TREE-RING DATES FOR CUTTING ACTIVITY AT THE CHARCOAL KILNS, PANAMINT MOUNTAINS, CALIFORNIA*

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ABSTRACT

Growth-ring studies were made on material from 28 pinyon *(Pinus monophylla)* stumps, cut in the late 1800's, near Charcoal Kilns, Panamint Mountains, Death Valley National Monument, California. Comparative material for tree-ring dating of the stumps consisted of increment borings from adjacent pinyon, limber pine *(Pinus flexilis)*, and bristlecone pine *(Pinus aristata)*; and from cross sections of two recently cut pinyon stumps and of numerous stems of big sagebrush *(Artemisia tridentata)*. Cutting in the period 1876-1879 is indicated by tree-ring dating for 26 trees presumed to have been utilized as material for the nearby Charcoal Kilns.

In the latter half of the nineteenth century, considerable woodcutting was carried on in the Wildrose Canyon area of the Panamint Mountains, Death Valley National Monument, California (Wallace and Taylor 1955). A settlement was established around Charcoal Kilns where charcoal was prepared for the Modoc Smelter. According to information posted at the Charcoal Kilns by the National Monument staff (M. H. Ryan, personal communication):

> These kilns were built in the late 1860's or early 1870's to supply charcoal for the Modock Smelter nearly 30 miles away in the mountains west of Panamint Valley. At that time charcoal was by far the best and cheapest ore-reducing fuel available in this remote area.
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> Three hundred men are said to have been employed here felling pinyon pine and juniper and firing it in the kilns. The wood was cut into four-foot lengths and then hauled to the kilns on crude drag sleds.

Known literature contained no exact references to the time of cutting activities in the Charcoal Kilns area, and this lack prompted an investigation to determine the possibility of dating the lumbering by tree-ring studies of the stumps. The basis for such dating was provided by dendrochronological studies in the immediate vicinity. Tree-ring studies of the bristlecone pine *(Pinus aristata)* in the Panamint Mountains were made by Schulman and Ferguson (Schulman 1956, Appendix C). Substantiating collections were made of limber pine *(Pinus flexilis)* and pinyon *(Pinus monophylla)*. Big sagebrush *(Artemisia tridentata)* from three sites in the Panamint Mountains was collected and dated by Ferguson (1960). The main comparative chronology for the dating of big sagebrush was provided by a mean ring record of thirteen trees consisting of four bristlecone pines, two limber pines, and four pinyons from the Panamint Mountains and two bristlecone pines and one limber pine from the White Mountains, 120 miles to the northwest (unpublished data on file in the Laboratory of Tree-Ring Research; Ferguson 1960). Additional comparative material was provided by the chronology for bigcone spruce *(Pseudotsuga macrocarpa)* in southern California (Schulman 1956).

Both pinyon and Utah juniper *(Juniperus osteosperma)* occur in the vicinity of the kilns. Stumps of these species are easily differentiated by the more resinous nature of the pinyon and by the lobed form of the juniper with its shreddy bark still retained in protected crevices. The pinyon was considered to be the potentially more usable species, and, in 1958, segments were collected from eight stumps on the slope immediately west of Thorndike Camp in the upper reaches of Wildrose Canyon at an

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elevation of 7,450 feet and about one mile by road south of the kilns (T19S, R45W, S35, Telescope Peak Quadrangle, Inyo County, California, 15-minute Series, U. S. Geological Survey, 1952). The pieces of the stumps ranged from four to ten centimeters in width and contained from 168 to 257 years of tree-ring record, a series of sufficient length to establish their dates despite the fact that in no instance did a segment contain the total radius. Ages of 400 years were indicated by the size of the stumps and by ages shown by cores from adjacent trees. Cross sections were prepared for examination by sanding with a belt sander. Critical areas, near the outside, were surfaced with a razor blade.

Initial examination of the ring series showed inconclusive crossdating throughout the ring sequence. The problem of interpreting micro-ring features characteristic of pinyon growing at the lower limits of its range made crossdating of the eight specimens apparently impossible. Comparable difficulty occurred with the cores from adjacent living trees. When it seemed evident that many annual growth rings were missing in the pinyon material from the Thorndike Camp area, an answer was sought through cores taken from pinyon near Mahogany Flat, 700 feet higher and a half mile south of Thorndike Camp. Four cores, collected near Mahogany Flat by Ferguson on July 9 and 12, 1955, had been dated by Schulman. Innermost ring years, averaging an estimated fifty years from the pith, were 1548, 1561, 1564, and 1632. These four cores, from pinyon of the same age class and lacking a growth trend, were measured and the absolute rather than standardized values were averaged to form a mean of four from 1700 to 1954 (Table 1). This chronology provided a control for the dating of the cores and stump sections from the Thorndike Camp area. Secondary controls were provided by chronologies of bristlecone and limber pines from the 10,000-foot zone and of big sagebrush from various sites between 6,800 and 9,600 feet.

TABLE 1. Mean ring widths: *Pinus monophylla,* four 400-year-old trees; Mahogany Flat, Panamint Mountains, California; tabulated in hundredths of a millimeter.

A.D.	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1700	81	59	72	16	40	59	51	10	34	53
1710	57	74	57	20	51	51	09	55	73	87
1720	85	68	38	50	72	56	83	87	15	24
1730	37	44	45	51	71	22	56	38	57	41
1740	66	63	55	91	75	107	82	73	43	39
1750	64	40	11	18	10	36	41	22	66	65
1760	83	73	97	73	86	43	89	75	103	92
1770	63	72	54	29	56	85	57	22	58	56
1780	61	70	17	72	97	63	69	75	43	92
1790	74	87	76	64	41	03	41	76	52	70
1800	50	64	75	76	67	25	83	57	83	90
1810	94	104	76	23	50	65	75	87	96	74
1820	38	103	38	37	45	68	69	47	70	29
1830	54	69	94	72	58	28	38	81	98	68
1840	58	28	23	06	32	07	43	13	66	81
1850	84	44	100	85	64	76	06	01	34	41
1860	42	59	66	45	15	36	57	83	98	57
1870	54	56	38	47	78	53	55	38	46	55
1880	42	34	27	21	34	41	35	43	53	41
1890	53	56	46	48	31	59	34	52	16	13
1900	37	76	45	54	23	71	62	63	79	64
1910	51	60	61	42	61	46	70	55	52	50
1920	55	69	64	39	83	38	73	92	61	37
1930	60	45	49	52	50	54	20	58	51	63
1940	64	50	68	71	53	52	83	64	41	61
1950	41	36	53	22	53					

Plotted ring measurements for each of the eight specimens from pinyon stumps are shown in Figure 1 in comparison with the derived mean of eight, the mean of four pinyon cores from Mahogany Flat, and a single specimen of big sagebrush from below Arcane Meadows, which is one and three-quarters miles southwest of Mahogany Flat and 1,200 feet higher. Agreement between all series is good and in no instance do all eight stump specimens indicate a missing ring for the same year. The breadth of material provided an absolute value for many rings that would have been absent on any given radius. Years of minimum growth, critical for dating, are 1773, 1782, 1795, 1805, 1807, 1809, 1813, 1820, 1822, 1823, 1824, 1829, 1835, 1836, 1843, 1845, 1847, 1851, 1856, 1857, and 1858. The ring for 1857 was present on only one specimen, PAN-3. The rings for 1856 and 1858 are often absent and, when present, may vary in relative width about the circuit. The ring for 1866 is of variable width. In the faster growing, more open series, it is of average width, often equal to or greater than the adjacent rings for 1865 and 1867. In contrast, 1866 in a closely compacted ring series is often a microscopic or missing ring.

Bark was not present on any of the eight stump specimens, but evidence that the outermost growth layers had not been noticeably eroded consisted of isolated, eroded lands amid extensive beetle galleries and passageways characteristically formed under the bark of dead trees. Beetle damage was present on specimens PAN-1, -2, -3, -4, and -5. The plotted series in Figure 1 do not include the outermost ring when growth was incomplete. Natural erosion of the wood, combined with beetle damage, in several cases nearly removed all positive evidence of a definite outer ring. This necessitated an intensive search for the outermost ring on each specimen. Dates for the outermost ring year are listed in Table 2. These dates are supplemented by material collected later and described below.

Weight (1960) described the Modoc Mine, for which the charcoal was prepared, as struck in 1875. Birnie (1876; 287-8) examined the mineral resources of the Lookout district in August, 1875, and stated that the district, including the Modoc, was discovered in May, 1875, and that it had been worked since its organization in July. Oliver Roberts de la Fontaine (1931), in his personal recollections, described activities in the Argus and Panamint Mountains. He mentioned visits to the charcoal camps in Wildrose Canyon, although he did not describe the beehive-shaped kilns as such. No actual dates were cited, but 1874 and 1875 were inferred.

The enigma presented by the assumed loss, due to erosion, of even one or two of the last-formed rings in the Thorndike Camp specimens, the high percentage of locally absent and missing rings following 1840, and the indirect evidence in the literature prompted the collection of material from more extensive areas. On September 2 and 3, 1961, outer portions were collected from nine pinyon stumps immediately west of the charcoal kilns, five pinyon and one juniper from the slope to the east of the kilns, and six pinyon from the north slope just below Mahogany Flat.

Experience with the earlier collection indicated that even an apparently smooth outer surface, presumably formerly covered with bark, may have suffered sufficient erosion to remove all or a portion of the outermost two or three rings. Hence, a search was made for stumps with uneroded outer surfaces or with bark attached. It was found that some stumps, their roots destroyed by termites, had fallen over or even had been washed down slope. Under these conditions the under surfaces were protected, either by the overlying stump or by rocks and soil that had washed against them.

Additional evidence was sought through cross sections from two trees, growing at slightly over 8,100 feet, removed in June, 1959, during the construction of the Rogers Peak access road from Mahogany Flat. The full

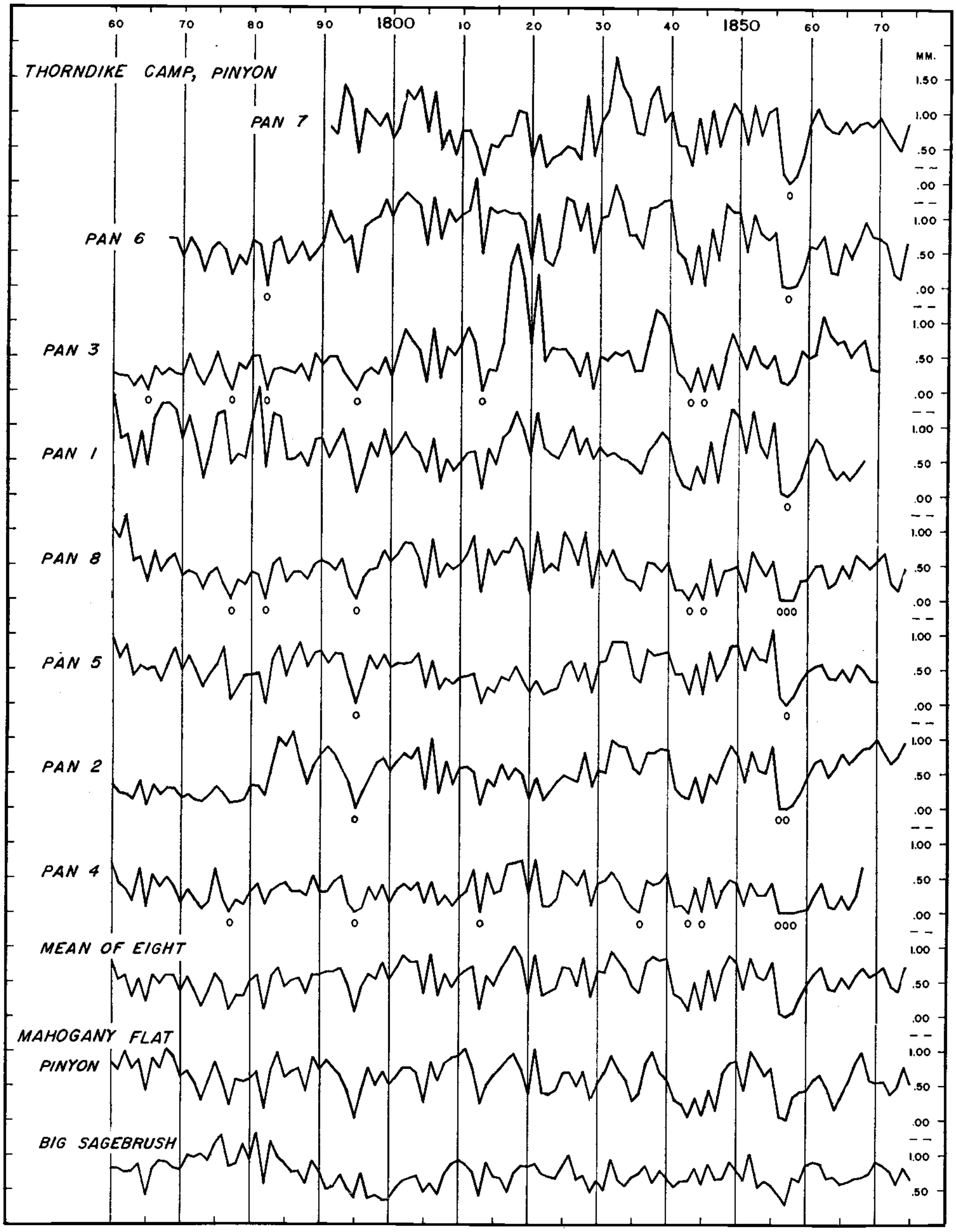

FIG. 1. Plots of measured ring widths for eight pinyon stumps from near Thorndike Camp; a mean of the eight; a mean of four from living pinyon in Mahogany Flat; and of a single specimen of big sagebrush from Arcane Meadows, above Mahogany Flat. Ring widths are expressed in hundredths of a millimeter and are plotted on a vertical scale of 50 millimeters to one centimeter. The "o" symbol indicates a ring missing on the specimen.

TABLE 2. Outermost ring year for material from stumps in the Charcoal Kilns area.

Specimen (PAN)	Outermost ring year	Comments*
Mahogany Flat		
24	1879	Incomplete; galleries
25	1876	Incomplete; galleries; eroded
29	1876	Complete; galleries
28	1869	Incomplete; galleries; eroded; possible absences
26	1867	Incomplete; galleries; eroded; many absences
27		Dated from 1722 to 1840; too many absences following 1840 to date with certainty
Thorndike Camp		
6	1875	Incomplete; eroded
7	1875	Incomplete; eroded
8	1874	Complete; eroded
2	1873	Incomplete; galleries; eroded
5	1871	Incomplete; galleries; eroded
3	1870	Complete; galleries; eroded
1	1869	Incomplete; galleries; eroded
4	1869	Incomplete; galleries; eroded
Charcoal Kilns, west		
9	1878	Complete; bark attached
16	1878	Complete
10	1876	Complete; galleries
17	1876	Complete; galleries
11	1876	Incomplete; eroded
14	1876	Incomplete; galleries; eroded
12	1874	Complete; eroded; many absences after 1840
13	1872	Incomplete; galleries; eroded
15		Not dated; many absences; resinous; bark attached; galleries
Charcoal Kilns, east		
21	1907	Complete; bark attached
19	1876	Complete; bark attached; galleries
20	1876	Complete; bark attached; many absences after 1850
22	1872	Complete; galleries; eroded
18	1868	Complete; bark attached; galleries
23		Not dated; juniper

*Complete: latewood formed and apparently complete.
Incomplete: latewood of the outermost ring either eroded or not formed.
Galleries: presence of galleries and passageways, formed by bark beetles under the bark of dead or dying trees, on the outer surface of the wood.
Eroded: major portions of the outer surface noticeably eroded by weather; probable loss of one or more rings.

cross sections, collected by M. H. Ryan, were polished to permit the examination of each growth layer completely about the circuit. The larger specimen, 34 centimeters in diameter, had a pith year of 1801. The smaller specimen, 27.5 centimeters in diameter, had a long radius, containing much compression wood, of 18 centimeters. The smaller specimen was much slower growing and had a pith year of about 1650.

In both cross sections, two small rings were present for what had been thought to be 1856 and 1857 in the kilns stumps. Between these two small rings, barely perceptible under a ten-power hand lens, was found an extremely small and locally absent ring for 1857. In the large cross sections the ring for 1862 was larger than average. The addition of 1857 to the chronology of the stump specimens, plus possibly either 1856 or 1858, placed the large ring, previously thought to be 1860 in many specimens, at 1862. This compounded the dating problem in that, in some specimens, three consecutive rings were missing: those for 1856, 1857, and 1858. Evaluation of the present collection suggests a small ring for 1858 in contrast to that in the Schulman chronology.

The plots in Figure 1 and the two modern cross sections were used to date the additional kilns collection. Visual examination, aided by a high degree of familiarity with the short time period involved, permitted the dating of 18 of the 20 pinyon specimens (Table 2). Pinyon specimens for which outer ring years were not reported (PAN-15 and -27) had ring series made difficult by the number of missing rings and by a heavy impregnation of the wood by resin. Portions of the ring sequence dated, indicating a general contemporaneity with the other dates, but the number of missing rings and the presence of resin made dating in the outer decades difficult, if not impossible. The only juniper collected (PAN-23) was not evaluated because of the lack of comparative material.

One specimen (PAN-19) was taken from the fairly extensive cribbing of a hand-constructed road which utilized trees and large limbs of both pinyon and juniper. A bark date of 1878 provides a strong indication that the road was built as a component part of the kilns activity.

An early bark date, 1868 in PAN-18, was from a cut trunk, with some bark still attached, surrounded by living branches arising from below the cut. The form of the cross section indicated that the bark-covered area may have been dead when the trunk was cut. An adjacent eroded surface over an area of expanded rings may have contained growth following 1868. Only the date of 1909 is out of phase with the bulk of the kilns material. Perhaps this noticeably later cutting date may be explained by the presence of a nearby Paiute camp occupied until the late 1930's (Wallace and Taylor 1955).

The two cross sections cut in 1959 showed an open sequence from 1859 to 1876. The width of the eight-year sequence from 1877 to 1884 was less than the average width for a single ring in the previous eighteen years. In that the kilns specimens were at elevations below the site where the two cross sections were secured, radial growth of these lower elevation trees may not have occurred in some of the years in the period 1877-1884. Hence, if trees were cut after 1876, growth rings for these years may not be found, even on bark-covered specimens.

The chronology of all specimens is easily identified in the 1677-1855 period. It is the difficulty and uncertainty of the post-1855 sequence that offers major problems in the correct determination of the cutting date. The present data are not conclusive, because of the possibility of even slight erosion of the outer surface and of the inferred absence of growth rings for 1877 and 1878 in most of the specimens. It would seem, however, that the presence of the ring for 1878 in two specimens from a site immediately adjoining the kilns and for 1879 in a Mahogany Flat specimen would indicate cutting in the area in 1878 rather than in 1876 as suggested by the bulk of the specimens.

In summary, a tree-ring chronology for pinyon in the Charcoal Kilns area has been established. Identification of individual years in the growth-ring sequence is progressively more difficult toward the lower elevational limits of the species, due to the high frequency of occurrence of locally absent and missing rings. Growth-ring studies of material from 28 pinyon stumps near Charcoal Kilns, Thorndike Camp, and Mahogany Flat indicate cutting in the period 1876-1879 for trees presumed to have been utilized as material for the nearby kilns.

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THE RELEVANCE OF DENDROGRAPHIC STUDIES TO TREE-RING RESEARCH*

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ABSTRACT

The annual increment growth measured by dendrographs on three different species is essentially a linear function of tree-ring width. The bark increment remains more or less constant. Records from dendrographs can therefore be employed in studying the environmental and physiological determinants of ring width.

During the past several years the author has been engaged in studies of daily tree growth. Dendrographs (Fritts and Fritts 1955) which were mounted on individual trees were used to record the daily range in size of each tree at a single radius. The dendrograph records were converted to daily growth by employing the equation $G = m_i - m_{pi}$ where G is growth, only when positive, m_i the maximum size for day i, and m_{pi} the maximum size obtained during any day preceding i. Changes occurring when the radial measurement is less than the previous maximum size are recorded as zero growth, so that all values represent only "new" increment and thus can be summed to provide a measure of the total increment. Such a definition is based upon the principle that new cell enlargement occurs only when the tissues are full of water and turgor pressure is high. Thus a series of positive daily growth increments is obtained which can be analyzed in terms of current environmental factors (Fritts 1958, 1960a) or summed up to provide the total annual increment.

However, the dendrograph measures changes in both the bark and xylem areas. This study is an attempt to determine what portion of the year's radial increment as measured by dendrographs can be ascribed to the xylem increment represented by the annual ring width.

Methods and results. The opportunity for this study was afforded by the termination of growth studies on six dominant forest trees near Charleston, Illinois, at the end of the 1960 growing season (Fritts 1959, 1960b). The dendrographs had been on two white oaks *(Quercus alba L.)* and a sugar maple *(Acer saccharum Marsh.)* for four years and on a second sugar maple and two red oaks *(Q. ruba L.)* for three years. A seventh dendrograph

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