

FIRE HISTORY OF THE RINCON MOUNTAIN WILDERNESS

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Modern fire records and fire scarred remnant material, including logs, snags and stumps, were used to reconstruct and analyze fire history in the mixed conifer and pine forest above 2,300m (7,500 feet) within the Rincon Mountain Wilderness of Saguaro National Monument, Arizona, USA. Dendrochronological crossdating of the remnant material allowed dating of fire events to the calendar year. A method for estimating seasonal patterns of fire occurrence is discussed. The mean fire interval over the Mica Mountain study area for the period 1657-1893 was 6.1 years with a range of 2-13 years for fires estimated to be larger than 200 ha. (500 acres) in size. The mean fire interval for the mixed conifer forest type within this study area (period=1748-1886) was 9.9 with a range of 3-19 years.

INTRODUCTION

The role of periodic fire in forest stands has been studied throughout the west by examination of fire scars occurring on coniferous tree species (Weaver 1951, Kilgore and Taylor 1979, Alhstrand 1980, Dieterich 1983, Swetnam and Dieterich 1983b, Caprio et.al. 1988). These studies as well as examinations of stand structure and establishment patterns (Cooper 1960, ...etc ... Pitcher 1987) have provided a base line of knowledge concerning the ecological function of lightning fire. However, fire regimes vary tremendously from region to region and there may also be considerable variation within a limited geographic area based on changes in elevation and aspect. Therefore, site-specific studies are often necessary in order to determine local patterns of occurrence.

Management of natural areas relies on an understanding of the local ecology and its interaction with disturbances such as

lightning fire and fire histories have been a preferred tool to derive such information. However, the mandate of such areas to minimize human impacts often limits or precludes the sampling techniques usually employed in fire history studies (e.g. felling of live trees to collect cross sections). With the use of dendrochronological crossdating techniques this study was able to rely exclusively on the analysis of dead or remnant material (with the exception of a limited number of increment borings collected from living trees) to reconstruct the local fire regime. The process of crossdating assigns each annual ring to the calendar year of formation allowing accurate cross-referencing between samples as well as enabling comparisons with historical records, detailed climate records and reconstructions or other proxy records. We believe this method is an attractive alternative where cross dating is possible. However, it should be noted that dead or remnant material is an endangered resource with a limited 'life' span, particularly as prescribed burning programs are reintroducing fire to many areas.

An additional source of information concerning local and regional variations in fire regime is the position of fire scars within the annual ring (Barrett 1981, Dieterich and Swetnam 1984?). A compilation of the relative position of many scars can reveal seasonal patterns of fire occurrence at a given site.

Modern records of fire occurrence for an area provide a valuable perspective on data generated from fire scars. Seasonal occurrence, patterns of ignition and other recorded data often shed light on the scar record itself.

The Rincon Mountains of Saguaro National Monument, comprise an island mountain chain with complex topography and diverse ecology, a situation little studied in relation to fire history. Several forest types occur here although this study was limited to the open pine and mixed conifer forest above 2300m (7,500 ft.).

The pre-1900 mean fire interval in ponderosa pine forests has been found to vary depending on conditions specific to the site. The range in Arizona and New Mexico is from 1.8 to 9.8 years (Swetnam 1988).

Less is known about fire ecology in the mixed-conifer forests of the southwestern U.S. Two studies in this forest type have reported somewhat lower fire frequencies, with intervals ranging up to twenty years due to more mesic conditions in these sites (Ahlstrand 1980, Dieterich 1980b). However, in some lower elevation mixed-conifer stands the interval may have been on the order of 5 to 12 years, more closely resembling the frequency in the ponderosa pine type (Weaver 1951).

Site description

The Rincon Mountains

The Rincon Mountain Unit of Saguaro National Monument (Figure 1) encompasses an area of 25,000 ha. (63,000 acres) consisting of the main mass of the Rincon Mountains, Tanque Verde Ridge, and the bajada area surrounding the monument headquarters. The mountains themselves belong to the Basin and Range province of southern Arizona.

The lower reaches of the monument at 800m (2,700 ft.) elevation are within the Sonoran desert scrub vegetation zone. The

vegetation is dominated by saguaro cacti and other succulents as well as many species of desert trees and shrubs. From the desert floor the mountains ascend to over 2,600m (8,600 ft.) at Mica Mountain, and just under 2,600m (8,500 ft.) at Rincon Peak. The area above 2,300m (7,500 ft.), supports mixed-conifer and ponderosa pine forest. At least 986 species of plants, 40% more than would be expected in an area of this size and range of elevation, occur in the Rincons attesting to the variety of conditions available (Bowers and McLaughlin 1987).

Over the range of elevations, five distinct cover types are encountered (Figure 2). Annual precipitation varies considerably with 280mm (eleven inches) falling at the lower elevations and 640 to 760mm (twenty-five to thirty inches) near the summit (Bowers and McLaughlin 1987). A snow pack often develops during the winter months above 2,100m (7,000 ft.), with considerable accumulation on north facing slopes.

The basin and range province of southern Arizona is subject to a bi-seasonal distribution of precipitation with winter and summer maximums. The Tucson basin receives an average of fifty-eight percent of its annual precipitation of 290mm (11.4 inches) between May and October with the peak occurring during the monsoon season in July and August. The winter maximum occurs during December and January (Sellers 198??).

Although samples were collected from Rincon peak, Tanque Verde peak, and Happy Valley Knoll as well as from Mica Mountain, the analysis focuses on the fire regime of Mica Mountain above 2,300m (7,500 ft.) (Figure 3). Within this area, approximately 1,600 ha.

(4,000 acres) in extent, the most complete collection of fire scarred samples was obtained. Other areas will be referred to as appropriate.

The Mica Mountain study area

This study area supports a coniferous forest which varies in species composition with aspect. The more mesic, north facing slopes support a mixed-conifer forest with considerable variation. Cooler north and northeast facing slopes have Douglas-fir (*Pseudotsuga menziesii*) / white fir (*Abies concolor*) dominated communities while northwest facing slopes support a more xeric community, including Gambel's oak (*Quercus gambelii*), southwestern white pine (*Pinus strobiformis*), ponderosa pine (*Pinus ponderosa*, var. *arizonica* and *scopulorum*) and Douglas-fir. Particularly favorable areas support stands of aspen (*Populus tremuloides*). The forest varies from closed canopy stands with dense understory to relatively open conditions on the drier slopes (Bowers and McLaughlin 1987).

Slopes with southerly aspect support pine communities of varying composition with various oak species (including *Q. arizonica*, *Q. emoryi*, and *Q. hypoleucoides*) playing a larger role at lower elevations. Flats and drier slopes near the summit have open stands of pine (*P. strobiformis* / *P. ponderosa*) with grassy (spp.?) understory broken by several dry meadow areas. This forest type will subsequently be referred to as "open pine" type.

*grassy seed
one
Muhlenbergia*

Strips of riparian vegetation follow drainages with semi-permanent surface flow. There are no perennial streams within the upper elevations although flow in the lower reaches of several drainages approaches permanence. There are a number of permanent springs at various locations. Larger riparian species found above 2,100m (7,000') include alder (*Alnus oblongifolia*), willow (*Salix exigua*), walnut (*Juglans major*), and maple (*Acer negundo*).

There are few topographic barriers to fire spread. Those that do exist are of limited extent, consisting of either large rock faces or jumbled, boulder-strewn slopes with patches of exposed bedrock. Drainage bottoms are often dry and covered with litter.

Changes in fuel composition would appear to be the main constraint on fire spread. The litter bed of the oak-pine and chaparral communities, which occur below the pine forest, will not support a surface fire as readily as the grass and pine litter found at the higher elevations. However, many of the chaparral species (pointleaf manzanita, *Arctostaphylos pungens*; hairy mountain mahogany, *Cercocarpus brevifloris*; and skunkbush sumac, *Rhus trilobata*) are considered pyrophytes (Wright and Bailey 1982) and during the annual fore-summer drought this change in fuel composition may not represent a significant fire barrier.

Fire scarred trees and burned stumps which can be found throughout the oak-pine forest and woodland types attest to the presence of fire in these communities. Some past fires probably originated within the lower forest type and spread into the higher elevation stands. For example, the lightning ignited Turkey Creek

fire of 1954 (National Park Service records) originated within the pine-oak woodland community and spread up into the coniferous forest, burning over 1,700 ha (4,200 acres) before it was suppressed. Fires occurring within or spreading into the lower elevations encounter the desert grassland and pine-oak woodland communities where grass is the primary fuel. This may have limited fire spread due to the inability of grassy cover to hold a fire overnight.

METHODS

Modern fire records

Saguaro National Monument has maintained records of fire occurrence within the monument boundaries since 1937. These records include date, size, location, fuel type, and a narrative description of the larger fires. A 1978 study by J. Barrows analyzed fire occurrence for the U.S. Forest Service's Region 3 (Arizona and New Mexico) for the period 1960-1974. These two sources were used to examine fire occurrence during the modern period, both in its own right, and to provide insight into the data generated from fire scars.

Dendrochronology

Snags, stumps and downed logs exhibiting multiple fire scars were collected and the dates of scarring events determined using dendrochronological methods. The exclusive use of remnant material for this study was chosen as an alternative to the method usually employed in fire history studies of sampling living trees, either

by the removal of partial or complete cross sections (Arno and Sneck 1977).

The upper elevations of the Rincons, with either ponderosa pine or mixed conifer overstory, were surveyed. Potential collection areas were targeted which included a range of aspect and plant associations, and which would contribute to attaining geographic coverage for the area (Arno and Sneck 1977). Samples were collected in clusters where possible in order to maximize the information obtained for each collection point, since individual trees rarely record every fire which burns within their vicinity (Arno and Sneck 1977, Kilgore and Taylor 1979).

Criteria used to select specific samples were: 1) number of scars showing as evidenced by the number of healing ridges observed on the scarred stem and 2) state of preservation i.e. degree of decay present (Swetnam 1983b). Occasionally two or more cross sections were cut from the same stem when it appeared that all of the scars visible within the wound would not be represented on a single section (Dieterich and Swetnam 1984). Although some sampled snags had been dead only a few years, an effort was made to locate specimens which were of greater antiquity as evidenced by the amount of weathering and erosion of sap wood.

Many tree species respond to injury through a process of sealing off injured areas from healthy tissue by including pathogen resistant compounds in woody tissue around the site of the wound (Shigo and Marx 1977). Some coniferous species appear to concentrate resins at the injury site and it has been observed that the entire stem around the site of a wound, such as a fire scar,

may become impregnated with resin over time. This resinous portion is highly water repellant, resisting decay very effectively and may persist for long periods of time in an excellent state of preservation (Swetnam 1988). Fire scarred remnants exhibiting this phenomena were sought out as potential samples.

A chain saw was used to fell snags and section logs and stumps. Where possible, as an alternative to felling snags, wedge sections were removed from the face of the scar as described by Arno and Sneek (1977). Forty-six cross sections or wedges were collected in this manner. Also used were seven samples collected in 1983 by monument personal.

The samples were sectioned with a band saw and sanded with a series of progressively finer grit belts (up to 400 grit) to prepare the surface so that the cellular structure was clearly visible. This step is critical in order to accurately assess the year and season of scarring. The cross sections were examined with a binocular microscope, and a skeleton plot was constructed for each sample as described by Stokes and Smiley (1968). The sequence of fire scars was noted on the plot including the position of the scar within the ring, where it was possible to discern, in order to provide an estimate of the season of fire occurrence (Alstrand 1980, Barrett 1981, Dieterich and Swetnam 1984).

In conjunction with the collection of fire scarred samples an increment borer was used to extract cores from living trees at selected sites within the study area. These cores were mounted, surfaced, crossdated and a "skeleton-plot" chronology developed to aid in dating the remnant material for which the outside or 'bark'

date was unknown (Douglass 1941, Stokes and Smiley 1968). Ring-width skeleton plots from the fire scarred samples were then crossdated using the master chronology developed from the living trees. The dates arrived at for the samples were checked by another dendrochronologist at the University of Arizona Laboratory of Tree Ring Research to ensure accuracy.

RESULTS AND DISCUSSION

Modern Lightning Fire Data

Fires ignited by lightning are possible, in southern Arizona, from April through November with peak occurrence just before the height of the monsoon at the end of July. By August, while thunderstorm activity is often very high, soils and woody fuels at upper elevations are typically saturated with moisture and fire activity is very limited. When drier conditions return toward the end of September, few thunderstorms are occurring and typically fire activity remains low.

Almost 60 percent of the acreage burned by lightning fires within the National Forests of Arizona and New Mexico originate from June fires. By contrast, May accounts for 17.1 percent of the acreage, July for 18.1 percent and August for only 2.5 percent (Barrows 1978).

The Coronado National Forest, which abuts the Rincon Mountain unit on several sides, leads the Southwest in the average annual acreage burned by lightning fires. (annual average: 6,312 acres; 3,401 acres / million acres protected: Barrows 1978).

The peak zone of lightning fire occurrence by elevation in southern Arizona is 1,700m (5,500 ft.) to 2,100m (7,500 ft.) with

53.16 percent of the total occurrence. The Barrows' study concluded that lightning fire ignitions in southern Arizona were distributed randomly by aspect and were weighted heavily to the ponderosa pine habitat types (48 percent), followed by grass (26.5 percent), brush (13.8 percent), mixed conifer (5.8 percent) and woodland (5.8 percent).

Saguaro National Monument has on file fire occurrence data for the fifty-year period from 1937 to 1986. During this period 411 lightning fires were recorded for an annual average of eight ignitions. The range was from a low of one fire, recorded one year, to a maximum of twenty-one fires. Figure 4 depicts the relative timing of precipitation, fire occurrence and total acreage burned. The data is for lightning fires only (prescribed natural fires, or PNFs, which were allowed to burn after 1971 were not included in the data).

Eighty-two percent of the recorded lightning ignitions occurred above 2,000m (6,500 ft.) in elevation and were concentrated around the summit of Mica Mountain (Fig. 5). Relatively few fires occurred on Rincon Peak during this period, which is nearly the same height. Forest Service records show a similar pattern of scattered fire occurrence on the southern flank of this peak, which is part of the Coronado National Forest. Local ranchers in the 1930's explained the unequal distribution of fires by noting that the sharply defined, exposed rock summit of Rincon Peak seemed to draw the lightning to it. Since the forested area does not ascend to the summit, few fires were ignited there (McDougall, 1937). In contrast, Mica Mountain lacks a well defined

summit and is heavily forested, providing ample fuel and ignition points. Tanque Verde Ridge has had widely scattered fire occurrence with the exception of a slightly clustered pattern along its northwestern tip between 900m and 1,200m elevation (3,000 and 4,000 ft.) . (Fig. 5)

The distribution of fires by cover type (inferred from elevation; type designation from Bowers and McLaughlin 1987) shows 89.2 percent of the total fire occurrence is split between the pine-oak forest (48 percent) and the ponderosa pine/mixed conifer forest (41.2 percent). The remaining ten percent is scattered in the lower elevations with three percent occurring within the desert scrub (Fig. 6).

These local patterns of fire occurrence are generally similar to the regional picture presented in the Barrows report. The peak zone of occurrence is slightly higher in elevation and the pine-oak forest type is somewhat more important as a zone of ignition. As indicated by Barrows, the month of June also has the highest total of acreage burned.

A number of large fires have occurred in the Rincons after 1912 in spite of the prevention and control efforts instituted at that time. A 600 acre fire occurred in 1927 when the mountains were still part of the Coronado National Forest. The first large fire to occur under National Park Service administration was the Manning Camp fire of June 6, 1943 which burned over 2,000 hectares (5,000 acres). The cause of this fire was never positively determined but is generally attributed to lightning in the fire records. Table 1 is a list of fires over 4 ha. (10 acres) in size

which have occurred since 1937, excluding PNFs. Figure 7 shows the location and extent of these fires.

In 1971 a natural lightning fire program was initiated at Saguaro National Monument and since 1972 many lightning fires have been allowed to burn under certain prescribed conditions. Several of these fires attained some size in spite of the relatively conservative prescription of this program. The largest of these, ignited on July 28, 1972, spread over 250 ha. (620 acres) before it was extinguished by wet weather in August, four weeks later.

Fire Scar Data

The trees sampled included 25 ponderosa pine, 20 southwestern white pine, and one silverleaf oak. Also used were samples from seven trees collected in 1983 by Monument personnel. Of this total of fifty-three, it has been possible to accurately date samples from 48. These sections preserved over 900 individual fire scars representing 593 scarring events. By cross dating the samples and subsequently assigning dates to the fire scars, a composite fire chronology was developed. This chronology spans almost 500 years beginning in 1495 with a record on Rincon peak, and ending in 1954 with a record of the modern Turkey creek fire. The 593 scarring events translate into 119 separate fire years listed in Table 2.

It should be emphasized that without the use of the crossdating procedures, it would have been impossible to develop an accurate fire chronology for this site. Increment cores from unscarred ponderosa pine and southwestern white pine used to develop the local chronology commonly lacked 10 to 15 annual growth

rings between 1940 and 1986 and were essentially undatable for this period. Other specimens showed stem growth for all years during this interval. Growth anomalies associated with fire scarring exacerbate this problem in scarred specimens. This phenomena is poorly understood at this time as it does not seem to be due only to senescence in the older trees, as some very old trees do not show it and some relatively young trees do exhibit it (Graybill and Rose 1989). Other problems included injury induced growth suppressions and identification of false rings. Due to these difficulties, use of ring counting methods on specimens collected exclusively from living trees would rarely have yielded accurate dates, and a record of fire occurrence so derived would be indecipherable because of the variability encountered. The use of dead material, upon which this study relied would have been impossible.

Problems in dating fire events were sometimes encountered in the early portion of the chronology (1500 to 1650) because of physical erosion and weathering of the scars which resulted in a plus or minus estimate instead of an exact date being assigned.

One of the lower elevation groups (CH - Cow Head) and the sample collected from Tanque Verde Peak comprise four of the five samples that were not dated. Neither these samples nor increment cores collected from living trees at these collection sites were successfully crossdated. Intra-annular bands of latewood cells (false rings) which are nearly indistinguishable from annual ring boundaries were very common in these specimens. These "false-rings" confuse the ring series making cross dating unreliable. The

longer growing season and more pronounced early summer drought present at lower elevations and on exposed slopes below 2,300m (7,500 ft.) may be responsible for this phenomenon as drought stress has been linked to the formation of latewood bands during the growing season (Fritts 1976).

The master fire chronology developed from the scar data is presented in Figure 7. This figure is a representation of areal extent and fire interval shown concurrently. The groups are arranged, to the degree possible, according to their proximity in space.

An examination of this figure reveals a pattern of wide-spread fires occurring at intervals of one to thirteen years. Smaller, or patchy fires occurred during some of these intervals, however the larger fires appear very clearly to dominate this fire regime. Several fire-free intervals of ten or more years duration accentuate this pattern. Before 1650 the sample depth is too limited at most collection sites to identify any patterns with clarity. By 1657, however, enough samples were recording fires to establish fire intervals with some confidence. For the purposes of this study a major fire will be defined as a fire recorded by more than one group of trees, with an estimated minimum size of 200 ha. (500 acres) based on the average distance between collection sites. Smaller fires with limited impact in the study area will not be considered in determining the mean fire interval (MFI) for the study area as a whole. Fire return intervals (FRI) for a point or group of trees will include all fires recorded by that group (Romme 1980).

The MFI for the Mica study area over the 234 year period 1657 - 1893 was 6.1 years. During this period 41 major fires occurred and fire intervals ranged from two to thirteen years. Fire intervals at specific sites ranged up to nineteen years. The 32 year interval in the record of the Mica tower (MT) group is probably due to the limited sample at that site. The fire of 1822 was recorded at every other site within the study area and it is highly unlikely that the centrally located summit escaped its effects. This mean interval is well within the range reported for the ponderosa pine forest type in the southwest (Swetnam 1988).

The Helens Dome (HD), Manning Camp (MC1, MC2), and Mica Meadow (MM) collection sites typify the open pine forest which occupies most of the study area. The roughly seven year FRI recorded at all three is probably typical of the return interval in this forest type throughout the study area (see Fig. 8).

The mixed-conifer site, with a MFI of 9.9 years, shows a greater variability in fire intervals with more decade or longer fire-free periods than the other sites. It is also probably the most productive site on the mountain, due to the more mesic environment. Frequent and regular fire occurrence tends to enhance the stability of forest stands by reducing fuel loading in smaller increments, and thinning them on a regular basis. The combination of increased fuel production and frequent decade or longer fire intervals would have tended to produce hotter fires with some mortality of mature trees. Thus, this site may have had a more dynamic vegetation mosaic than the more xeric open pine sites. However, no evidence was noted in the stand structure within this

type of the occurrence a large-scale crown fire. All the areas sampled, including the open pine sites, had occasional fire-free intervals of ten to thirteen years, with some recording a nineteen year interval between 1822 and 1841.

Although small fires did occur, over 50% of the 27 major fires between 1729 and 1886 appear to have burned over the whole study area on Mica Mountain. Some of these fires may have exceeded 3,200 ha.(8,000 acres) in size, based on the location of the sample points. The two largest modern fires, both of which occurred during June, spread rapidly over several thousand hectares in spite of active suppression efforts. Thus ignitions during the fore-summer drought would be expected to spread readily. The last of these widespread fires occurred in 1886. Smaller fires continued to occur, but the overall pattern ceases abruptly at this point.

Seasonal Occurrence Of Fires

Individual fire scars were examined in an attempt to determine the season of occurrence of the pre-suppression fires (Barrett 1981). This procedure has some limitations including: 1) it involves the judgment of the observer, 2) ring widths at the site of the injury are often so small that the exact position of the scar within the ring is impossible to determine, and 3) the initiation and cessation of cambial growth is assumed to vary from year to year, micro-site to micro-site and species to species. However, with these limitations in mind, the potential value of the information is considerable. Additional insight can be gained by examining scars resulting from fires of known calendar date.

H.C. Fritts studied stem growth in ponderosa pine growing in the Santa Catalina Mountains of southern Arizona over the five year period 1963-1967 (Fritts 1976). The trees studied were growing at an elevation of 2,600m (8,500 ft.) on an arid site. As this site is located only a few air miles from the Rincon Mountains, and is roughly similar in elevation, the findings of the 1960's study were deemed applicable to the Rincon Mountains.

Fritts found that cambial activity was initiated in late April, increased steadily through May and June, was most rapid during July and early August, and had generally ceased by mid-September. This indicates that a May fire of scarring intensity would show as having occurred during the period of earlywood formation. A scar occurring between the latewood of one years growth and the earlywood formed the subsequent year, or dormant season scar, would indicate a fire having occurred between mid-September and late April. However, during 1967, Fritts observed that mature xylem cells were not formed until June, so that under some conditions a fire resulting in what might appear to be a dormant season scar could occur during the month of May. A scar occurring within the band of latewood cells would indicate a fire which occurred in August or early September. Since southern Arizona's lightning season begins in late April or early May and there is little lightning activity in the fall, dormant season scars are dated by convention to the spring of the coming year unless there is some contraindication, such as a latewood scar on one tree associated with dormant season scars on others (Swetnam 1983a).

When both sides of a sampled fire scarred stem recorded a fire date, a seasonal determination was made by examining both scars. Of the scars examined from the Mica Mountain fire chronology, a seasonal designation was not determined for 35%. This was due to erosion or weathering of the scar, small size of annual rings, or growth distortion in the area of the scar. Of the remaining scars, 87.5% were identified as earlywood scars, 12% as dormant season scars, and 0.5% as latewood scars. These percentages confirm a late spring and early to mid-summer fire season for the study area over the complete length of record available. This conclusion is also consistent with the modern fire occurrence data (see Fig.3).

In addition to a determination of dormant, early, or late occurrence, where possible a further sub-classification was made for earlywood scars. A total of six categories were established: D dormant season (appearing between rings); EE early-earlywood (1st 1/3 of earlywood); E generic earlywood, no further distinction possible; ME mid-earlywood (second 1/3); LE late earlywood (third 1/3); L latewood; (see Fig.13).

D will be interpreted as late April or early May occurrence, EE as May or early June occurrence, E will be considered neutral in weight, the other categories for that scar-year defining the season, ME as June or early July occurrence, LE as late June or July occurrence, and L as August or early September occurrence. A D scar occurring in conjunction with L scars on the previous year could represent fire occurrence in October or November, however this combination was not found in this study. Fire scars from the large modern fires occurring on June 6, 1943 and June 20, 1954 were

examined for position as a check on these conclusions. Only one sample tree clearly recorded both of these fires. It showed $1/3$ of the ring formed by June 6th and $1/2$ formed by June 20th. These scars would have been noted as EE and ME respectively.

These data were compiled, sorted by fire date, and a series of histograms constructed for 30 major fires between 1689 and 1893. These are presented in Figures 9a and 9b. In spite of expected differences in cambial phenology between individual trees as well as differences between species growing under a variety of micro-site conditions, certain patterns are evident in the data. The fires of 1703, 1748, 1773, 1780, 1806, 1822, and 1835 all appear to have occurred quite early in the growing season, perhaps during the month of May. The fires of 1707, 1711, 1759, 1851, and 1873 appear to have occurred well into the growing season, probably during late June or July.

Prescribed natural fires in wilderness areas of the southwest often continue to burn for a month or longer, with periods of inactivity punctuated by brief intervals of relatively rapid spread under favorable conditions. The range of values for the fires of 1738, 1763, 1768, and 1841 may represent this type of behavior. Another possibility is that the spread of values in some cases is the result of separate fires occurring at different times during the same year.

Two of the major fires occurring before 1900 are mentioned in historical accounts. In 1879 the Arizona Weekly Star published the following notes; "Fires have been raging in the mountains east and south of here [Tucson] for some time past..." May 22, 1879. "The

southeastern slope of the Santa Catarina [Catalina] and the west slope of the Rincone [Rincon] mountains have been ablaze for the last four days..." June 19, 1879 (cf. Bahre 1985). The seasonal histogram for the fire of 1879 shows a concentration of EE and D scars, three E scars and one LE scar. It is possible that the EE and D scars were created by an early season fire (the Rincons are directly east and within easy view of Tucson) referred to in the May 22 account, and that the LE scar is related to a second fire of June 15-19. Lt. J. Bigelow refers to a fire burning in the Rincons on June 4th, 1886 (Bigelow 1968). The histogram for this fire year shows a spread from D to ME which is not inconsistent with this date.

SUMMARY

Using only remnant material, such as logs, snags and stumps, combined with increment cores from living trees a 300-year record of fire history was developed for a 1,600 ha. (4,000 acre) study area. Sufficient material was located to provide spatial coverage and dendrochronological techniques were used for dating the majority of samples. This process effectively utilized a perishable resource to provide baseline data for land management in a wilderness area.

The fire occurrence records for the Rincon Mountains substantiate that lightning is a very effective ignition source. Over the last fifty years, lightning has ignited an average of eight fires each year. At least one lightning fire occurred every year for which records were available and during some years,

fifteen to twenty fires were ignited. Modern fires ignited in June have an excellent potential for spread and have attained considerable size in several cases. The largest fires were limited in size only by suppression efforts, no natural fire barriers having been reached.

The pre-1900 fire history, reconstructed from fire scars, revealed a fire cycle dominated by an episodic pattern of widespread fires. Smaller fires also occurred. However the fire regime appears to have been dominated by these larger fires. The MFI (mean fire interval) calculated for major fires (fires recorded by more than one group of sample trees; est. min. size: 500 acres) between 1657 and 1893 was 6.1 years. The shortest interval recorded between major fires was 2 years and the longest was 13. An interval of at least 3 years appeared to be necessary to generate enough fuel to carry a fire throughout the study area. Intervals between such fires were more commonly in the range of 4-7 years. Of the 27 major fires which occurred between 1729 and 1900, 14 appear to have burned over the entire study area on Mica Mountain.

The MFI recorded in the mixed conifer timber of the north slope was 9.9 years with a range of 3-19 years. The average fire return interval for the open pine forest, which dominates most of the study area, was 7 years with a range of 2-19 years.

The majority of the fire scars examined were positioned within the earlywood portion of the annual ring. Only 0.5% were identified as latewood scars. This evidence strongly indicates a late spring/early to mid-summer fire season, throughout the 300

year record. Comparisons of scar position from fires of known date generally confirmed the seasonal estimates.

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TABLE 2

FIRE SCAR DATES

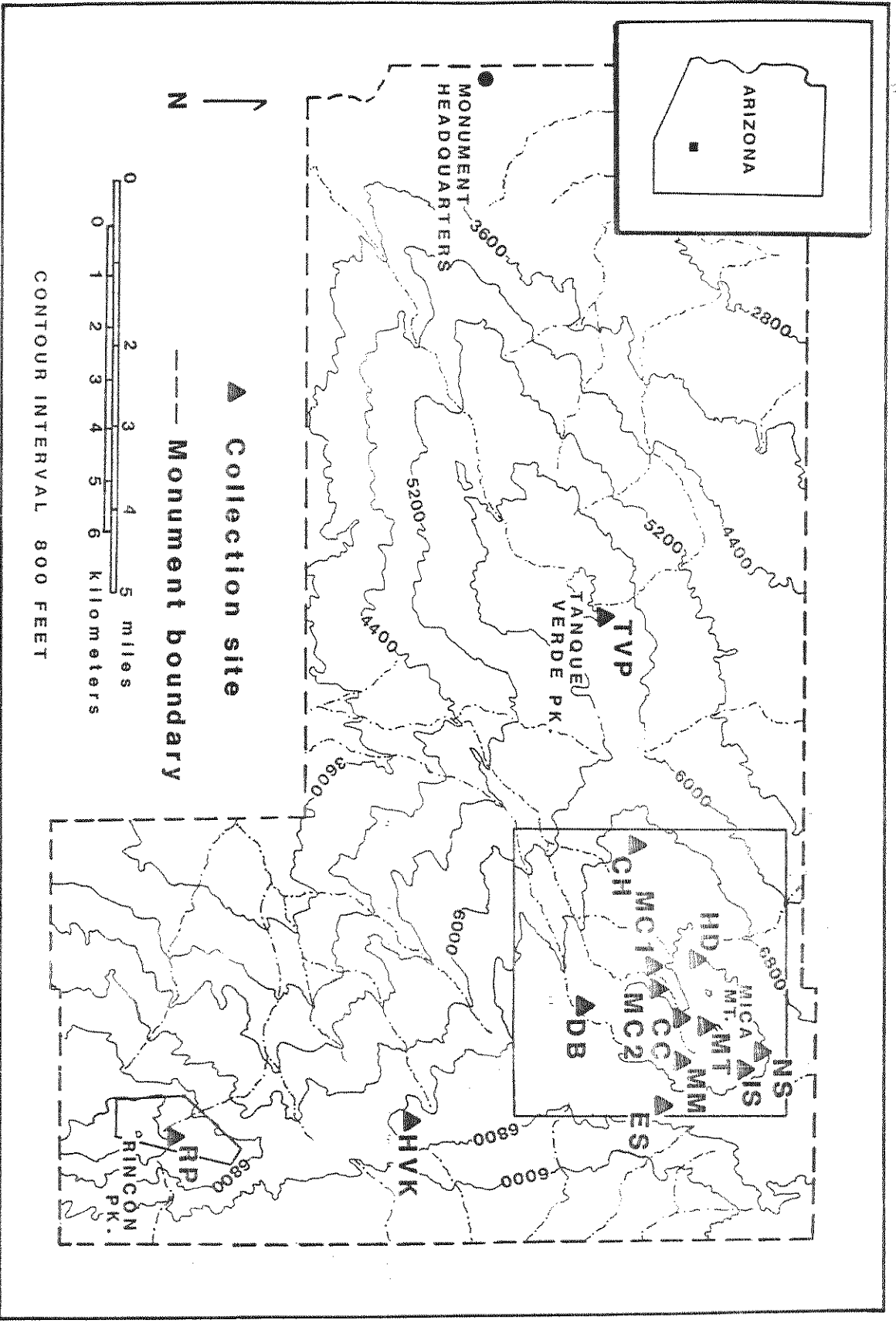
MICA MOUNTAIN

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RINCON PEAK

1495, (1516), 1534, 1542, 1550, 1556, 1563, 1574, (1586), 1590, 1593, (1595), 1605, 1622, (1634), 1648, 1659, 1668, (1687), (1695), 1715, (1722), 1748, 1763, 1766, 1819, 1867, 1879, 1893

* Dates in parentheses are approximate ($\pm$ 1-3 years)



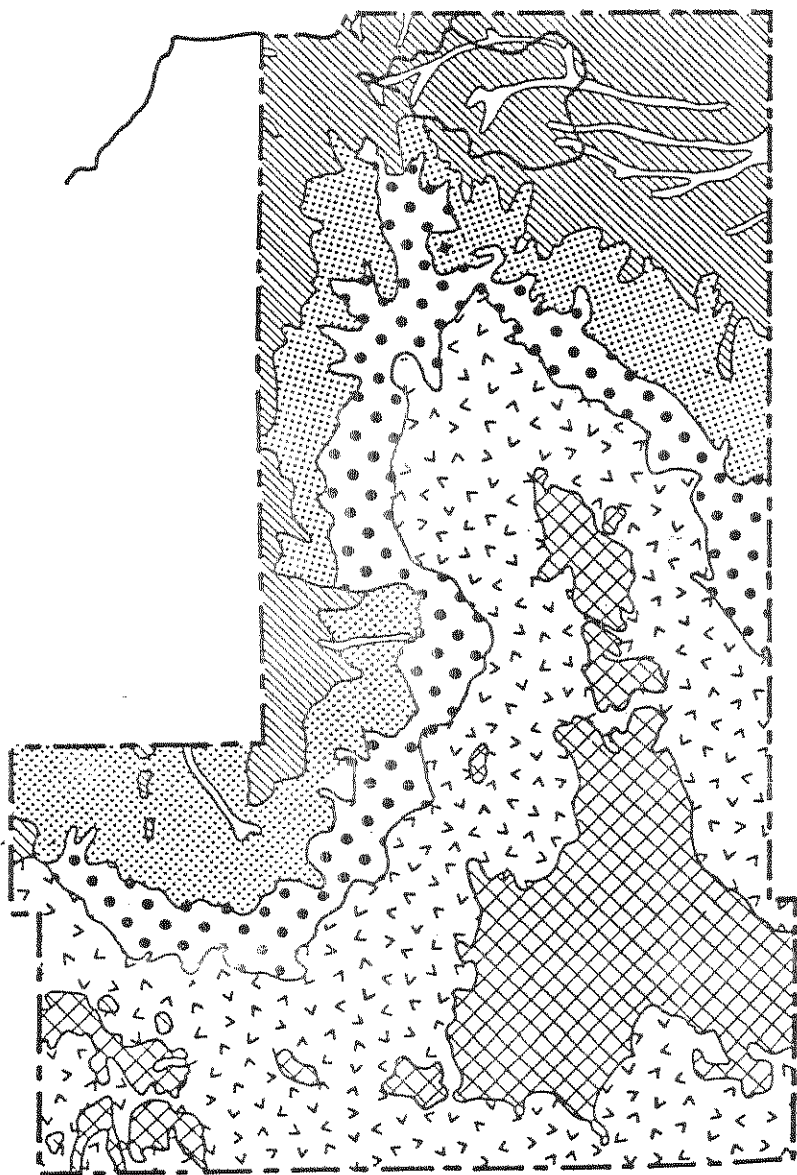
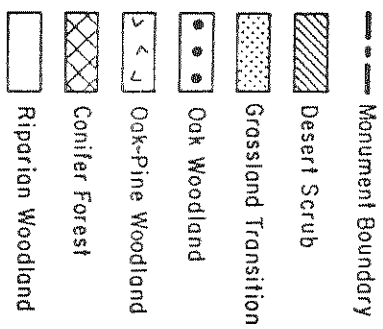
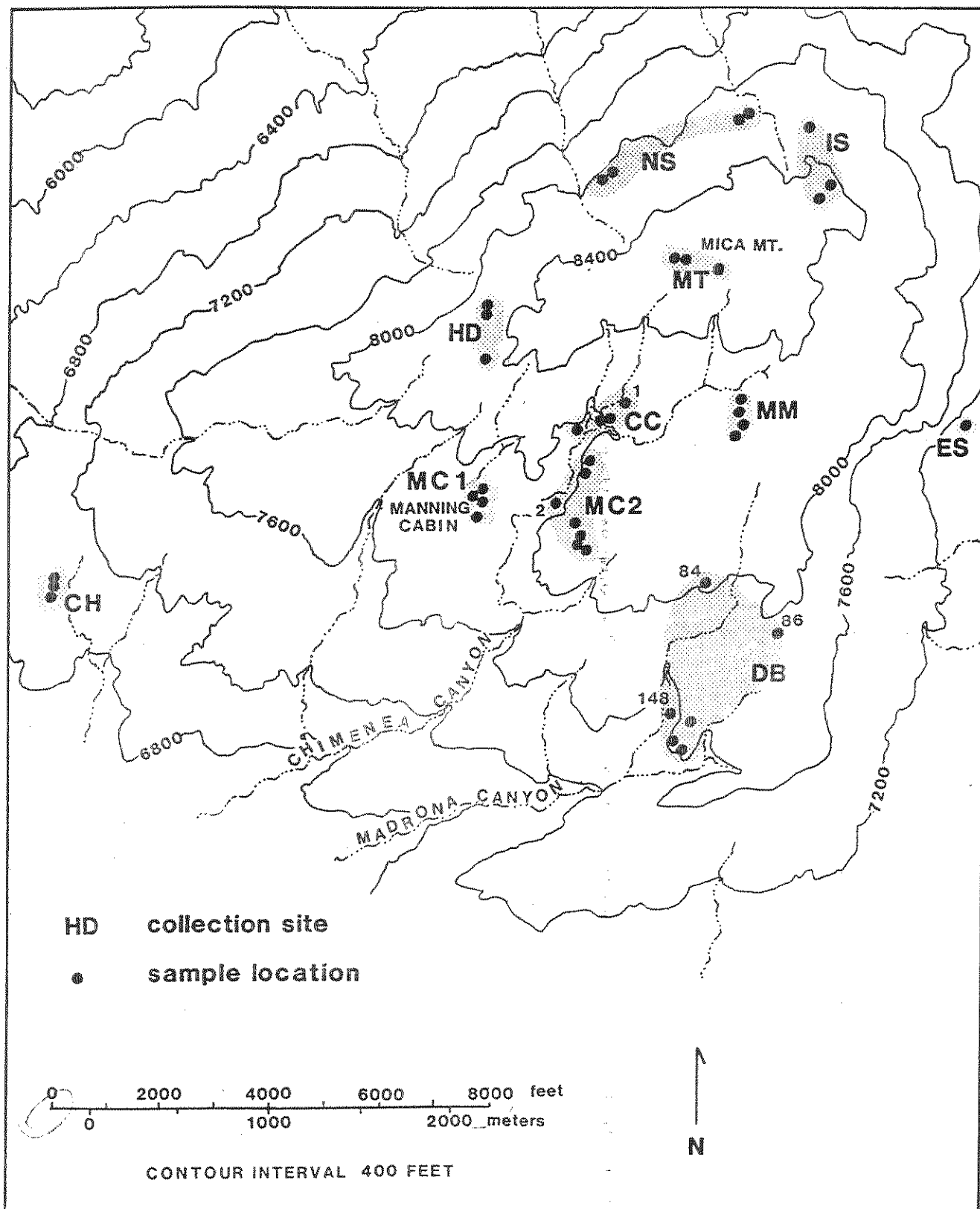
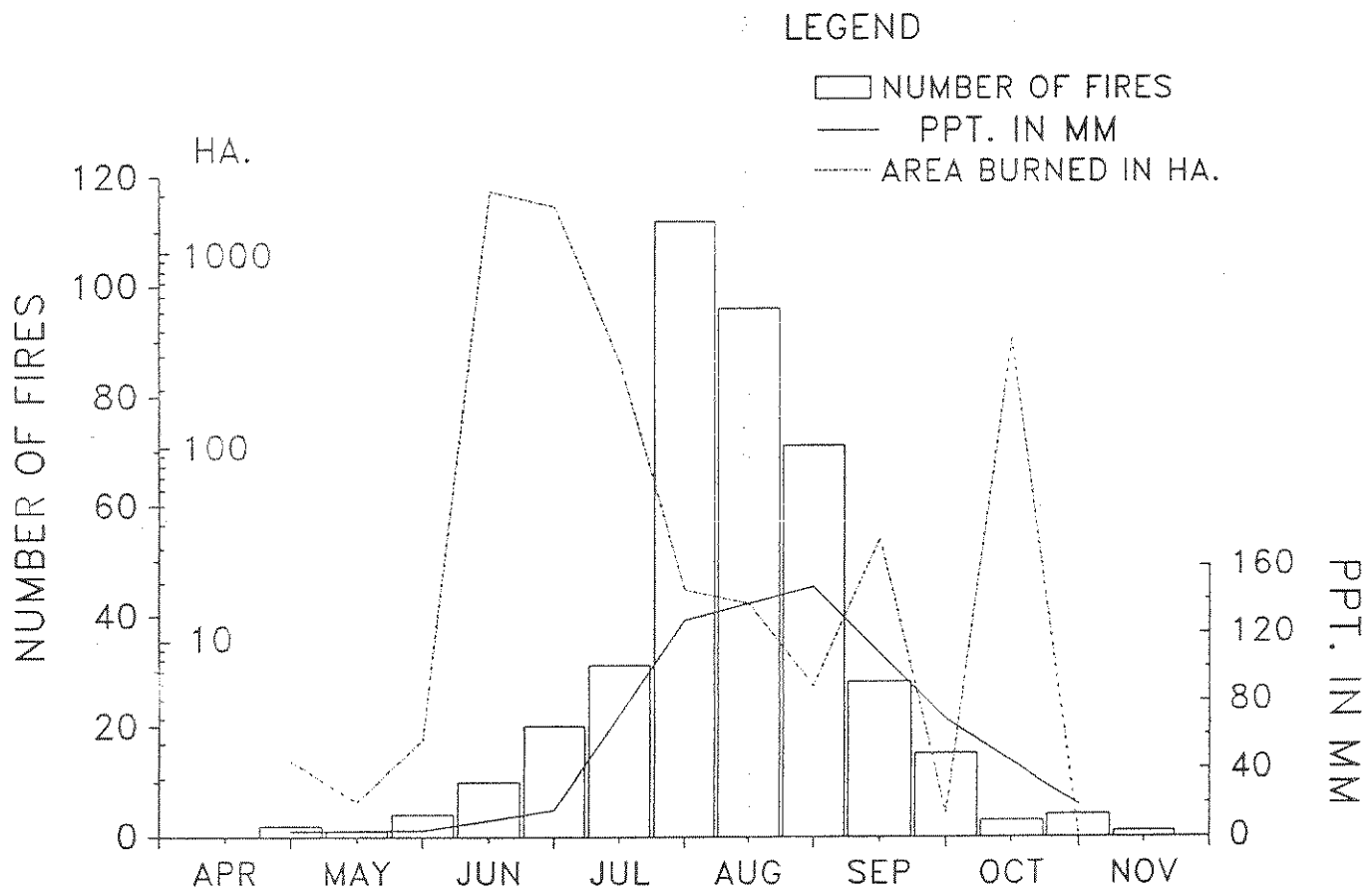
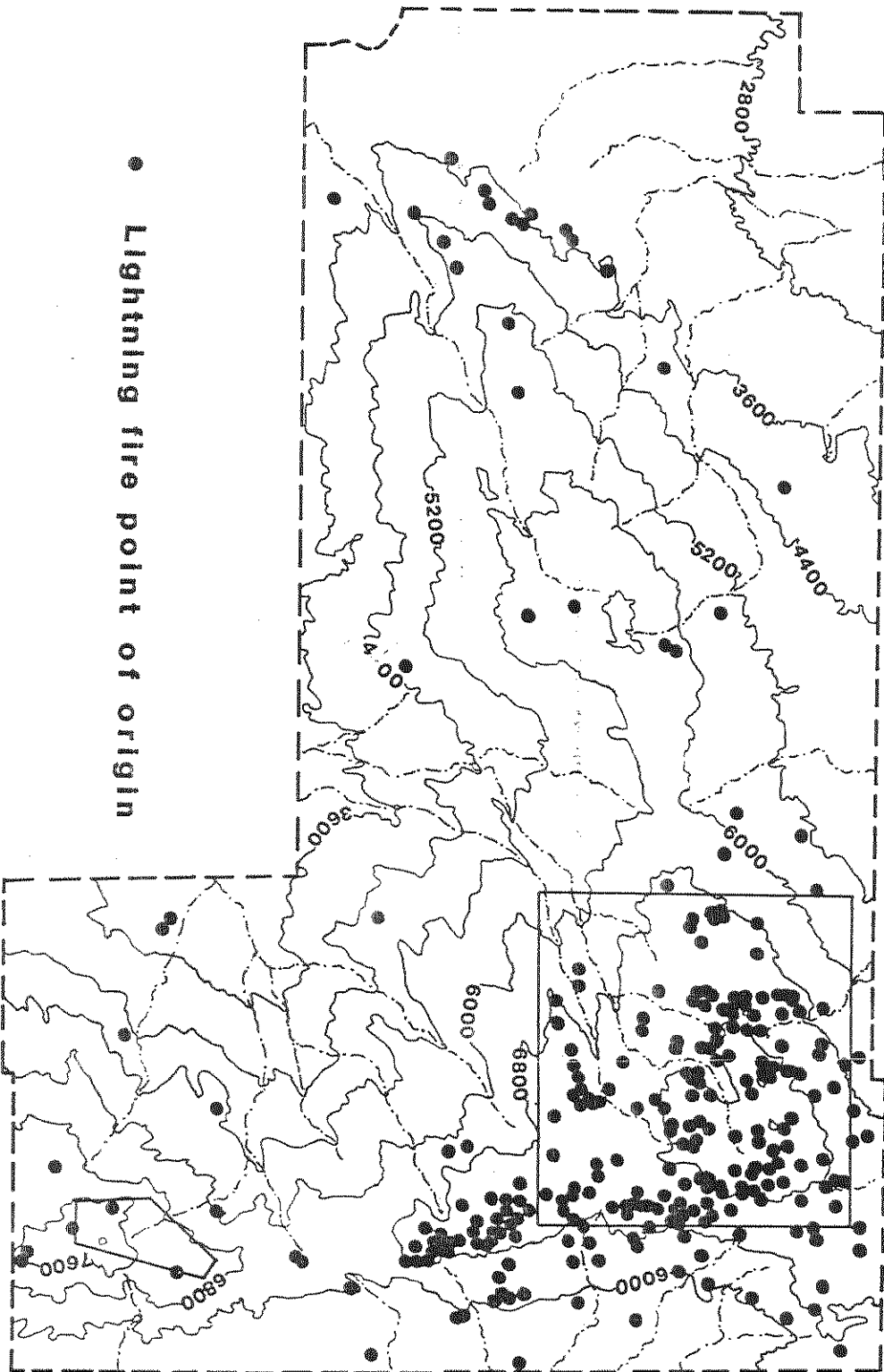


Figure 3. Vegetation map of Saguaro National Monument, Rincon Mountain Unit.





• Lightning fire point of origin



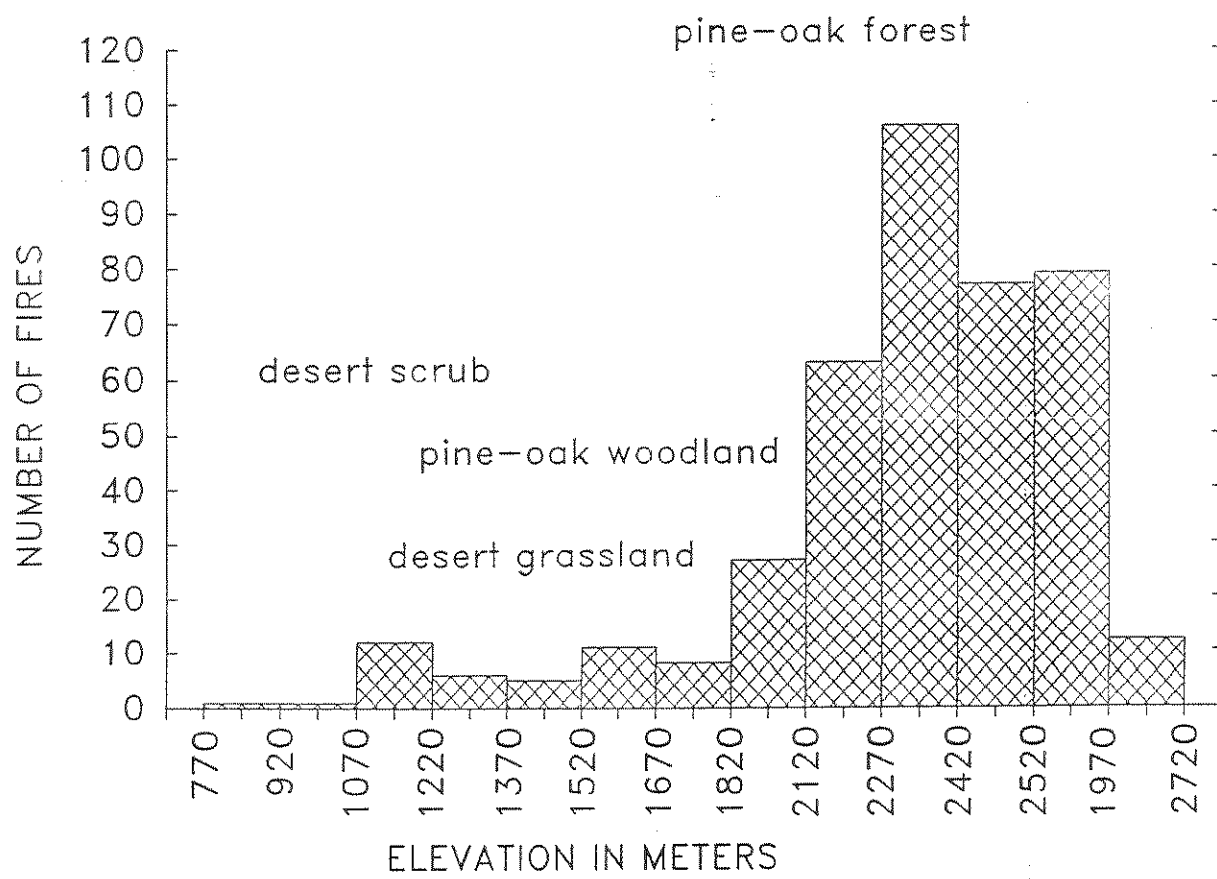
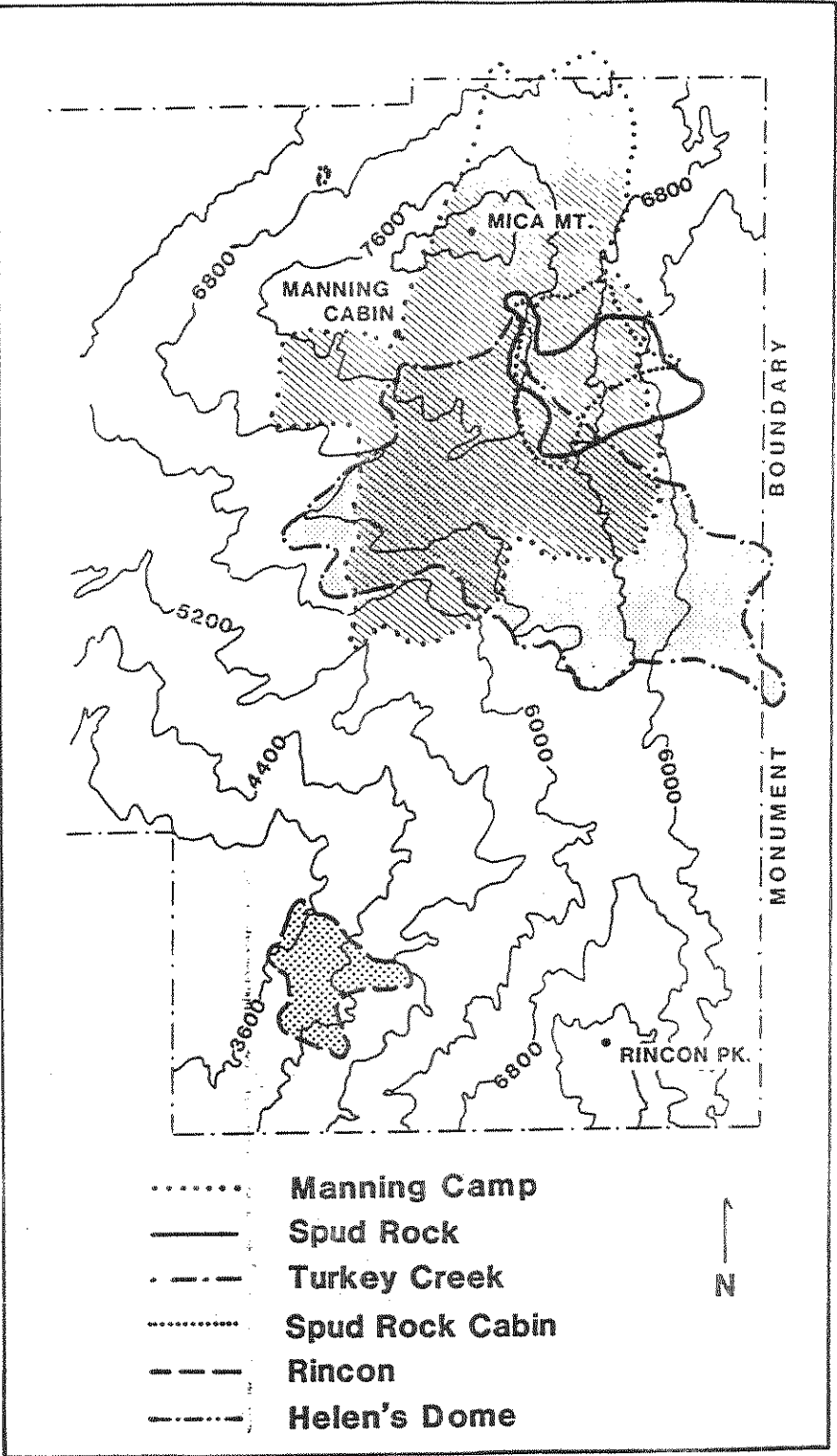
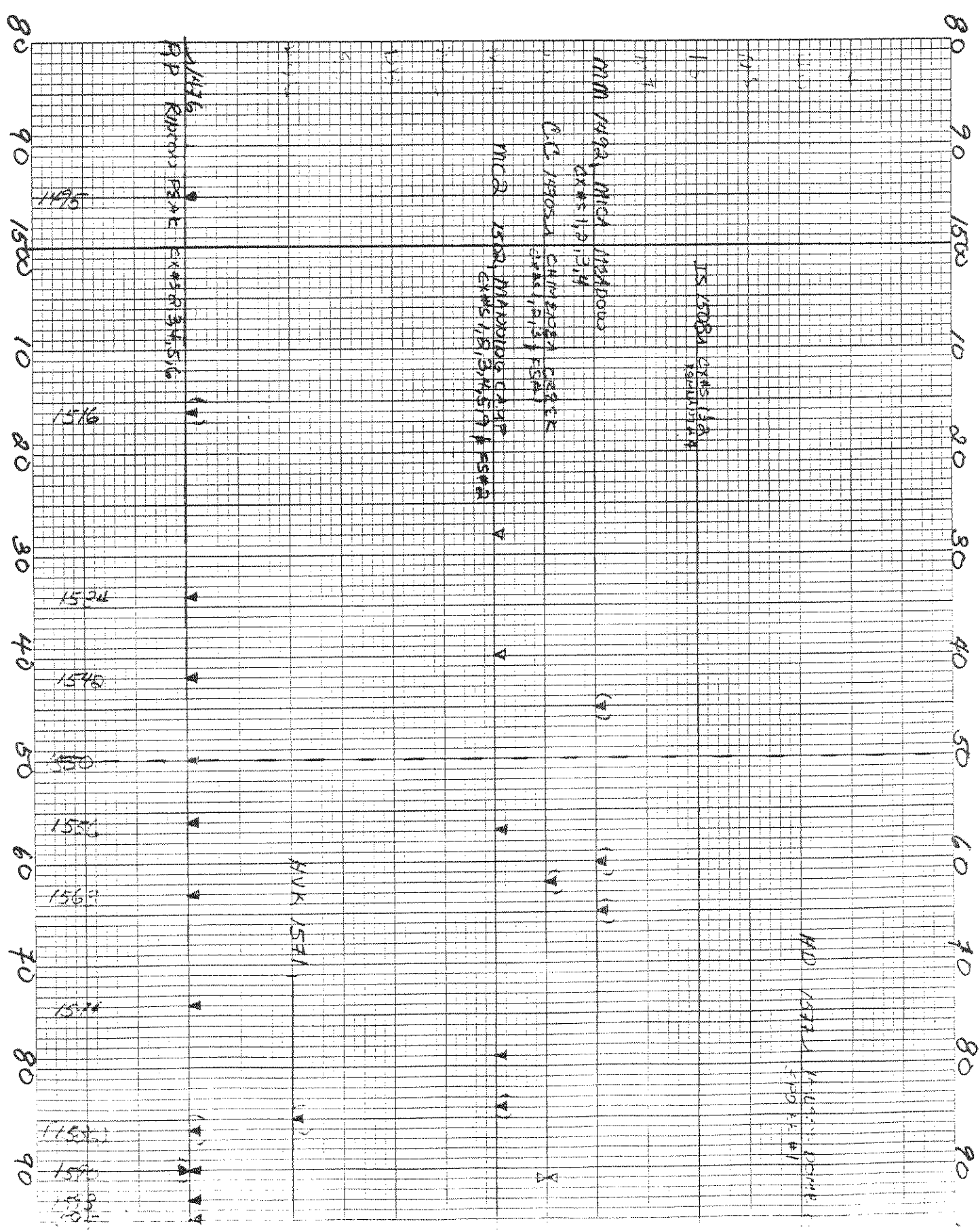


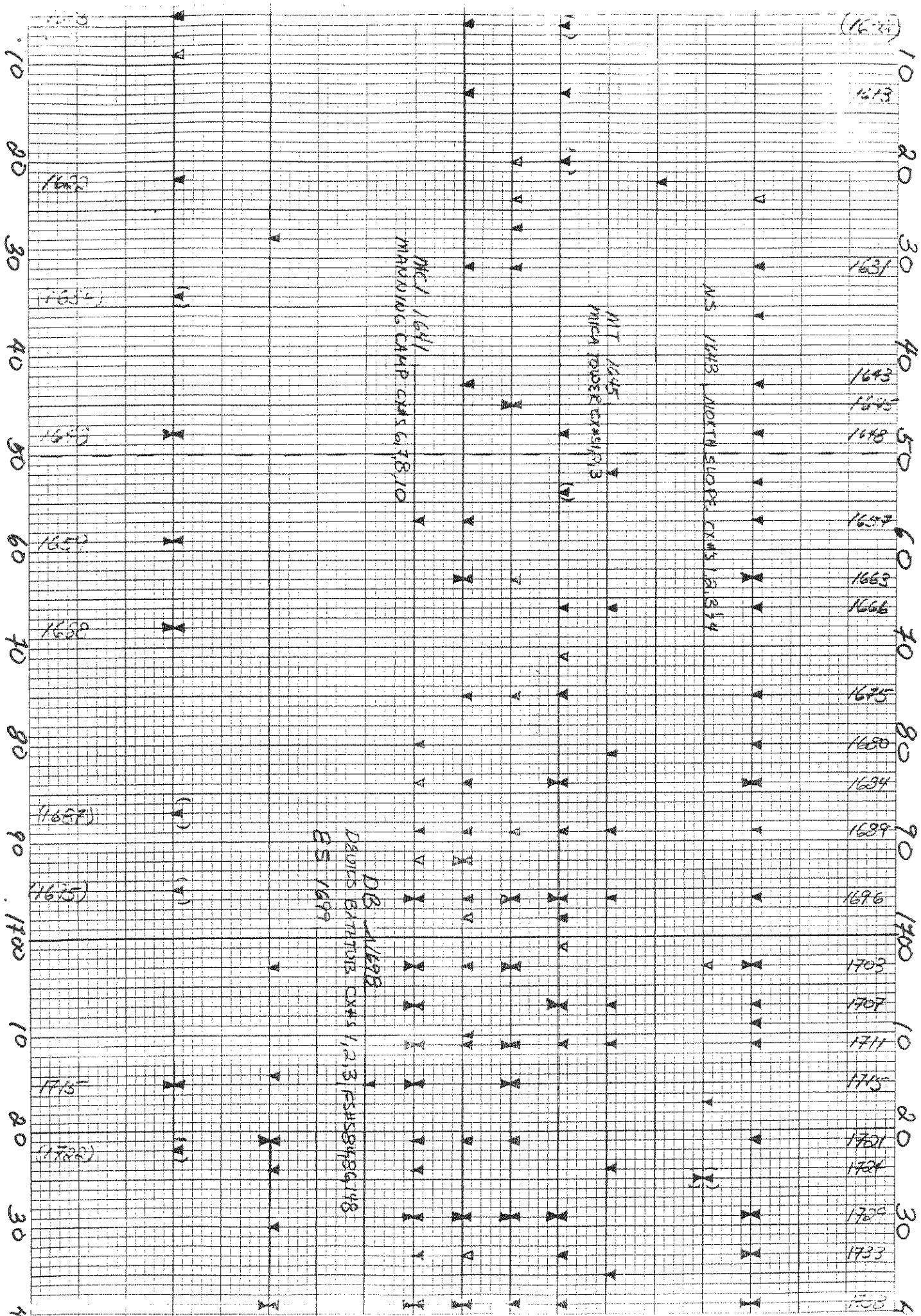
Figure 7.

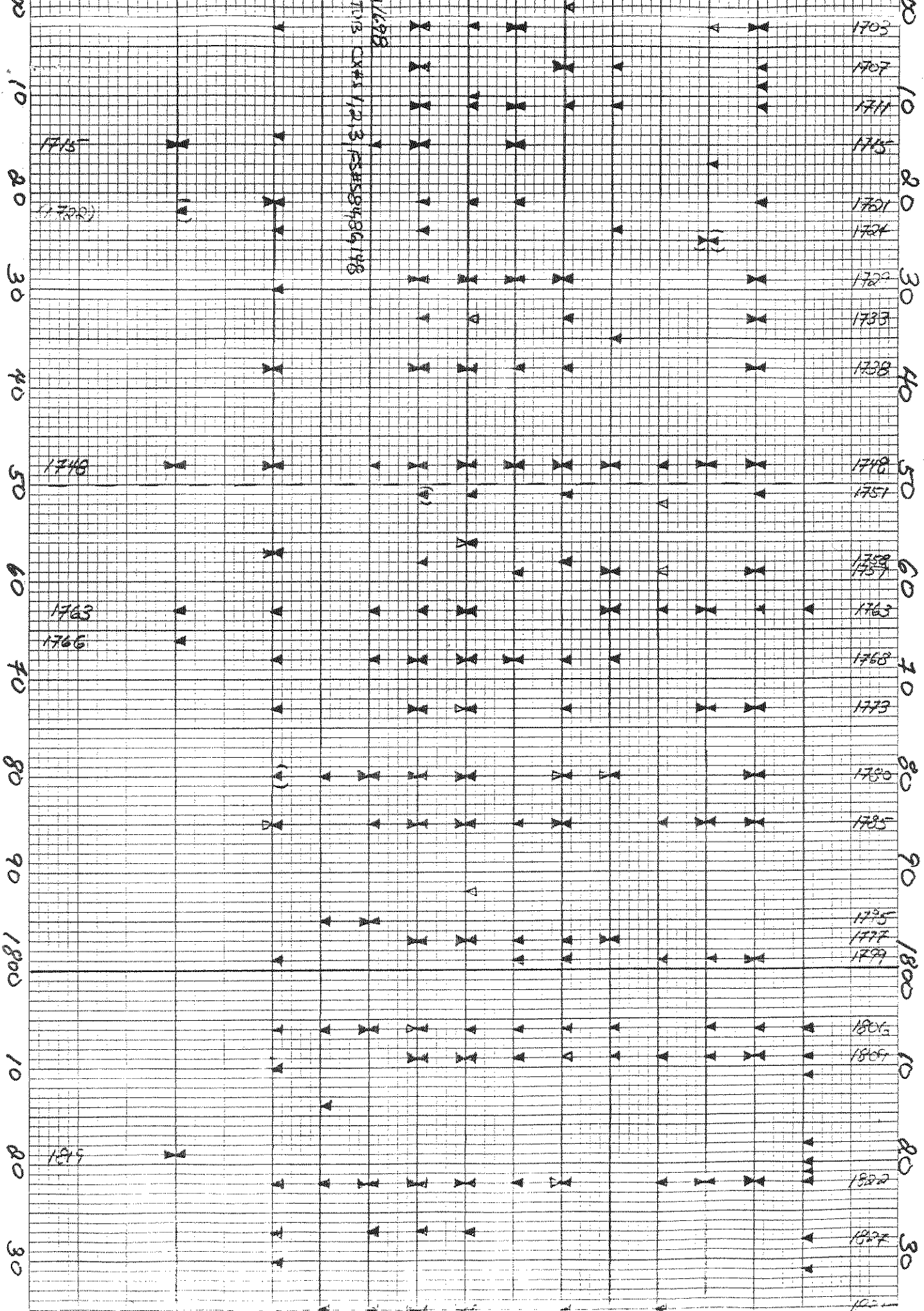
TABLE 2

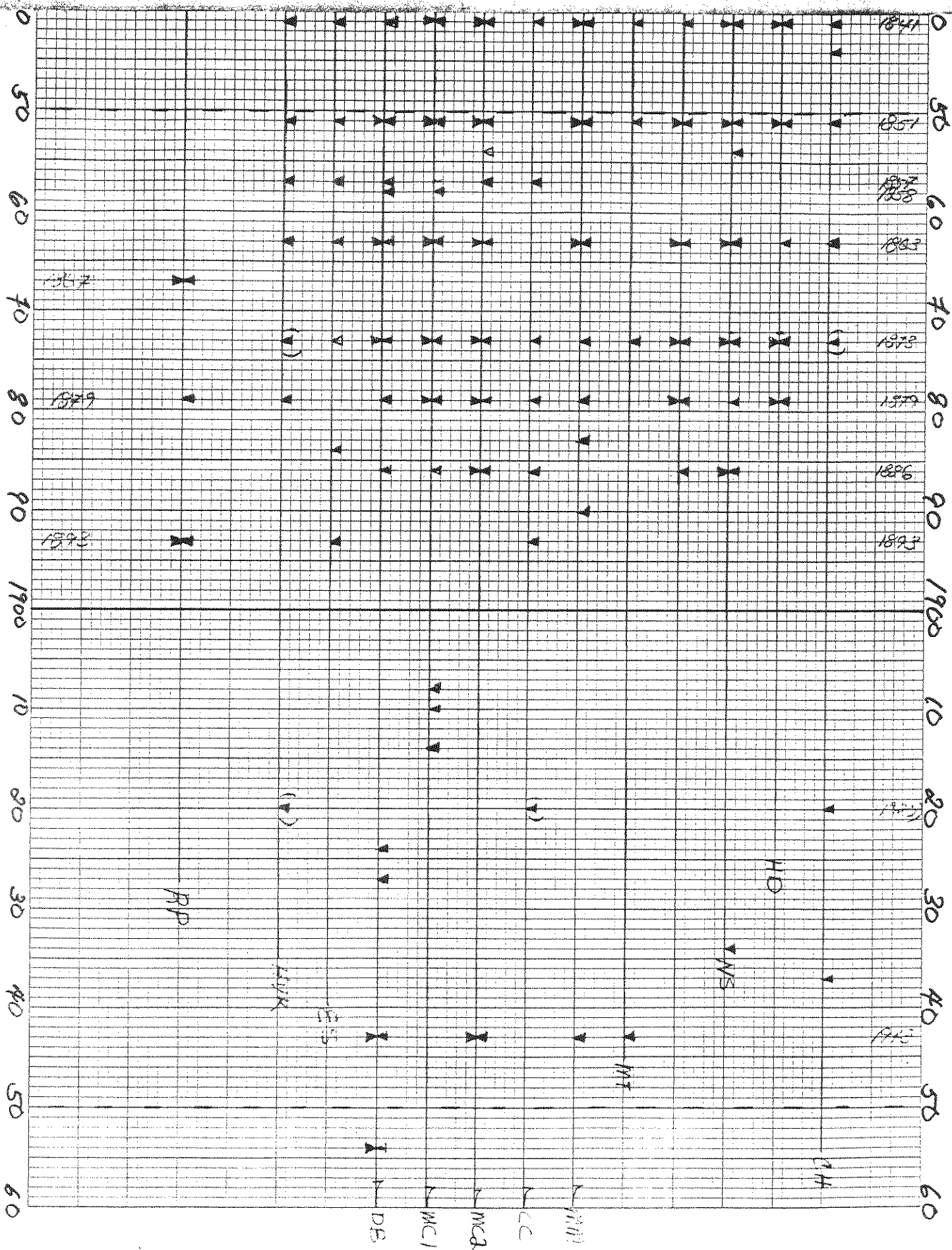
FIRE NAME	DATE	ACREAGE	CAUSE
Manning Camp	June 6, 1943	5,065	(lightning)
Spud Rock	July 1, 1950	550	lightning
Turkey Creek	June 20, 1954	4,270	lightning
Spud Rock Cabin	October 1, 1956	900	lightning
Rincon	June 5, 1960	100	lightning
Helens Dome	June 21, 1966	21	lightning

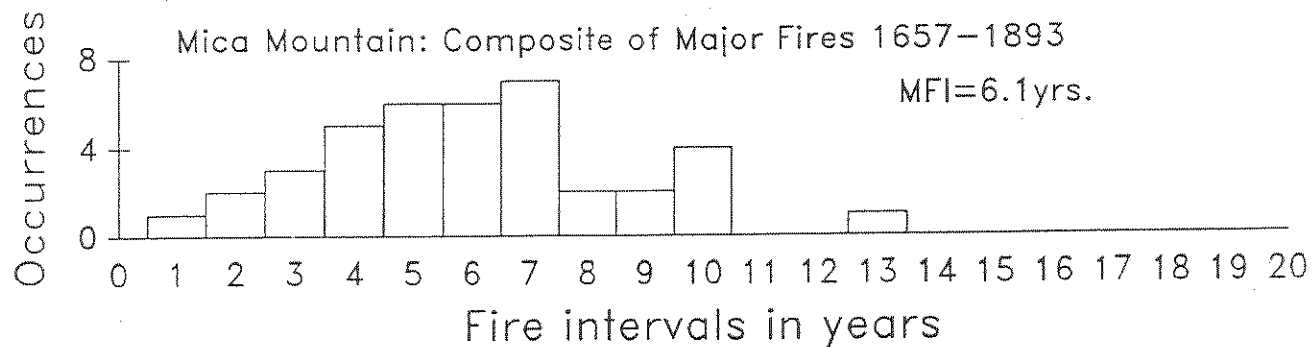
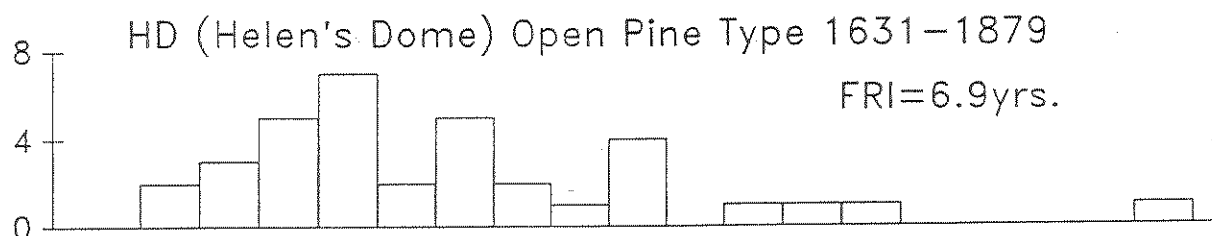
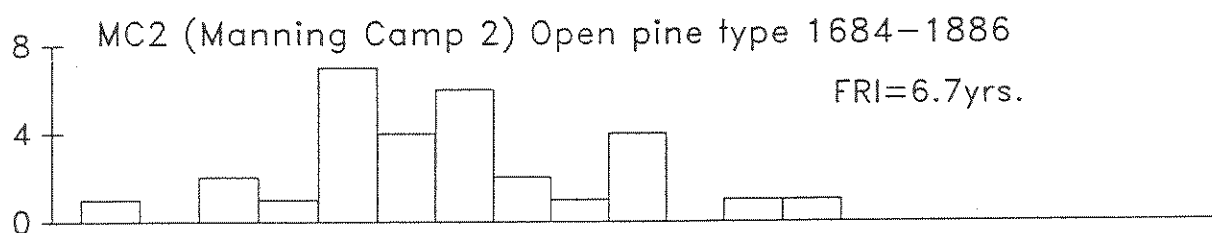
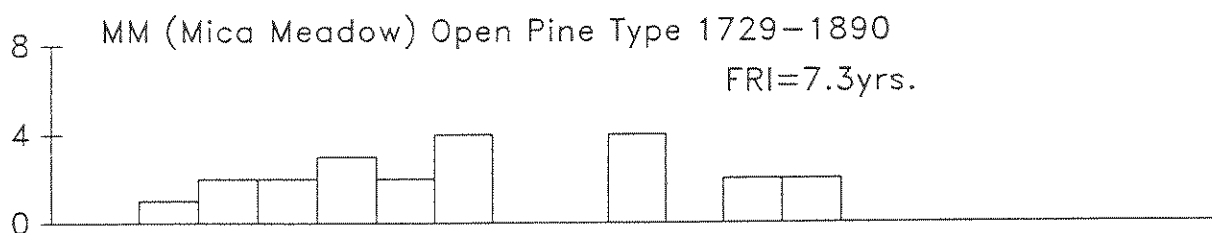
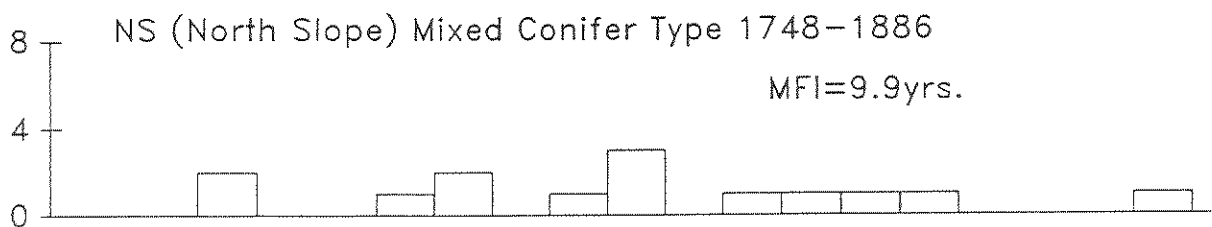












**Mica Mtn. Study Area
Seasonal Pattern of Scarring**

50

10-

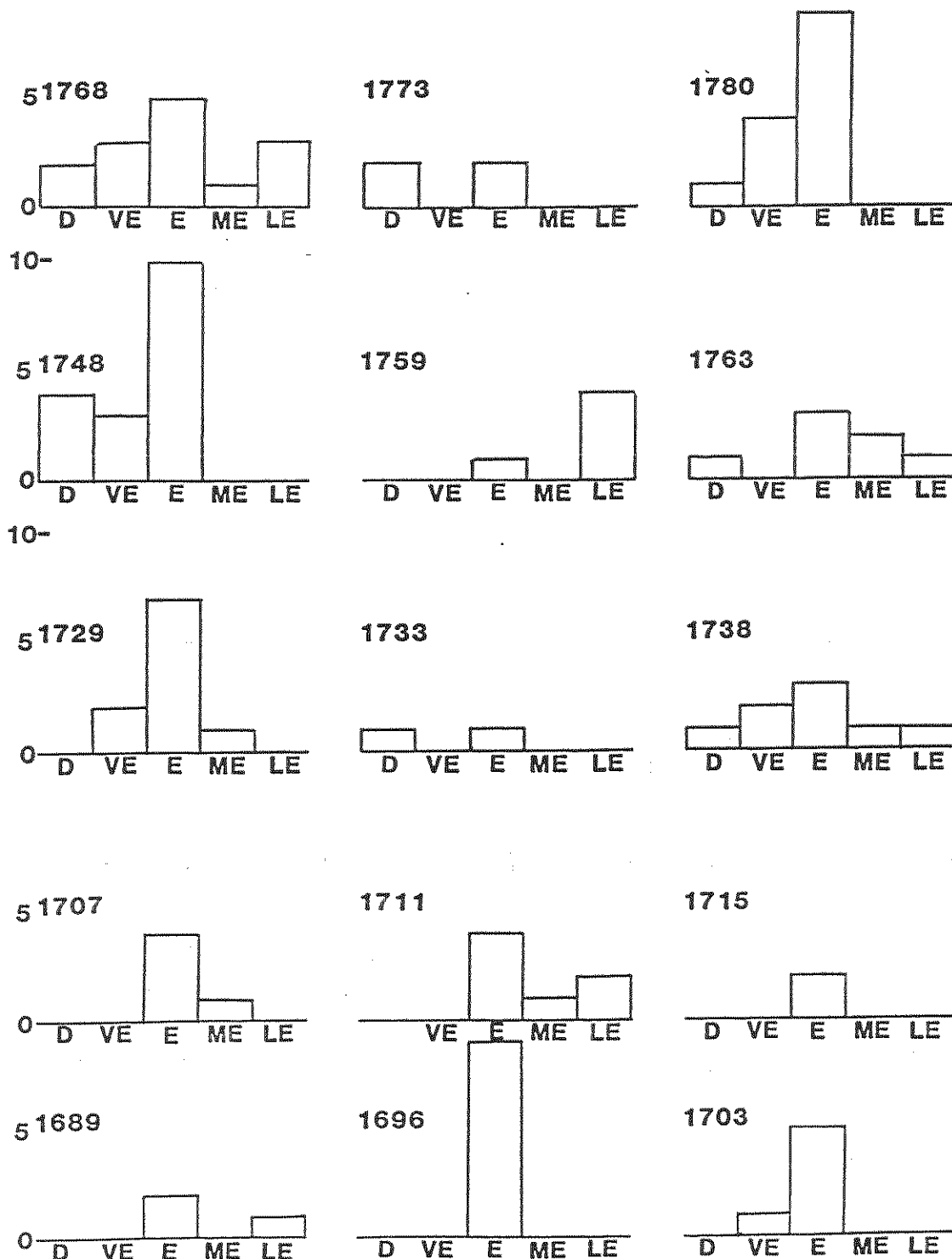


Figure 12.a Patterns of Seasonal Scarring by Fire Years
Catagories established for scar position within the annual ring
 1) D - dormant season 2) VE - very early; within the first 10% of the earlywood formed 3) E - earlywood; no further distinction possible
 4) ME - mid earlywood 5) LE - late in the earlywood; within the last 10% formed 6) L - latewood scar 7) UID - seasonality not determined

**Mica Mtn. Study Area
Seasonal Pattern of Scarring**

51

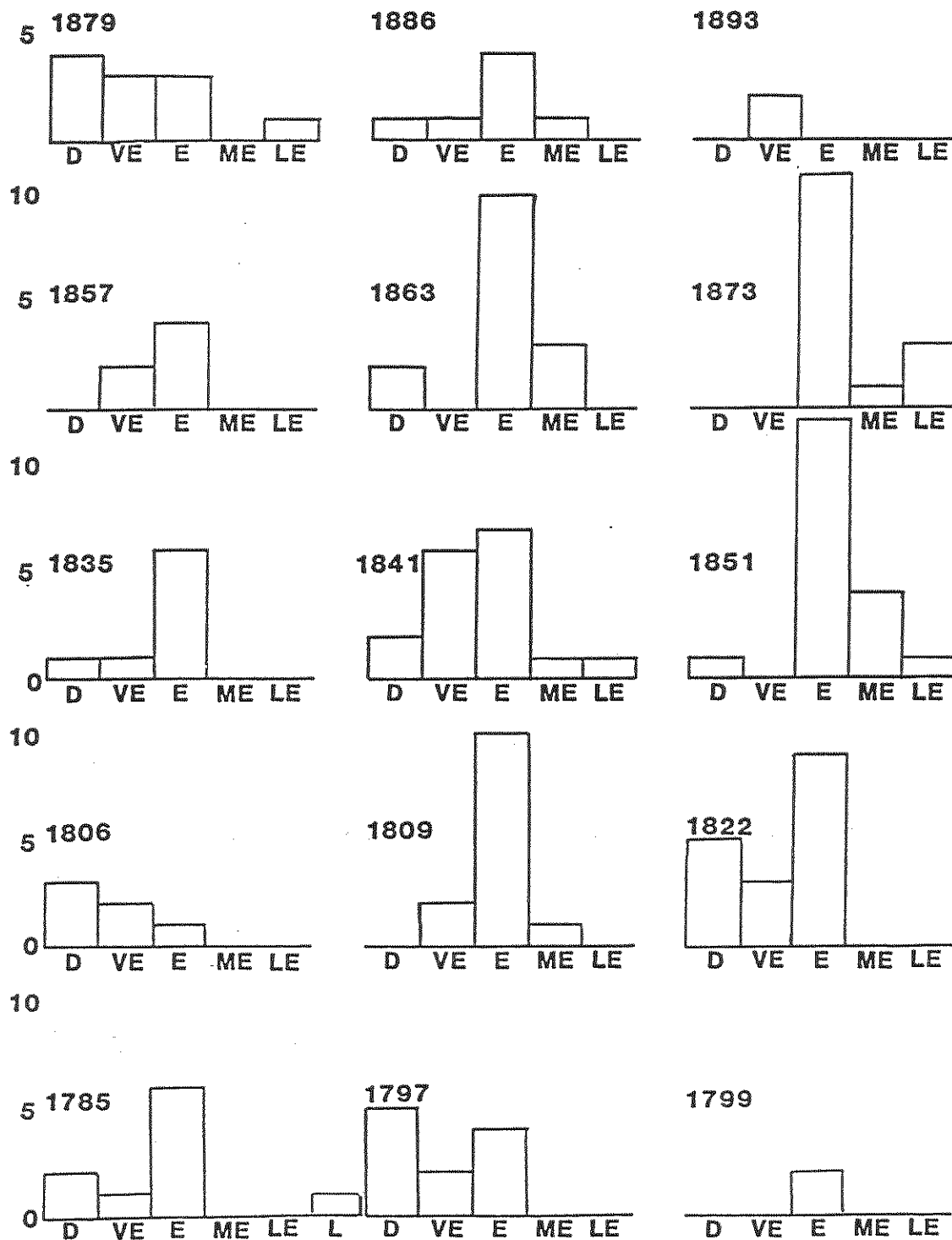


Figure 12.b Patterns of Seasonal Scarring by Fire Years
Catagories established for scar position within the annual ring
 1) D - dormant season 2) VE - very early; within the first 10% of the earlywood formed 3) E - earlywood; no further distinction possible
 4) ME - mid earlywood 5) LE - late in the earlywood; within the last 10% formed 6) L - latewood scar 7) UID - seasonality not determined