed after the lean began are largely compression wood in the area toward the lean, while on the opposite side the wood is the normal type. Compression wood is an old story in leaning trees. But in apparently plumb old-growth trees there often also appear areas of compression wood. A group of rings, collectively, will form a crescent-shaped body of compression wood, some of the rings often being discontinuous some distance from the crescent. More interesting, however, is the formation of compression wood in a continuous spiral. Each new growth ring develops compression wood for several inches along the circumference, but each year this strip of compression wood begins and ends a fraction of an inch farther to one side. Collectively, this series of compression wood strips, therefore, appears to spiral around the tree. Fig. 1a is a reproduction of a pen-and-ink sketch of the cross section of tree no. 1596. Only such part of each growth ring as exhibits compression wood is reproduced. Within the zone of compression wood there is no discontinuity of rings, and the rings are wide and easily

[1]E. Fritz and J. L. Averell, Discontinuous growth rings in California redwood, Jour. Forestry, 22, 31-38, 1924.

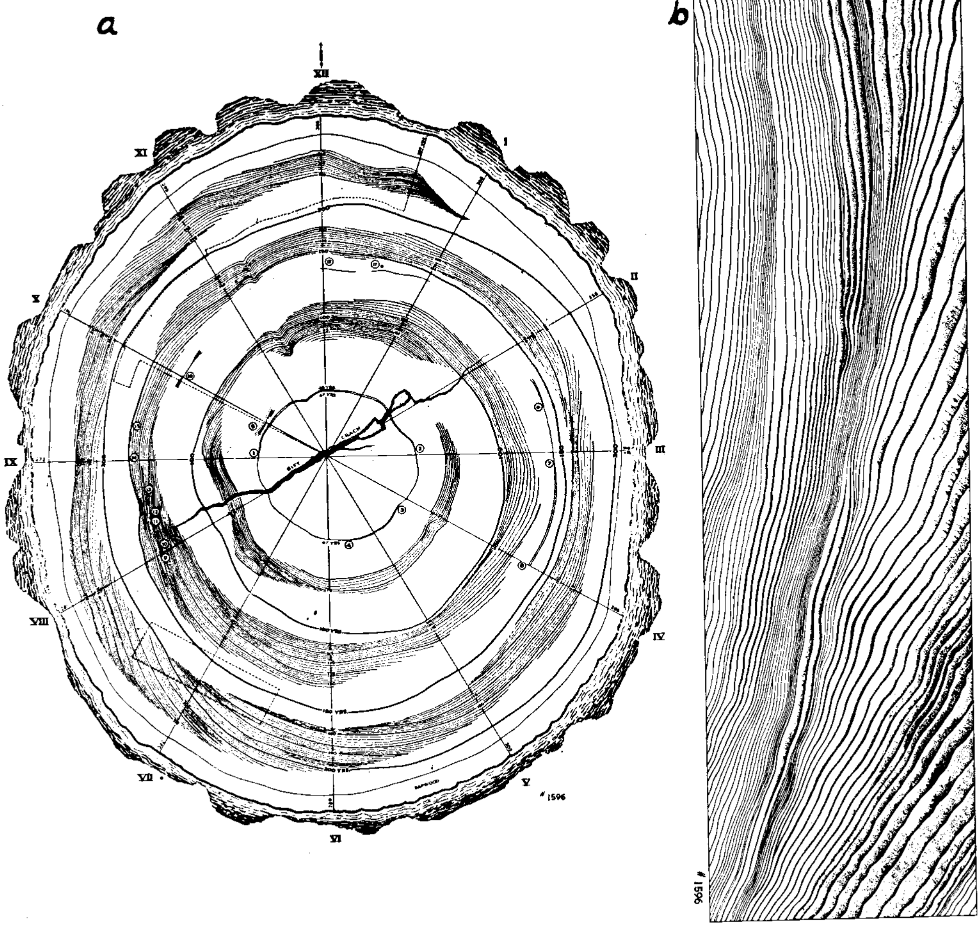


Fig. 1a. Spiral compression wood in California coast redwood.
Fig. 1b. An enlargement of the area enclosed in the rectangle in 1a.

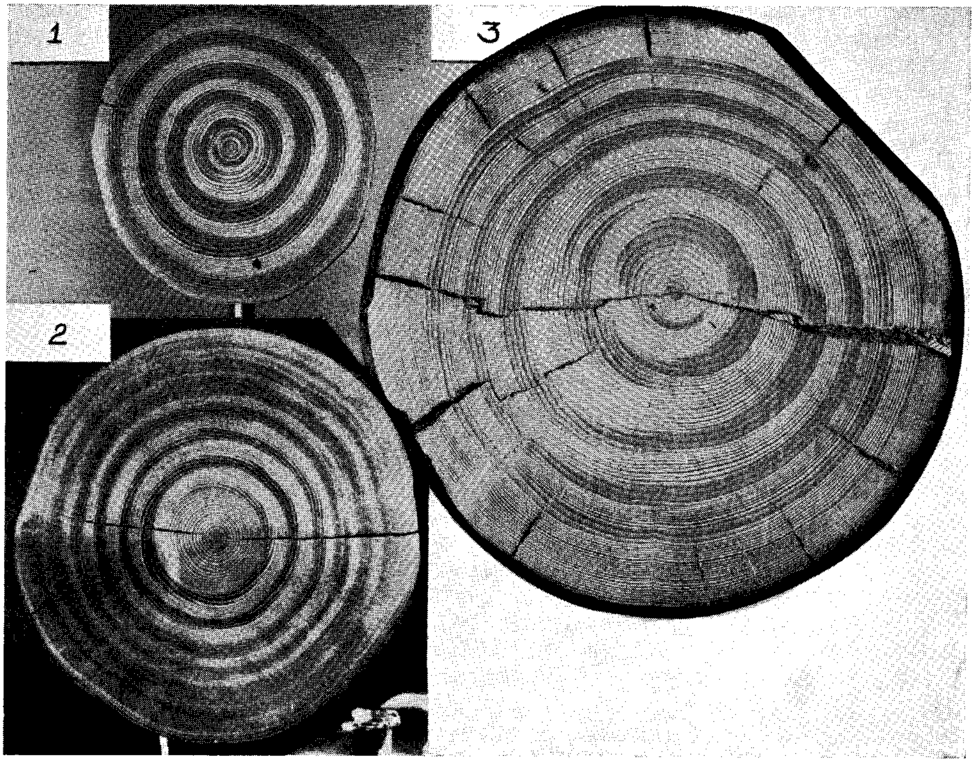
followed. Immediately outside the zone the rings may continue as wide as within the zone but lack compression wood characteristics. Soon, however, the reverse of wide-ringed zones is encountered, when the rings become narrow and abruptly converge while some disappear. In fig. 1a the spiral makes three circuits of the trunk. In another specimen recently studied eight full circuits are made. Obviously, the abnormal thickness of the growth rings in the compression wood area is not related to climatic factors, and borings into such spiralled trees are worse than worthless to a student attempting to determine a relationship between rings and climate. Fig. 1b is a pen-and-ink sketch of the area, denoted by the rectangle in fig. 1a. With a low-power hand lens the discontinuity is easily noted. Typical compression wood portions are stippled to distinguish them from non-compression wood portions.

Redwood's two-millenium span of life makes it an especially valuable tree, but obviously specimens must be selected with great care and studied with due attention to the anomalies mentioned before they can be regarded as reliable recorders of past climatic conditions.

EXAMPLES OF SPIRAL COMPRESSION WOOD

A. E. Douglass

The photographs in fig. 2 show three very interesting cases of spiral compression wood. Numbers 1 and 2 show two sections in the Skogshögskolans Botaniska Avdelning, Stockholm, Sweden. Picture no. 1 was forwarded by Dr. Carl Malmström at the request of Professor T. Lagerberg;



Scale: Nos. 1 and 3 are ½ actual size, no. 2 is ¼ actual size.

Fig. 2. Photographs of cross-sections showing spiral growth of compression wood.

it is labelled "Picea Abies (L) Karst. Jämtland, 1922; H. Andrén." Number 2 is an enlargement from a kodak picture taken by the writer in 1930; it is labelled "Picea Abies (L) Karst. Mora, February 18, 1924; Magnus Nordquist." On August 20, 1930, I made the measures given below of radial distances and ring count from the center of the tree to the centers of the compression bands.

Number 3, measures below, shows an Alaskan spruce (*Picea* sp.) in the collection of Dr. Irving W. Bailey.[1] He was kind enough to give us a thin slice. From knots in it we can determine the upper surface and find rotation of this compression wood is clockwise outward when seen from above the tree, as it is in Fritz's[2] spec. 1596.

[1]See Pillow and Luxford, U. S. D. A. Tech. Bul. 546, pl. 7, 1937.
[2]Personal communication.

No. 1, 63 rings.				No. 2, 140 rings.				No. 3, 83 rings.			
To Left		To Right		Lower Left		Upper Right		To Left		To Right	
mm.	yrs.	mm.	yrs.	mm.	yrs.	mm.	yrs.	mm.	yrs.	mm.	yrs.
7	7- 8	5	5	31	27	25	21	10	8	10	7-8
15	16-17	12	13-14	43	40	38	34	23	21	20	14
22	27	20	22	55	52-53	50	46-47	42	37-38	36	30
31	41	28	34	66	70-71	62	60	52	48	48	43
		36+	56+	75	85	73	78-80	62	60	57	54
				84	103-04	83	94-95			66	65
Inside of Bark:				96 mm.		102 mm.				76 mm.	

CLIMATIC CHRONOLOGY IN SOME COAST REDWOODS

EDMUND SCHULMAN

The purpose of this note is to emphasize the fundamental difference in ring record in two general classes of coast redwood sequences. One is characterized by lack of circuit uniformity and by discontinuous rings as described by Fritz[1]—rings which often "wedge out" as a group in some small arc of the cross-section, although quite large elsewhere; it is evident that these "wedged-out" rings are *non-climatic* and have in general no relation to years of climatic stress. The other class is characterized by the usual circuit uniformity found in trees of the Southwest used in tree-ring analysis; the occasional locally-absent rings found in such records are *climatic* in origin and indicative of dry years. In such cases there is apparently insufficient food supply to permit cambial activity everywhere on the trunk. The usual "wedging-out" ring group is so different in character from the normal locally-absent *climatic* ring that it may serve as a good indicator of an unusable record.

Botanists have given much attention to the coast redwood, among them Bailey,[2] Shreve,[3] Haasis,[4] and MacDougal.[5] Shreve found much evidence in the southerly groves of non-uniformity in width of the annual ring in different directions from the axis of the tree. MacDougal points out that while Monterey pine may grow on a soil which at times has a moisture content of less than 5%, the coast redwood apparently must always tap some soil which is saturated.

Douglass[6] studied small groups of specimens from Santa Cruz and Scotia in 1921 and 1925, but found no general crossdating. More extensive and highly selected groups were apparently needed. Accordingly, in July, 1931, he collected 25 large sections and 86 cores with the cooperation of I. W. Bailey and H. L. Person. These represented substantially the whole red-

[1]E. Fritz and J. L. Averell, Jour. Forestry, 22, 31-38, 1924.
[2]I. W. Bailey, Jour. Arnold Arboretum, 15, 233-254, 1934.
[3]F. Shreve, Carnegie Inst. Wash. Pub. 350, 89-116, 1924.
[4]F. W. Haasis, Carnegie Inst. Wash. Pub. 450, 1934.
[5]D. T. MacDougal, Carnegie Inst. Wash. Pub. 462, 1936.
[6]A. E. Douglass, Carnegie Inst. Wash. Pub. 289, II, 55, 1928.

wood region. Preliminary reductions were carried through by the writer[7] in 1932. Recently, the dating was reviewed and extensions made.

Asymmetric radial growth appears closely related in these collections to lack of crossdating. Cross section SMR 1c in the Smith River group, from the 140 foot level above the ground, showed good crossdating between opposite radii for the first 600 years of growth, with no missing rings and approximately concentric growth. For the next 340 years, however, growth became extremely compressed and one-sided and the short radius showed 99 rings missing as compared with the long radius in this interval. The "wedging-out" of these rings and the lack of crossdating destroy completely the value of the outer one-third of this specimen as a climatic record.

The very complacent Weott sections WT 6 and WT 5 (enormous average ring-width of 2.5 mm. for 1574-1930) provided the opening to a dated sequence. Dating was then extended to other more sensitive Weott trees and then carried into several other groups so that finally about half of the sections and cores were crossdated.

Of particular interest is the group of cores from the Willits-Ft. Bragg region. These were taken from felled trees at levels mostly of a hundred feet or so above the base, and dated readily. Thin rings were common for 1924, 1918, 1913, 1867, 1846, 1844, 1834, and 1824. Examination of several sets of sections at various levels supported the theory that going to upper levels in the trunk minimizes the effects of root influences and of mechanical stress or other factors favoring irregular growth about the circuit.

The fact of crossdating over considerable areas in some coast redwoods can only mean that in such specimens variations in climate are leaving an intelligible record. Fog is a characteristic of the redwood habitat, but no relationship appears in our curves between seasonal variation in fog and tree growth. The relationship to seasonal precipitation, however, is good for the extreme years; of the eight outstanding thin rings since 1824, seven correspond to dry years and only 1834 is erratic. The interval of large growth from 1914 to 1917 corresponds to the heavy precipitation of those years; the ring for 1894, however, is much thicker than the rainfall for that year would warrant. Temperature effects have not yet been studied. It is evident that a year of highly deficient rainfall is likely to leave its mark on redwoods growing on sensitive sites; under normal circumstances, however, there are apparently so many factors having an important bearing on the total growth that correlation with any one of them is not feasible.

We may say in conclusion then, that by proper selection of redwoods with special attention to freedom from neighbors and to upper level radii, it is possible to find a fair degree of crossdating in the hitherto unsolved ring records of this very long-lived species.

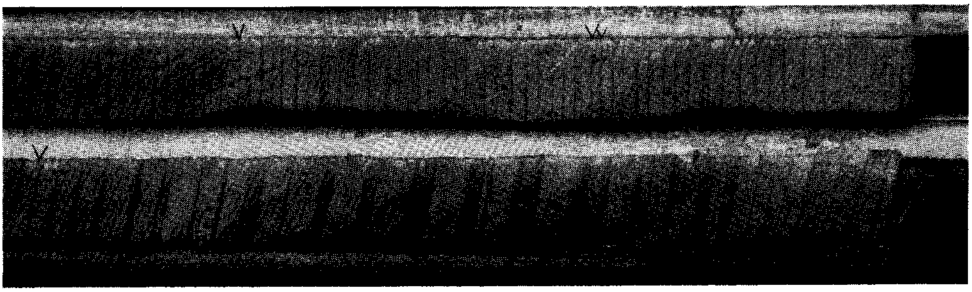
7Carnegie Inst. Wash. Yearbook, 208, 1933.

COMPRESSION WOOD AND THE RECENT CHRONOLOGY IN MESA VERDE FIRS

A. E. Douglass

The accompanying photographs show the outer rings of MVD-7 and 7A which contain features that are important in the correct interpretation of these superb Douglas fir ring series. The specimens are Swedish increment cores taken on the upper and lower sides of one of the firs (spruces) showing in the "site" picture in the October, 1939 number of this bulletin. On that site in lower Fewkes' Canyon, Mesa Verde, the ground slopes very steeply in a northerly direction. The trunks of the older trees usually are curved in the lower 6 to 10 feet; they start up at the ground with a slant in the down-hill direction of possibly 20 degrees from the vertical and at higher points gradually approach the vertical position. The borings were made in the lower part of the curve where the strain of the tree's weight is very great. Here there is a longitudinal pull on the upper side and a pressure on the lower side.

Dates are shown by pinpricks. A single pinprick indicates a decade ring, two indicate a mid-century date (e.g., 1850), and three pinpricks indicate the year 1900. A microscopic ring is indicated by opposite pinpricks on each side of the ring. If the ring is missing then the two pinpricks are not opposite each other. The outside ring in each core is 1939 and shows in 7A on July 29 with some latewood at the very edge.



Scale 3:1

**Fig. 3. Above: upper side of trunk, MVD-7, 1840-1939.
Below: lower side of trunk, MVD-7A, 1899-1939.**

The upper photograph showing the growth of the upper side of the trunk gives a normal series of rings in a dry area. The rings in the other photograph, from the lower side of the trunk, present highly exaggerated changes from year to year with greatly increased growth in favorable years. The sapwood on the upper side has a thickness of 22.2 mm. and includes growth from 1888 to 1939. The sapwood on the lower side covers 54 mm., nearly 2½ times as much, and includes rings from 1889 to 1939. This shows an agreement in years but not in dimension. The length of the core on the upper side is 175 mm. and reaches the center of the tree in the year 1654; on the lower side it is 236 mm. long reaching only to the year 1724. Compression wood constitutes substantial parts of the increased growth on the lower side. Deficient years appear much alike on the two sides. Thus 1902 is absent in each; 1904 is absent above and miscroscopic below; 1899, 1896, and 1894 are much the same on each side and are very thin or microscopic.

A striking difference between these two sides is the presence in 7A only of doubles of the Douglas fir type for 1908 and 1930. In these doubles the red color persists in the interval between the false ring and the final annual ring. However, this color is only seen readily under a power of 50 to 100 and in the photograph it is not at all evident. In 1917-1918 taken together there is much the same effect but each has, in fact, a real annual ring. Another such double is the ring of 1724 in IF-20. The ring of A.D. 302 in M-106, a piece of charcoal with a superb ring record, shows this sort of double in a part of the circuit. The charcoal of course does not show the red color but there is a continuity of thickened cell walls between the two latewoods which shows their relation.

This type of double in the Douglas fir was first seen in 1923 in the case of BE-11 which gave an excellent ring series in the 1300's; 1361 had a ring of this type which caused a great deal of study. Its dating was not solved till 1928 when many additional specimens were secured and adequate comparisons were made.