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TREE-RING DATES FROM THE NAVAJO LAND CLAIM III. THE SOUTHERN SECTOR

M. A. Stokes and T. L. Smiley

Abstract

Data derived from specimens received from the Southern Sector, Navajo Land Claim, are presented. This Sector includes East Central Arizona and West Central New Mexico. Of the 797 specimens worked, 299 yielded dates.

With this, the third in a series of four articles, we present the results of work on Navajo Land Claim specimens from the Southern Sector (see Fig. 1). Dates of specimens from the Eastern Sector are to follow in another issue. The NLC Project, started in 1951, will then be terminated. A few specimens continue to come in from time-to-time, but collecting of new specimens is essentially finished. The final results may appear in print *before* the judicial decree is handed down by the U. S. Indian Claims Commission.

Figure 1 gives the outline of the boundary of this sector, as well as the relationship to other areas (divisions) of the Navajo Land Claim. From the northernmost point near Tohatchi, New Mexico, the boundary crosses the Chuska Mountains, and then follows the divide between north and south drainages. Junction with the Little Colorado River is made just east of where the Oraibi Wash enters into the Little Colorado. The western boundary follows approximately the Canyon Diablo mainstream. In Arizona, the southern boundary is the Mogollon Rim. Eastward, this boundary swings around the southern and eastern hills bordering the San Augustin Plains in New Mexico. The continental divide marks the eastern boundary up to the vicinity of Thoreau, New Mexico on U. S. Highway 66. From that point the boundary swings north and west to the Chuska Mountains.

Within this rather large sector, three areas have been delineated as given in the code index (Table 1). These are the Alamo-Salado area, the Upper Little Colorado area, and the Middle Little Colorado area. The Upper Little Colorado is the largest of the three, embracing the entire drainages of the Puerco of the West, the Zuni River, as well as the upper reaches of the Little Colorado. The Alamo-Salado area centers on the Datil Mountains and the headwaters of the Salado River. The Middle Little Colorado includes the Leroux Wash-Pueblo Colorado Wash, Chevelon Creek and Diablo.

The results of cross-dating between specimens from the Southern Sector is a bit more difficult to present than the two previously reported sectors (Stokes and Smiley 1963; 1964). This Sector represents a dendrochronologi-

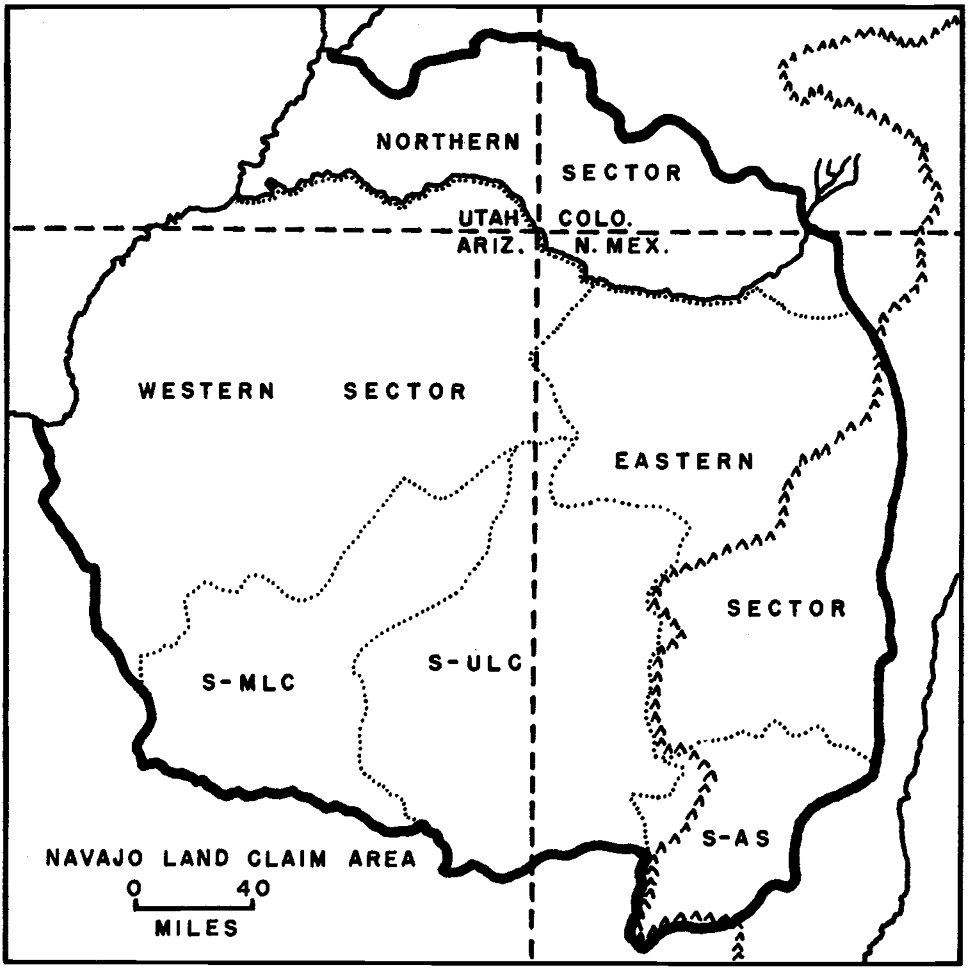

FIG. 1. Map of the Navajo Land Claim. Areas of the Southern Sector are indicated by letter designations and are defined by dotted lines. The position of the Continental Divide is indicated by the line of capital lambdas. The approximate limits of hogan collections is indicated by the heavy line.

cally more complex situation. Some of the specimens that were worked on exhibited ring patterns that differed in some respects from all known chronologies; they differed from that of the Rio Grande Chronology and from those chronologies found in trees growing on the Colorado Plateau provence. Differences were evident even between specimens from the same area. It was determined that these specimens had growth characteristics which fit what is to be defined, in another article, the "Continental Divide Chronology." For this reason, the task of plotting and deriving indices was more difficult, especially for the area S-ULC which is the largest and most varied area. Plots of the standardized indices for two of the three areas are given in Figure 2. Area S-MLC is omitted since too few specimens were received and dated.

The procedure outlined in the first report of this series (Stokes and Smiley 1963) was followed in processing and dating the samples. From the three areas involved in the Southern Sector, the field parties at the Navajo Land Claim sent 839 specimens in to the Laboratory of Tree-Ring Research. Of these now on file, the Laboratory has worked 797 specimens with 299 yielding dates. The dates are listed by areas and sub-areas in Table 2. Indices are presented in Tables 3 and 4.

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1963 Tree-Ring Dates from the Navajo Land Claim. I. The Northern Sector. *Tree-Ring Bulletin,* Vol. 25, Nos. 3-4, pp. 8-18. Tucson.

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TABLE 1. Index Code for Southern Sector

AS:	Alamo Salado Area	
	AC:	Alamocita Creek
	AM:	Allegro Mountain
	D:	Datil Mountains
	GB:	Gallina-Bear Mountains
	L:	Ladron Mountains
MLC:	Middle Little Colorado Area	
	CD:	Canyon Diablo (east side)
	CH:	Chevelon Creek
	LP:	Lower Puerco
ULC:	Upper Little Colorado Area	
	CZ:	Carrizo Wash
	EM:	Escondido Mountain
	UP:	Upper Puerco (of the West)
	ZR:	Zuni River

TABLE 2

SOUTHERN SECTOR

NLC	Group	Specimen	Tree-Ring Laboratory Date, A.D.
		ALAMO SALADO AREA	
117	S—AS—AC—A	Hogan 1	1815± fc—1888 inc
65	S—AS—AC—B	Sheep Corral 3	1790± p—1898+
66	S—AS—AC—C	Hogan 1	1750± p—1886+ inc
67	S—AS—AC—C	Hogan 2	1740 p—1841 inc
68	S—AS—AC—C	Hogan 2	1705± p—1883+ G
1064	S—AS—AC—C	Hogan 2	1679± p—1887+ G
1065	S—AS—AC—C	Hogan 2	1675 p—1890+ G
69	S—AS—AC—C	Hogan 3	1614 p—1872+ G
1071	S—AS—AC—C	Hogan 3	1690± p—1891+ G
1072	S—AS—AC—C	Hogan 4	1688± p—1873+
1073	S—AS—AC—C	Hogan 4	1606± p—1872+
76	S—AS—AC—C	Hogan 5	1648± p—1865+
1066	S—AS—AC—C	Hogan 6	1696± p—1899+ G
1067	S—AS—AC—C	Hogan 6	1780± p—1855+
1968	S—AS—AC—C	Hogan 6	1720± p—1880+
78	S—AS—AC—C	Sheep Corral	1749± p—1875+
80	S—AS—AC—F	Hogan 1	1704 p—1798+ inc C
80–1	S—AS—AC—F	Lamb Pen 1	1802±nc—1877 inc G
81	S—AS—AC—G	Hogan 1	1802±nc—1877 inc G
1075	S—AS—AC—G	Hogan 2	1711± p—1875+ G
1076	S—AS—AC—G	Hogan 4	1808± p—1880+
84	S—AS—AC—H	Hogan 2	1695±nc—1869+ G
89	S—AS—AC—H	Hogan 2	1790± p—1874 inc
152	S—AS—AC—L	Hogan 1	1656 p—1816+
153	S—AS—AC—M	Sheep Corral 3	1788± p—1897+
154	S—AS—AC—M	Windbreak 2	1819± p—1911 inc
155	S—AS—AC—M	Windbreak 2	1815± p—1900+ G
94	S—AS—AC—Q	Hunting Corral 1	1729± p—1871+
95	S—AS—AC—Q	Hunting Corral 1	1790± p—1871+
1062	S—AS—AC—Q	Antelope Corral	1650± p—1866+ G
87	S—AS—AC—Q	No site	1850± p—1950 inc
160	S—AS—AC—R	Windbreak 1	1801± p—1890 inc
118	S—AS—AC—T	Hogan 1	1542 p—1628 inc C G
3632	S—AS—AC—W	Hogan 6	1759± p—1848 inc G
3633	S—AS—AC—W	Hogan 7	1775 p—1832 inc
3638	S—AS—AC—W	Hogan 8	1735 nc—1848+ inc G
1203	S—AS—AC—X	Windbreak 1	1820± p—1872 G
311	S—AS—AC—Y	Hogan 3	1682± p—1845+
312	S—AS—AC—Y	Hogan 3	1680 fc—1807+
313	S—AS—AC—Y	Hogan 3	1695 p—1835+
314	S—AS—AC—Y	Hogan 3	1669± p—1769+
315	S—AS—AC—Y	Hogan 6	1692± p—1865+
316	S—AS—AC—Y	Hogan 6	1685± p—1876+
317	S—AS—AC—Y	Hogan 6	1695± p—1870+
318	S—AS—AC—Y	Hogan 6	1703 fc—1858 G
287	S—AS—AC—Z	Hogan 1	1674± p—1854 inc G
288	S—AS—AC—Z	Hogan 1	1646± p—1843+ G
289	S—AS—AC—Z	Hogan 1	1653± p—1855+
290	S—AS—AC—Z	Hogan 1	1740 p—1867 inc G
292	S—AS—AC—Z	Hogan 2	1802± p—1870+ G
295	S—AS—AC—Z	Sweathouse 3	1662 p—1765 inc
300	S—AS—AC—Z	Sheep Corral 4	1705± p—1862+
1078	S—AS—AC—BB	Hogan 3	1724± p—1796 G
1079	S—AS—AC—BB	Hogan 3	1718± p—1797 G
1080	S—AS—AC—BB	Hogan 5	1644 p—1767+
1081	S—AS—AC—BB	Hogan 5	1642 p—1786+
1082	S—AS—AC—BB	Hogan 5	1655± p—1792+
1156	S—AS—AM—B	Hogan 1	1619 nc—1774+ inc
1158	S—AS—AM—B	Hogan 1	1470 fc—1622+ inc
1159	S—AS—AM—B	Hogan 1	1630± p—1800+ inc
1141	S—AS—AM—B	Hogan 4	1600 fc—1789+ inc
1143	S—AS—AM—B	Hogan 4	1501 nc—1704 inc G

TABLE 2. (Continued)

NLC	Group	Specimen	Tree-Ring Laboratory Date, A.D.
1140	S—AS—AM—B	Windbreak 3	1450± p—1691+ inc
97	S—AS—D—B	Windbreak 1	1640 p—1846+ inc C
99	S—AS—D—C	Hogan 1	1611± p—1785+
106	S—AS—D—D	Hogan 2	1682 nc—1853+ G
107	S—AS—D—D	Hogan 2	1727± p—1837 inc G
108	S—AS—D—D	Hogan 2	1705± p—1881+ G
110	S—AS—D—D	Windbreak 1	1720 nc—1835+ inc
111	S—AS—D—D	Windbreak 1	1719 p—1833 inc
112	S—AS—D—D	Windbreak 3	1717 p—1819+ G
113	S—AS—D—D	Windbreak 3	1671± p—1847+
114	S—AS—D—D	Windbreak 3	1723 p—1817 inc
1126	S—AS—D—E	Hogan 1	1670± p—1876+
1094	S—AS—GB—E	Hogan 1	1642 p—1848+ G
1096	S—AS—GB—E	Hogan 1	1704± p—1827+ G
1097	S—AS—GB—E	Windbreak 2	1665 p—1816+ B
1098	S—AS—GB—E	Windbreak 2	1697 p—1868+
1099	S—AS—GB—E	Windbreak 3	1655 p—1824+ G
1101	S—AS—GB—E	Windbreak 3	1647± p—1847+
143	S—AS—GB—G	Hogan 1	1860 fc—1922 G
1102	S—AS—GB—M	Hogan 1	1725± p—1867 B
1105	S—AS—GB—M	Hogan 1	1706 p—1876+ G
1106	S—AS—GB—M	Hogan 1	1766± p—1892+ G
1112	S—AS—GB—O	Windbreak 2	1696± p—1879+ B
1113	S—AS—GB—O	Corral 3	1669 fc—1846+ G
1116	S—AS—GB—O	Windbreak 5	1680± p—1874+ G
1117	S—AS—GB—P	Windbreak 2	1690 nc—1821+
1207	S—AS—GB—S	Hogan 1	1702± p—1855+ G
1209	S—AS—GB—S	Hogan 1	1687± p—1838+ G
1210	S—AS—GB—S	Hogan 1	1705± p—1842+ G
1211	S—AS—GB—S	Rack 2	1699± p—1791+
1214	S—AS—GB—S	Windbreak 4	1711± p—1861+ G
1216	S—AS—GB—S	Windbreak 4	1670± p—1852+ G
1219	S—AS—GB—T	Hogan 1	1695 p—1824+ G
1220	S—AS—GB—T	Hogan 1	1664 p—1833+ G
1221	S—AS—GB—T	Hogan 1	1778 p—1880+ G
1222	S—AS—GB—T	Hogan 1	1682 p—1855+ G
1223	S—AS—GB—T	Hogan 1	1720 p—1892+ inc G
3608	S—AS—GB—Y	Loom 7	1740 nc—1850+ B
3614	S—AS—GB—AA	Hogan 1	1704 p—1837+
3642	S—AS—GB—DD	Hogan 1	1682± p—1869+ G
1174	S—AS—L—C	Windbreak 1	1839± p—1924+ G
1175	S—AS—L—C	Windbreak 1	1858± p—1925 inc G
1170	S—AS—L—C	Corral 2	1789± p—1926 c G
1171	S—AS—L—C	Corral 2	1818± p—1911 inc G
1172	S—AS—L—C	Corral 2	1963 p—1921 inc G
1145	S—AS—L—J	Corral 1	1683 p—1836+
1147	S—AS—L—J	Corral 1	1692 p—1780+ G
1149	S—AS—L—J	Corral 1	1693 p—1820+ G
1150	S—AS—L—J	Corral 1	1656 p—1829+
	MIDDLE LITTLE COLORADO		
1502	S—MLC—CD—F	Sheep Corral	1778± p—1890+ B
1503	S—MLC—CD—F	Sheep Corral	1750 fc—1870 inc
1505	S—MLC—CD—G	Hogan 1	1672± p—1869 inc
206	S—MLC—CD—G	Hogan 1	1741 p—1842+
1506	S—MLC—CH—H	Windbreak 1	1820± p—1928 G
1507	S—MLC—CH—H	Windbreak 1	1852 p—1927 inc G
3648	S—MLC—LP—O	Hogan 3	1662 p—1762 G
3649	S—MLC—LP—O	Hogan 5	1632 p—1757+ G
3650	S—MLC—LP—O	Hogan 5	1648 p—1751+ G
3652	S—MLC—LP—O	Hogan 5	1696 p—1762 inc
3653	S—MLC—LP—O	Hogan 7	1660 p—1758+
3654	S—MLC—LP—O	Hogan 8	1653± p—1750+
3655	S—MLC—LP—O	Fortification 9	1644± p—1764 inc G
3657	S—MLC—LP—O	Fortification 9	1654± p—1764 inc G

TABLE 2. (Continued)

NLC	*Group*	*Specimen*	*Tree-Ring Laboratory Date, A.D.*
		UPPER LITTLE COLORADO AREA	
31[illegible]	S—ULC—CZ—A	Hogan 2	1360 nc—1535+ c
3[illegible]	S—ULC—CZ—A	Hogan 2	1396 nc—1581+ inc
31[illegible]	S—ULC—CZ—A	Hogan 2	1433 p—1687+ inc
3120	S—ULC—CZ—A	Hogan 2	1340± p—1641+ inc
3192	S—ULC—CZ—A	Hogan 2	1311 p—1601+ inc
3193	S—ULC—CZ—A	Hogan 2	1391 p—1647+
3195	S—ULC—CZ—A	Hogan 2	1322 p—1718+ inc
3214	S—ULC—CZ—A	Hogan 7	1593 fc—1735+
3186	S—ULC—CZ—A	Windbreak 1	1585 fc—1771+ inc
3187	S—ULC—CZ—A	Windbreak 1	1425 p—1588+
3188	S—ULC—CZ—A	Windbreak 1	1430 fc—1664+
3189	S—ULC—CZ—A	Windbreak 1	1426± p—1699+ inc
3190	S—ULC—CZ—A	Windbreak 1	1316 nc—1484+
3200	S—ULC—CZ—A	Windbreak 4	1354± p—1510 inc
3202	S—ULC—CZ—A	Windbreak 5	1740 fc—1830 inc
3204	S—ULC—CZ—A	Windbreak 5	1669± p—1834+
3205	S—ULC—CZ—A	Windbreak 5	1390 p—1634+
3206	S—ULC—CZ—A	Windbreak 5	1695 fc—1813+
3208	S—ULC—CZ—A	Windbreak 5	1584± p—1732+
3209	S—ULC—CZ—A	Windbreak 5	1368± p—1578+ inc
3071	S—ULC—CZ—B	Hogan 1	1320 p—1387 inc
3073	S—ULC—CZ—B	Hogan 1	1317± p—1394+
3074	S—ULC—CZ—B	Hogan 1	1367 p—1521+
3075	S—ULC—CZ—B	Hogan 1	1301 p—1558 inc
3086	S—ULC—CZ—B	Hogan 2	1298 nc—1393 inc
3088	S—ULC—CZ—B	Hogan 2	1365 p—1478+ inc
3076	S—ULC—CZ—B	Hogan 4	1384 nc—1553+ inc
3077	S—ULC—CZ—B	Hogan 4	1352 p—1424+ inc
3078	S—ULC—CZ—B	Hogan 4	1301 p—1451+
3080	S—ULC—CZ—B	Hogan 4	1295 nc—1448+
3081	S—ULC—CZ—B	Hogan 4	1235± p—1421+
3082	S—ULC—CZ—B	Hogan 4	1385 fc—1504+
3083	S—ULC—CZ—B	Hogan 4	1295 nc—1464+ inc
3084	S—ULC—CZ—B	Hogan 4	1360 nc—1462+ inc
3085	S—ULC—CZ—B	Hogan 4	1338 nc—1474 inc
3089	S—ULC—CZ—B	Shelter 3	1360 p—1535+
3105	S—ULC—CZ—C	Hogan 1	1528± p—1764+ inc
3107	S—ULC—CZ—C	Hogan 1	1460 nc—1653+ inc G
3109	S—ULC—CZ—C	Hogan 1	1399± p—1655 inc
3114	S—ULC—CZ—C	Hogan 1	1429 p—1542+ inc
3115	S—ULC—CZ—C	Hogan 1	1420 fc—1510+ inc
3094	S—ULC—CZ—C	Windbreak 4	1360 nc—1587+ inc
3097	S—ULC—CZ—C	Windbreak 4	1601 p—1726+ inc G
3098	S—ULC—CZ—C	Windbreak 4	1424 p—1675+ inc
3093	S—ULC—CZ—C	Lean-to 3	1315 p—1447+
3215	S—ULC—CZ—AA	Windbreak 2	1655± p—1794 inc
1485	S—ULC—EM—G	Hogan 2	1608± p—1786+
1487	S—ULC—EM—G	Hogan 4	1650 nc—1815+ B
1488	S—ULC—EM—G	Hogan 4	1618 nc—1761+
3293	S—ULC—EM—G	Hogan 6	1680 nc—1823 inc
1495	S—ULC—EM—I	Windbreak 1	1815± p—1905 inc
2030	S—ULC—EM—K	Hogan 1	1708 p—1890+ inc G
2031	S—ULC—EM—K	Hogan 2	1747± p—1926+ B
2032	S—ULC—EM—K	Hogan 2	1765 p—1935 inc
3254	S—ULC—EM—Z	Hogan 1	1630 fc—1701 inc G
3257	S—ULC—EM—Z	Hogan 1	1619 p—1821+ inc G
3258	S—ULC—EM—Z	Hogan 1	1670 nc—1808 inc G
3259	S—ULC—EM—Z	Hogan 1	1696 p—1764+ inc
3261	S—ULC—EM—Z	Hogan 1	1679 p—1742+ inc G
3262	S—ULC—EM—Z	Hogan 1	1653± p—1815+ inc G
3263	S—ULC—EM—Z	Hogan 1	1643 p—1850 inc
3264	S—ULC—EM—Z	Hogan 1	1694 p—1820+ inc G
3265	S—ULC—EM—Z	Hogan 1	1654± p—1819+ inc G
3218	S—ULC—EM—AA	Hogan 1	1469 p—1721+ inc
3219	S—ULC—EM—AA	Hogan 1	1400± p—1590+ inc

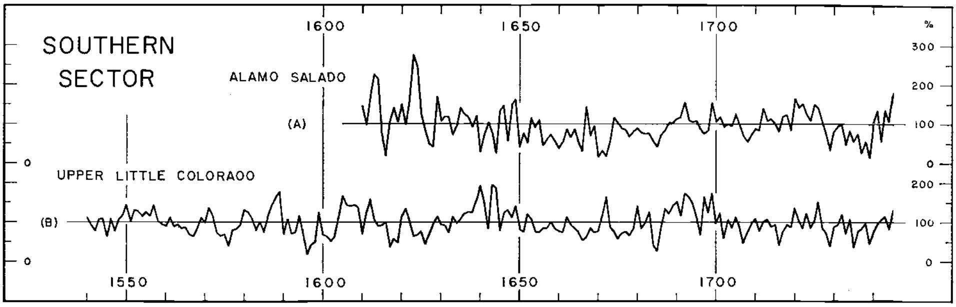

FIG. 2. Standardized indices for the Southern Sector.

TABLE 2. (Continued)

NLC	Group	Specimen	Tree-Ring Laboratory Date, A.D.
3220	S—ULC—EM—AA	Hogan 1	1452± p—1713+ inc
3226	S—ULC—EM—AA	Hogan 3	1451± p—1758+ inc
3246	S—ULC—EM—AA	Hogan 6	1365± p—1569+ inc
3247	S—ULC—EM—AA	Hogan 6	1333± p—1541+ inc
3266	S—ULC—EM—AA	Hogan 10	1745 p—1833 c B
3271	S—ULC—EM—AA	Hogan 11	1709 p—1812 inc
3296	S—ULC—EM—GG	Windbreak 2	1810 fc—1914 inc G
956	S—ULC—UP—B	Hogan 1	1656± p—1866+ inc G
958	S—ULC—UP—C	Hogan 1	1707± p—1871+ inc G
959	S—ULC—UP—C	Hogan 1	1661 p—1872+ G
960	S—ULC—UP—C	Corral	1893 p—1923+ G
961	S—ULC—UP—C	Corral	1845 p—1918 c G
964	S—ULC—UP—E	Hogan 3	1714± p—1882+ G
965	S—ULC—UP—E	Hogan 3	1738 p—1886 G
858	S—ULC—UP—I	Hogan 1	1703 p—1868 inc G
859	S—ULC—UP—I	Hogan 1	1715± p—1864+
1956	S—ULC—UP—N	Ceremonial Hogan	1784 p—1898 inc G
1957	S—ULC—UP—N	Ceremonial Hogan	1792 p—1901+ G
1980	S—ULC—UP—N	Ceremonial Hogan	1710 p—1889+
1981	S—ULC—UP—N	Ceremonial Hogan	1701± p—1890+ inc
1982	S—ULC—UP—N	Ceremonial Hogan	1723 p—1897+
1985	S—ULC—UP—P	Game Corral	1543± fc—1798 G
1989	S—ULC—UP—Q	Game Corral	1616± p—1797+
1990	S—ULC—UP—Q	Game Corral	1533± p—1705+
1994	S—ULC—UP—Q	Game Corral	1866 p—1923 inc G
1996–7	S—ULC—UP—R	Game Corral	1540± fc—1758+
2000	S—ULC—UP—R	Game Corral	1649±nc—1802+
2002	S—ULC—UP—R	Game Corral	1599± p—1745+ inc
2008	S—ULC—UP—R	Game Corral	1623± p—1777 G
2010	S—ULC—UP—T	Hogan 1	1534± p—1846+ G
2011	S—ULC—UP—T	Hogan 1	1691 p—1755+ inc
2014	S—ULC—UP—T	Hogan 2	1678± p—1804+
2015	S—ULC—UP—T	Hogan 2	1788± p—1856 inc G
2017	S—ULC—UP—T	Hogan 2	1777 p—1856 inc G
2019	S—ULC—UP—U	Hogan 1	1715± p—1851+
2020	S—ULC—UP—U	Hogan 1	1687 p—1848 inc G
2022	S—ULC—UP—U	Hogan 2	1728± p—1857 inc G
2023	S—ULC—UP—U	Hogan 2	1619± p—1832+ G
2658	S—ULC—UP—AA	Hogan 4	1619 p—1755 inc
3344	S—ULC—UP—JJ	Hogan 4	1707 p—1788+ inc
3345	S—ULC—UP—JJ	Hogan 4	1680 p—1794 inc G
3348	S—ULC—UP—JJ	Hogan 4	1700 p—1802 inc G
3304	S—ULC—UP—LL	Hogan 1	1677 p—1761 inc G
3306	S—ULC—UP—LL	Hogan 1	1679 p—1758 inc G
3308	S—ULC—UP—LL	Hogan 2	1594± p—1763 inc G
3309	S—ULC—UP—LL	Hogan 2	1641 p—1760 inc G
3310	S—ULC—UP—LL	Hogan 2	1607± p—1745+ inc G
3311	S—ULC—UP—LL	Hogan 2	1665 p—1752+ inc G
3313	S—ULC—UP—LL	Hogan 3	1705± p—1763 inc G
3318	S—ULC—UP—LL	Hogan 5	1680 fc—1761 inc G
3319	S—ULC—UP—LL	Hogan 5	1685 fc—1759 c G
3320	S—ULC—UP—LL	Hogan 5	1654 p—1760 inc G

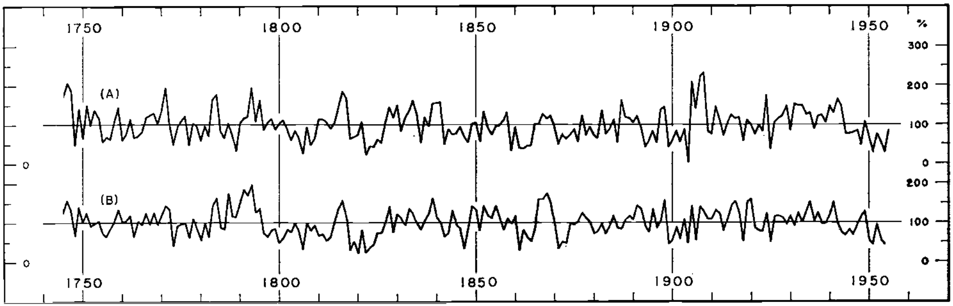

FIG. 2. (Continued)

TABLE 2. (Continued)

NLC	*Group*	*Specimen*	*Tree-Ring Laboratory Date, A.D.*
3321	S—ULC—UP—LL	Hogan 5	1682 p—1763 c G
3322	S—ULC—UP—LL	Hogan 5	1690 p—1764 c G
3329	S—ULC—UP—LL	Hogan 11	1604 p—1759 inc G
3330	S—ULC—UP—LL	Hogan 12	1634 nc—1755 inc G
3334	S—ULC—UP—MM	Hogan 1	1612 p—1762 inc G
3337	S—ULC—UP—MM	Hogan 1	1676 p—1758 inc G
3338	S—ULC—UP—MM	Hogan 1	1677 p—1721 inc G
3340	S—ULC—UP—MM	Hogan 1	1680 fc—1760 inc G
3	S—ULC—ZR—B	Sheep Corral 2	1699 p—1837 C
8	S—ULC—ZR—D	Hogan 1	1651 p—1925 inc
1789	S—ULC—ZR—D	Hogan 3	1815 p—1904 c G
1790	S—ULC—ZR—D	Hogan 3	1818± p—1893 G
1791	S—ULC—ZR—D	Hogan 4	1839 p—1895 inc G
9	S—ULC—ZR—E	Hogan 1	1790 p—1861 inc G
10	S—ULC—ZR—E	Hogan 1	1796 p—1861 inc G
11	S—ULC—ZR—E	Hogan 2	1721 p—1826+
12	S—ULC—ZR—E	Hogan 2	1720± p—1861 inc
3041	S—ULC—ZR—E	Hogan 2	1729 nc—1861+ inc G
3042	S—ULC—ZR—E	Hogan 2	1700 nc—1851+ inc G
3043	S—ULC—ZR—E	Hogan 2	1700 nc—1849+ inc G
3047	S—ULC—ZR—E	Hogan 3	1720 nc—1861+ inc G
3053	S—ULC—ZR—E	Hogan 3	1690 p—1839 G
3054	S—ULC—ZR—E	Hogan 4	1720 nc—1861+ G
3055	S—ULC—ZR—E	Hogan 4	1700 nc—1860+ inc
3057	S—ULC—ZR—E	Hogan 4	1709± p—1858 inc
18	S—ULC—ZR—E	Hogan 5	1681 p—1850 inc
3059	S—ULC—ZR—E	Hogan 7	1707 nc—1863 inc G
3060	S—ULC—ZR—E	Hogan 7	1708 p—1844+ inc G
3062	S—ULC—ZR—E	Hogan 7	1701 p—1856+ inc G
22	S—ULC—ZR—E	Hogan 8	1718 p—1859 inc
3063	S—ULC—ZR—E	Hogan 9	1729± p—1860 inc G
3064	S—ULC—ZR—E	Hogan 9	1620 p—1852+
3065	S—ULC—ZR—E	Hogan 9	1770 nc—1861 inc G
3066	S—ULC—ZR—E	Hogan 9	1733 p—1861 inc G
280	S—ULC—ZR—F	Hogan 1	1740± p—1908 G
281	S—ULC—ZR—F	Hogan 1	1757 p—1908 G
282	S—ULC—ZR—F	Hogan 3	1760± p—1909 c G
284	S—ULC—ZR—F	Hogan 4	1690 p—1840+
29	S—ULC—ZR—G	Hogan 1	1781 p—1892+ inc
33	S—ULC—ZR—G	Lamb Pen	1633 fc—1761+ inc
36	S—ULC—ZR—H	Hogan 1	1750± p—1909 G
37	S—ULC—ZR—H	Hogan 4	1787± p—1907 inc G
1964	S—ULC—ZR—P	Game Corral	1484± fc—1720+
1979	S—ULC—ZR—S	Sheep Corral 4	1726 p—1877 inc
3001	S—ULC—ZR—W	Hogan 1	1568± p—1781 inc
3005	S—ULC—ZR—W	Hogan 2	1590 fc—1673+ inc
3006	S—ULC—ZR—W	Hogan 2	1778± p—1876 inc G
3007	S—ULC—ZR—W	Hogan 2	1356 p—1543+
3216	S—ULC—ZR—Z	Hogan 1	1638 nc—1791+ inc
3217	S—ULC—ZR—Z	Hogan 1	1648 nc—1774+ inc
2993A	S—ULC—ZR—DD	Hogan 2	1721 p—1800+ inc

TABLE 2. (Continued)

NLC	*Group*	*Specimen*	*Tree-Ring Laboratory Date, A.D.*
2994	S—ULC—ZR—DD	Hogan 2	1713 fc—1857 inc G
2996	S—ULC—ZR—DD	Hogan 2	1709 p—1793 inc G
2999	S—ULC—ZR—DD	Hogan 3	1504± p—1812+ inc G
3000	S—ULC—ZR—DD	Hogan 3	1549± p—1857+ inc G
3010	S—ULC—ZR—EE	Hogan 1	1716 p—1812 inc G
3012	S—ULC—ZR—EE	Hogan 1	1700 p—1818 inc G

TABLE 3. Southern Alamo Salado Indices

A.D.	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1610	145	98	170	228	213	75	20	105	141	104
1620	150	99	156	277	244	128	84	50	42	170
1630	108	120	119	71	93	141	127	118	91	121
1640	29	70	104	77	26	133	147	57	150	162
1650	40	78	52	117	90	111	43	61	73	57
1660	38	52	89	68	89	56	30	142	70	95
1670	18	33	19	57	117	102	89	88	69	81
1680	90	79	76	78	58	41	72	85	103	103
1690	112	118	156	111	106	109	88	76	82	154
1700	106	118	92	100	95	127	99	69	54	73
1710	89	83	140	109	113	101	81	120	124	84
1720	164	141	152	127	109	150	140	104	76	33
1730	80	95	100	48	83	55	75	27	57	16
1740	105	133	57	135	106	172	207	187	49	141
1750	66	150	99	138	119	57	69	62	109	145
1760	60	76	115	68	70	81	120	125	131	104
1770	137	198	103	49	93	110	123	49	103	99
1780	60	98	71	166	179	88	66	103	74	36
1790	102	117	120	194	108	163	88	105	116	88
1800	102	111	90	61	86	66	29	95	49	67
1810	114	115	107	90	107	146	185	168	64	69
1820	74	108	22	46	43	63	53	107	145	119
1830	150	84	118	136	162	126	54	120	95	153
1840	155	158	51	88	75	77	96	70	54	102
1850	106	57	134	92	74	95	98	110	131	34
1860	95	42	39	47	47	101	101	128	116	124
1870	98	50	74	66	74	89	56	124	72	95
1880	73	64	138	76	88	114	54	162	121	118
1890	106	124	93	41	58	82	54	139	147	41
1900	60	84	56	88	04	208	142	222	232	82
1910	75	145	112	71	101	126	114	119	58	111
1920	100	73	98	83	176	38	106	116	121	148
1930	85	152	147	147	123	130	88	120	123	104
1940	148	128	166	146	74	77	78	85	48	108
1950	66	30	73	55	29	84	......	......	......	......

TABLE 4. Southern-Upper Little Colorado Indices

A.D.	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1540	113	93	78	108	110	65	109	77	107	118
1550	144	100	131	129	114	125	116	144	102	95
1560	90	112	90	94	86	88	69	64	84	112
1570	99	137	115	73	67	70	40	81	83	92
1580	131	126	110	80	101	76	111	141	162	178
1590	70	109	71	75	117	69	20	43	50	125
1600	69	64	51	65	115	168	145	141	146	139
1610	71	123	159	109	90	93	101	38	58	49
1620	115	136	105	67	69	77	46	69	96	117
1630	95	92	76	116	98	108	121	128	126	156
1640	193	152	84	196	187	80	124	131	112	141
1650	83	76	121	108	74	76	86	86	102	84
1660	78	76	114	95	83	76	54	62	87	74
1670	78	117	166	90	79	59	72	78	68	86
1680	142	86	100	128	42	28	89	136	122	142

TABLE 4. (Continued)

A.D.	0	1	2	3	4	5	6	7	8	9
1690	154	118	173	166	149	114	69	165	126	174
1700	99	125	61	108	86	114	88	48	76	96
1710	110	79	101	108	90	94	42	77	95	87
1720	135	107	86	122	85	107	152	85	70	40
1730	89	94	119	71	108	37	78	83	99	46
1740	74	95	107	116	82	126	157	131	68	141
1750	100	124	92	99	107	75	63	84	102	133
1760	102	104	119	65	106	95	125	96	127	95
1770	119	143	134	42	92	98	99	62	111	85
1780	57	101	63	145	164	89	84	175	118	115
1790	150	186	170	196	127	136	75	63	81	85
1800	50	62	84	76	100	77	32	100	81	95
1810	69	72	54	65	102	137	155	111	32	52
1820	23	82	24	38	45	74	74	101	141	77
1830	125	114	95	138	123	100	83	109	127	165
1840	119	102	65	76	132	97	85	34	89	143
1850	132	80	142	119	111	144	114	81	111	99
1860	119	30	82	63	52	90	161	160	176	152
1870	102	34	51	49	101	95	104	125	112	102
1880	72	78	98	71	90	119	87	84	108	118
1890	108	145	135	93	76	137	86	106	160	45
1900	56	89	59	110	48	145	53	142	132	110
1910	110	134	124	78	110	144	156	124	52	153
1920	161	86	80	78	123	50	114	117	112	94
1930	116	92	123	100	128	152	102	125	98	98
1940	120	156	101	76	68	82	69	94	116	128
1950	56	43	94	59	43	......	......	......	......	......

Explanation of symbols used with dates: p—pith ring; nc—indicates that the pith was gone from the specimen and that the inside dated ring is "near center"; fc—used when the pith is gone from the specimen and the inside dated ring is determined to be quite far out from the pith; ±—center portion is difficult to date and this symbol indicates a ring count only; +—indicates that either the outermost rings are very small and a ring count only could be made to the outside, or that the outermost dated ring is one just preceding what is usually a small, micro or absent ring which may be missing from the specimen; inc—indicated that the outside ring of a specimen is incomplete in growth; c—outermost ring is complete in growth; C—outermost ring is continuous around the circumference of the specimen, implying that the date is close to the cutting date; G—beetle galleries present; B—bark present on the specimen.

A PARTIALLY AUTOMATIC TREE RING INTERVAL COUNTER AND KEYPUNCH: (PATRICK)

JAMES WEINMAN, VAL MITCHELL and MARY NAY

ABSTRACT

A microscope that enables an investigator to rapidly measure and simultaneously record tree ring intervals on data-cards is described. A resume of sources and magnitudes of errors is included.

INTRODUCTION

The use of statistical methods utilizing computers has rendered it possible to rapidly analyse a considerable amount of tree ring width data. This in turn has necessitated increased speed and efficiency in the measurement of ring series and in digitally recording this data. A Partially Automatic Tree Ring Interval Counter and Keypunch (PATRICK), was therefore developed to enable an operator to rapidly measure and simultaneously record increment widths on data-cards.

DESCRIPTION OF APPARATUS

The PATRICK shown schematically in Figure 1 consists of a motor driven specimen stage which is a Societe Genevoise dividing machine,[1] a screw position encoder that feeds pulses into a scaler unit,[2] an IBM 26 (printing) card punch, and a stereo-microscope with illuminator.[3] A variable speed drive motor enables the operator to vary the velocity of translation of the specimen stage from 0 to 1.0 mm/sec.

The drive screw of the dividing machine is connected to the motor by an electromagnetic clutch. The clutch plates are spring loaded and scoured to insure rapid separation when the clutch is disengaged. The screw is connected to a disc within the screw position encoding unit through a 1:4 gear train. Around the perimeter of the disc are 50 equally spaced holes. As the disc rotates, light from a point light source is transmitted through these holes, one at a time, to a photojunction. Each light pulse generates an electric pulse which is recorded in the scaler.

The scaler indicates the number of accumulated pulses corresponding to the distance traversed during a transect. The circuitry for transferring the scaler output to the punch is designed to leave the punch suitable for conventional manual operation when the PATRICK is not in use. (Details of the circuitry are available upon request.) Each card processed by the IBM 26 card punch records the radial coordinates of eight tree rings to five digit accuracy. Mathematical operations such as the determination of individual ring widths are performed by electronic computer.

A weight is attached to one end of the specimen stage to hold it against one side of the screw threads to eliminate backlash. Interval measurements are therefore conducted by translating the stage only in the direction opposing the weight. A fast automatic return cycle is initiated when the stage has moved across the entire length of the dividing machine.

A stereo-microscope, with a cross-hair reticle in one eyepiece, capable of magnification of 72 and 144X, and an illuminator are mounted above the specimen stage. In measuring a specimen, only one magnification at a preset focal condition is used during a particular transect to avoid errors introduced by parallax. The surface of the specimen must therefore be uniform to avoid the need for frequent focusing of the microscope; such specimen surfaces have been obtained by employing the sanding method of Bowers.[4]

The operator is provided with two switches. One switch disengages the clutch and, after a specified delay, causes the number recorded in the scaler to be punched on a data-card by the card punch. Only upon completion of the punch cycle can the clutch be re-engaged. This switching cycle avoids introducing spurious pulses into the card punch during the 3 sec. print and punch cycle. Although a magnetic tape read-out would be faster than the present data-card read-out system, the operator is now able to quickly determine whether the scaler output is being faithfully recorded. As each ring passes under the cross-hair of the microscope, the operator must only press the first switch button to initiate the punching cycle. A second switch disengages the clutch only. This switch enables the operator to stop the translation of the stage without punching a number on the card. This is advantageous when there are cracks in the specimen. The operator stops the stage on one side of the crack, moves the specimen so as to bridge the crack by means of a manually operated substage mounted on the specimen stage, and resumes measuring from the opposite edge of the crack. Once the microscope is properly focused and a convenient velocity of translation selected, the operator must only press a button as each ring passes under the microscope cross-hairs.

RESULTS AND DISCUSSION

Saxon[1] calibrated the drive screw and found the pitch to be 1 ± 10^{-5} mm. A micrometer scale attached to the drive screw allows the position of the stage to be measured to within .001 mm. Since the smallest increment of motion recorded by the pulse monitoring system is .005 mm, subsequent calibration of PATRICK employed this micrometer as a standard.

Tests were conducted to demonstrate the reproducibility and the magnitude of errors associated with starting, stopping, and variation of the motor drive speed by comparing measurements obtained from a 39.37 line/cm Ronchi ruling. A .0035 mm standard error, observed at very slow translational velocities, is the irreducible error introduced by digitizing the measured intervals in .005 mm increments. The digital shaft position encoder utilized in the present device was fabricated by our technical staff; encoders capable of measuring smaller increments are commercially available.[5] Although the operator anticipates the passage of the reference line under the cross-hair, the .050 sec standard deviation in his reaction time introduces the most significant velocity dependent contribution to the standard error. Standard errors in the reaction time to visual stimuli of this magnitude have been cited by Woodworth and Schlossberg.[6] This velocity dependent source of error could be eliminated by using a photo-electric trigger, sensitive to changes in the intensity of light reflected from the specimen, to initiate the print and punch cycle. The operator thus would only be required to visually discriminate against cracks or unusual flaws in the specimen. The PATRICK is not used sufficiently at this time to necessitate high translational velocities; this added expense is therefore not warranted at present. The operator's reaction time and the PATRICK'S time resolution contribute a velocity dependent standard error approximately 0.06v mm, where v is the velocity of translation in mm per sec. These factors combine to introduce a total standard error

$$\triangle w = \sqrt{(.0035)^2 + (.06V)^2} \quad \text{mm}$$

in each measured tree ring interval. This error is small compared to the natural ring width variation of species currently under investigation at the University of Wisconsin Tree Ring Laboratory.

In order to minimize cost, PATRICK was designed to utilize equipment already available. The present design, therefore, while entirely adequate, should not be considered optimal.

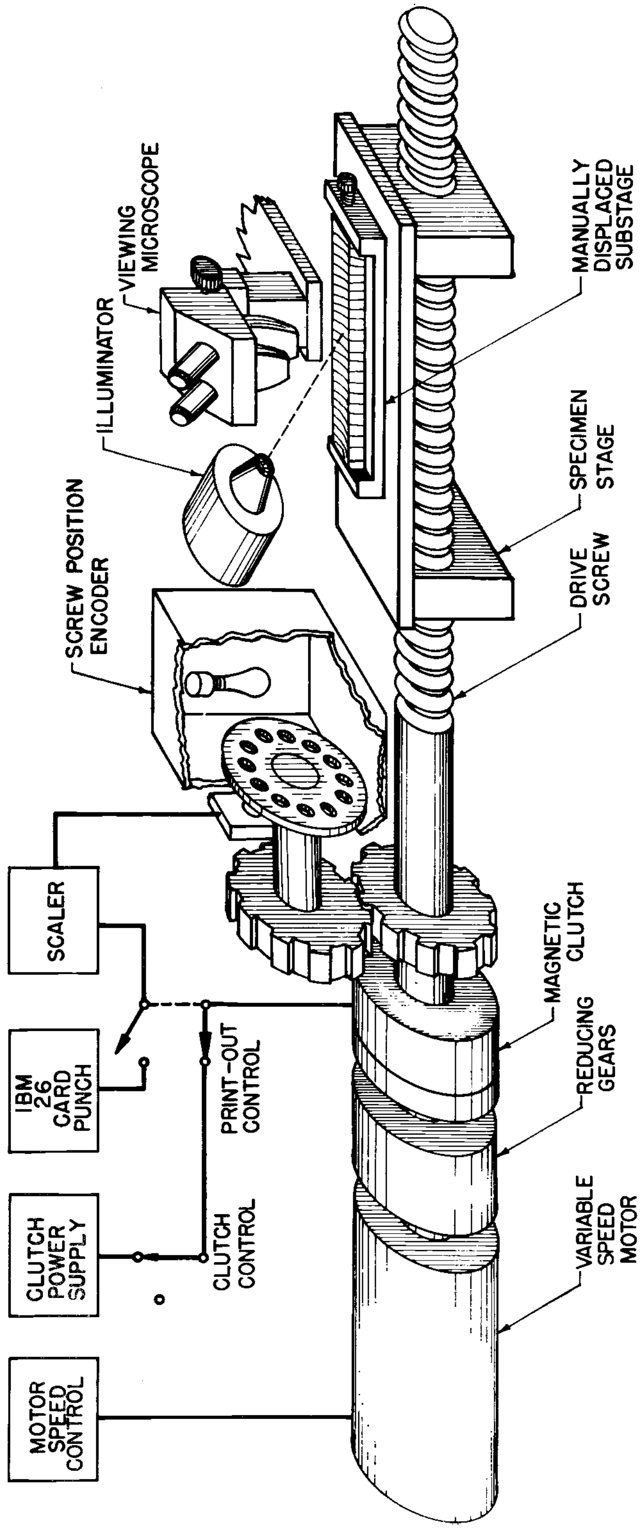

FIG. 1. Schematic Diagram of the PATRICK.

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FOOTNOTES

1) D. Saxon, *The X-Ray Spectra of Some Heavy Elements*. Ph.D. Thesis, University of Wisconsin, p. 24. 1954.

2) Beckman Universal Eput Scaler and Timer, model 7360R.

3) Leitz Stereomicroscope (GRUKY). One eyepiece is fitted with a cross-line reticle. An American Optical Company Cyclospot Microscope Illuminator is attached to the microscope base.

4) N A. Bowers, New Method of Surfacing Wood Specimens for Study. *Tree-Ring* *etin*, Vol. 26, Nos. 1-4, p. 2, June, 1964. Tucson, Arizona.

5) Available from W & L E Gurley Co., 514 Fulton St., Troy, N. Y.

6) R. S. Woodworth and H. Schlosberg, *Experimental Psychology*, pp. 8-39, 1954.